From: David Welch

Sent: Fri Jan 31 12:28:53 2020

To: Gelman,Desmond (CONTR) - NSSP-4; Erin Rechisky

Cc: Petersen,Christine H (BPA) - EWP-4; Chong,Jay (BPA) - NSSP-4; Erin Rechisky

Subject: [EXTERNAL] RE: BPA Contract 81498 Mod 1; 1996-017-00 EXP Survival in Large Western Rivers; No Cost Time Extension & Scope Change, Data Analysis

Importance: Normal

Attachments: 81498 Mod 1-Signed (31 Jan 2020).pdf

Dear Desmond-

Please find attached my signature on the contract amendment. For simplicity, I have signed the first page but just scanned in the first 4 pages of the entire file that you had emailed to me; if you should need the whole document scanned and returned, just ask.

Kind regards,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: (b)(6) [redacted]

Skype: david.welch.kintama

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

From: Gelman,Desmond (CONTR) - NSSP-4 <dxgelman@bpa.gov>
Sent: Thursday, January 30, 2020 2:00 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch <David.Welch@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Chong,Jay (BPA) - NSSP-4

<jxchong@bpa.gov>
Subject: BPA Contract 81498 Mod 1; 1996-017-00 EXP Survival in Large Western Rivers; No Cost Time Extension & Scope Change, Data Analysis

Good afternoon,

Attached for your review is the subject Contract modification document. Please review the document and if acceptable, sign and promptly return one fully executed copy to me via E-mail.

Regards,

Desmond Gelman (CONTR)

Flux Resources

Contract/Acquisitions Specialist Admin. 2

Grants and Agreements Team, NSSP-4

Bonneville Power Administration

Bpa.gov / Office: (503) 230-4960

U.S. DEPARTMENT OF ENERGY
BONNEVILLE POWER ADMINISTRATION
AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT/ORDER

OMB

PAPERWORK REDUCTION ACT BURDEN DISCLOSURE STATEMENT

This data is used to amend a solicitation or modify a contract or order. This form will assist in ensuring all changes are applied appropriately. Public reporting burden for this collection of information is estimated to average 15 minutes per response, including the time for reviewing instructions, searching for existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send any comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Office of the Chief Information Officer, Enterprise Policy Development & Implementation Office, IM-22, Paperwork Reduction Program (OMB) US Department of Energy, 1000 Independence Ave, SW, Washington, DC 20585-1290; and to the Office of Management & Budget (OMB), OIRA, Paperwork Reduction Project (OMB), Washington, DC 20503.

1. Solicitation/Contract/Order Number: BPA- 19 - C - 81498	2. Amendment/Modification Number: BPA-20 - M - 001

3. Effective Date: 02/01/2020	4. Requisition/Purchase Req Number *(used for COOP event only)*: CCR - 43458	5. Contract Specialist *(Name, Phone, Email)*: Jay Chong, 503-230-4007, jxchong@bpa.gov

AMENDMENTS OF SOLICITATIONS

6. The above numbered solicitation is amended as set forth in Item 12. The hour and date specified for receipt of Offers, ☐ is extended to ☑ is not extended.

Offerors must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation. If a signature is requested in Item 11, acknowledge this amendment by completing Items 13 and 14 and returning the amendment with your proposal. Failure of your acknowledgment to be received at the place designated for the receipt of proposal prior to the hour and date specified may result in rejection of your proposal. If by virtue of this amendment you desire to change a proposal already submitted, such a change must be received prior to the due date and hour specified in the solictation.

MODIFICATIONS OF CONTRACTS/ORDERS (Modifies the contract/order as described in item 12.)

CHECK ONE	
☐	7. This unilateral modification is issued pursuant to: *(specify authority below)*. The changes set forth in item 12 are made in the Contract/Order in Item 1.
☐	8. The above numbered Contract/Order is modified to reflect the administrative changes *(such as changes in paying office, spelling correction, etc.)* set forth in item 12 pursuant to the authority of BPI Part 14.10.3(b)(1).
☑	9. Bilateral/Other *(specify authority)*: IAW BPI Clause 28-6 Changes

10. Accounting and Appropriation Data *(used for COOP event only)*:
EW / CFW / WO / 00112280 / 01 / 199601700

IMPORTANT 11. Contractor ☐ is not, ☑ is required to sign this document and return via email to the Contract Specialist.

12. Description of Amendment/Modification *(Attach additional documentation if needed and state SEE CONTINUATION SHEET.)*

1. The purpose of this modification is to extend the performance period end date from 1/31/2020 to 3/31/2020.

2. No new work is being added and this modification does not change the scope of the original award.

3. The total contract value will not change and remains the same at $75,000.

(Please see continuation sheet for additional modification description)

Except as provided herein, all terms and conditions of the document referenced in Item 1 or 2 remain unchanged.

13. Company Name:
Kintama Research Services Ltd

14a. Name, Phone and Title of Signer: David Welch		15a. Name of Contracting Officer: Stephanie Green	
14b. Contractor/Offeror By: [redacted] *(Signature of person authorized to sign)*	14c. Date Signed: 31/1/2020	15b. Signature of Contracting Officer By: [redacted] *(Signature of Contracting Officer)*	15c. Date Signed: 01/30/2020

Modification of Contract: 81498 Mod 1
Description (Cont.)

4. The following Work Elements (WE) will be modified as a result of the extended end date and need to re-write the journal article associated with this project;
- A-185: Periodic status reports for BPA
- B-183: The coast-wide collapse in marine survival of North American Chinook salmon
- E-119: Administer contract

5. The following Work Elements will be canceled due to the changes in this mod;
- C-162: Evaluate survival rates of Snake River spring Chinook smolts in four regions
- D-183: The contribution of hydrosystem survival to adult return rates of Snake River Yearling Chinook salmon

6. A conformed copy of the Statement of Work is hereby attached.

7. All other terms and conditions remain unchanged.

8. No other changes are authorized with this modification.

[End of Description of Mod]

Statement of Work Report

Data Current as of: 01/28/2020
Report Printed: 01/28/2020

Project Title:	Technical and Analytical Support for ESA Activities/Issues		
Project #:	1996-017-00		
Contract Title:	1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS		
Contract #:	81498	**Amendment #:**	1
Province:	Non-Provincial	**Subbasin:**	Basinwide
Workorder Task(s):	WO: 00112280 Task: 1		
Perf. Period Budget:	$75,000	**Perf. Period:**	2/11/2019 - 3/31/2020
Contract Type:	Contract	**Pricing Type:**	Firm Fixed Price
Contractor(s):	Kintama Research (Prime - KINTRESE00)		
BPA Internal Ref:	Amd1		
SOW Validation:	Last validated 01/15/2020 with 8 problems, and 0 reviewable items		
Contract Documents:	Transmittal Memo (01/15/2020)	CCR Transmittal Memo for CCR-43458	

Contract Description:

There are two objectives in this contract: 1) If accepted, to respond to reviewer's comments on our paper submitted to PLoS ONE "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or a deeper failure?". This paper was submitted in 2018 under contract 75025. If not accepted at PLoS ONE, we will reformat and submit the paper to a fisheries journal and/or submit our manuscript to BPA as the final deliverable of this work element. 2) We will continue our analysis on the survival rates of Snake River spring Chinook smolts in four regions initiated under contract 75025. We will submit this paper to a high ranking peer-reviewed journal. The working title is "The contribution of hydrosystem survival to adult return rates of Snake River Yearling Chinook Salmon".

Project background: From 2006-2011, the Coastal Ocean Acoustic Salmon Tracking project (COAST; formerly the Pacific Ocean Shelf Tracking project, POST; BPA project 2003-114-00) managed by Kintama Research used a large-scale acoustic telemetry array to track Columbia River basin yearling Chinook salmon smolts during their seaward and early-ocean migration. More than 8000 salmon smolts were tagged with VEMCO acoustic transmitters; tracking arrays extended from the Snake River basin to southeast Alaska. The tracking data were used to estimate estuarine and early marine survival and to perform a series of experiments to test key hypotheses related to the possible delayed effects of the Federal Columbia River Power System (FCRPS) on Chinook smolt survival. Results from project 2003-114-00 were peer-reviewed and published in several top research journals (e.g., Rechisky et al. 2009, Welch et al. 2011, Rechisky et al. 2012, Rechisky et al. 2013, amongst others).

In 2017-2018, under contract 75025, Kintama collated and compared CWT or PIT tag-based SAR estimates available for wild and hatchery-reared Chinook and steelhead originating from the Columbia River basin with populations from rivers originating in Oregon, Washington's outer coast, Puget Sound, all regions of British Columbia, and SE Alaska to provide a broader geographic perspective on how Columbia River basin survival compares to regions without dams. We also provided an update to Kintama's paper on "Survival of Migrating Salmon Smolts in Large Rivers With and Without Dams" published in PLoS Biology in 2008 by including river survival data obtained in 2008 and 2009 for Snake River spring Chinook originating from Dworshak Hatchery as part of BPA project 2003-114-00. We also included more recent data from a Fraser River population of Chinook salmon that travel a comparable distance down river before reaching the ocean, as well any other published estimates for populations outside of the CRB. Both of these data sets were included in the submitted paper "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or a deeper failure?".

For the survival rate paper (objective 2), we will include results from the survival rate analysis (survival per unit time or distance) completed under project #2003-114-00 which compared and contrasted various measurements of Snake River spring Chinook smolt survival in four regions: (1) the hydropower system, (2) the undammed lower Columbia River and estuary, (3) the Columbia River plume, and (4) the coastal ocean. We will continue our evaluation on whether smolts moved out of the FCRPS by management actions are likely to fare better in the ocean, and quantify how variability in survival during the remainder of the marine life history may affect the statistical power of correlations between environmental conditions during smolt outmigration and adult return rates several years later. We will also include in this paper a rigorous quantitative evaluation of how much influence survival in the FCRPS has on determining the SAR. We will publish this paper or submit the paper as a report to BPA as the final deliverable for this work element.

These reports will provide an important perspective on the survival of Columbia River salmon relative to salmon stocks in other regions, which is currently lacking. If the Columbia's rebuilding targets of 4-6% SARS are not being met anywhere else without dams, it raises question of whether they are realistic for the Columbia. It will also contribute perspective on the relative importance of ocean and freshwater factors in affecting the potential recovery of the Columbia River Basin salmon stocks.

Contacts:

Name	Role	Organization	Phone/Fax	Email	Address
Benjamin Zelinsky	Interested Party	Bonneville Power Administration	(503) 230-4737 / NA	bdzelinsky@bpa.gov	KEWB-4 905 NE 11th Ave. Portland, OR 97208 Portland OR 97208-3621
David Welch	Supervisor	Kintama Research	(250) 739-9044 / (250) 729-2622	david.welch@kintama.com	3727 Vista View Crescent Nanaimo BC V9V 1N8
Erin Rechisky	Contract Manager	Kintama Research	(250) 667-6951 / NA	erin.rechisky@kintama.com	BC
Kristen Jule	F&W Approver	Bonneville Power Administration	(503) 230-3588 / NA	krjule@bpa.gov	
Christine Petersen	COTR	Bonneville Power Administration	(503) 230-4695 / NA	chpetersen@bpa.gov	
Elham Zolmajd-Haghighi	Administrative Contact	Bonneville Power Administration	(503) 230-7414 / NA	ezolmajd-haghighi@bpa.gov	P.O. Box 3621 Mailstop - NSSP-4 Portland OR 97208-3621
Lisa Dexter	Administrative Contact	Bonneville Power Administration	(503) 230-3893 / NA	lldexter@bpa.gov	905 NE 11th Ave. Portland 97232
Tybee Sheidler	Administrative Contact	Bonneville Power Administration	(503) 230-3820 / NA	tasheidler@bpa.gov	P.O. Box 3621 Mail Stop NSSP-4 Portland OR 97208-3621
Jay Chong	Contracting Officer	Bonneville Power Administration	(503) 230-4007 / NA	jxchong@bpa.gov	

Work Element Budget Summary:

Work Element - Work Element Title	EC Needed*	Estimate	(%)
A : 185. Produce Pisces Status Report - Periodic Status Reports for BPA		$437	(0.58 %)
B : 183. Produce Journal Article - The coast-wide collapse in marine survival of North American Chinook salmon		$21,188	(28.25 %)

From: Gelman,Desmond (CONTR) - NSSP-4

Sent: Fri Jan 31 12:29:06 2020

To: David Welch

Subject: Automatic reply: BPA Contract 81498 Mod 1; 1996-017-00 EXP Survival in Large Western Rivers; No Cost Time Extension & Scope Change, Data Analysis

Importance: Normal

Teleworking 1/31 until 10 am.

From: Erin Rechisky

Sent: Fri Jan 31 15:06:03 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Milestone "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" is due today

Importance: Normal

Thanks, Christine,
Have a good weekend,
Erin

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: January 31, 2020 2:59 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Milestone "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" is due today

Yes - this should be reset for the end of March as the final status report. Please ignore it. If it stays at this date in cbfish, please let me know.

I'm glad this contract modification finally went through.

Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Friday, January 31, 2020 2:47 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: Milestone "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" is due today

Hi Christine,
Should I ignore this?

Erin

-----Original Message-----
From: donotreply@cbfish.org <donotreply@cbfish.org>
Sent: January 31, 2020 5:00 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Milestone "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" is due today

Dear Erin,

Milestone "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" of work element "185 - Periodic Status Reports for BPA" on contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") is due today and has not been marked complete.

If you feel this email has reached you in error, please contact your COTR, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Pisces

Sent: Thu Feb 06 12:34:55 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

This is a quick reminder that we plan to release an upgrade to Pisces Web this afternoon at 5 PM. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6 PM, but we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov.

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Mon Feb 10 13:50:11 2020

To: Monroy Flores,Luisa F (BPA) - EWB-4

Subject: Position Posted: Fish and Wildlife Administrator, GS-0480-13, EWL – Portland, OR

Importance: Normal

Hello,

The Fish and Wildlife Administrator position just opened in the Oregon Implementation (EWL) org. This position has a primary focus on habitat implementation.

Announcement #: DOE-BPA-20-13867-MP

Position Title: Fish and Wildlife Administrator, GS-0480-13, EWL – Portland, OR

Opening Date: 02/10/2020

Closing Date: 02/19/2020

USAJOBS Link: https://www.usajobs.gov/GetJob/ViewDetails/559397000

Individuals that are eligible to apply are:

- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Military Spouses
- Peace Corps & AmeriCorps Vista
- Specials Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

Bonneville Power Administration
bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

Facebook-Icon_31x31_v3Flickr-Icon_31x31Instagram-Icon_31x31LinkedIn-Icon_31x31Twitter_31x31YouTube_

31x31

From: David Welch

Sent: Fri Feb 21 22:42:46 2020

To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Cc: Aswea Porter

Subject: [EXTERNAL] RE: Clearing Up, Issue 1940

Importance: Normal

Attachments: Delayed Mortality-2006-09 Rechisky et al (PNAS 2013).tif

Thanks for this-- very interesting.

(b)(5) [redacted]
Columbia River!

Here is the quote from Ed Bowles in Clearing Up:

"He told me one way to understand why latent mortality
makes sense, even if the precise cause is not understood, is
to compare adult fish returns (known as smolt-to-adult return
ratios, or SARs) to Lower Granite Dam (the fourth dam on
the Snake River) with adult returns to the John Day system
in Oregon (the third dam up the Columbia River main stem).
Spring Chinook from both watersheds experience the
same estuary and the same ocean conditions, he noted. ".

And attached is the key figure from Erin's PNAS paper; all the survival segments line up on the 1:1 line, not the 1:3.4 line (which was the relative Yakima:Dworshak SAR by the time adults from those years came back). We just didn't find any evidence in support of the theory.

I would certainly agree with Scott Levy's quote:

"Millions of juvenile salmon are perishing in the lower
Snake River and we should not be going into this next
spill season unnecessarily blind," he said".

A couple of questions:

(1) Does NOAA's COMPASS model also depend on PIT tag-based SARs for calibration, or CWTs? (I assume PIT tags, but don't really know).

(2) Can you send us the prior week's column, "(CU No. 1938 [8])"? I am just about to send the completely revised draft SAR comparison to Aswea for review (then Erin), but it piqued my interest that K.C. Mehaffey says that she did a "deep dive" into methods of measuring juvenile survival in the prior week's newsletter.

Have a great weekend, David
-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Friday, February 21, 2020 4:23 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Clearing Up, Issue 1940

Hi,

There was a sort of interesting interview on various perspectives on juvenile survival around the region in the Energy newsletter this week. The most surprising might have been Scott Levy, a long term critic, seeming to take gas bubble trauma seriously - although he is mostly advocating for removing dams.

Use the pdf link and go to page 4.

Have a nice weekend

-----Original Message-----
From: NewsData LLC <dispatch@newsdata.com>
Sent: Friday, February 14, 2020 6:09 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Clearing Up, Issue 1940

You can access this week's issue of Clearing Up on the Web or as a PDF...or both!

For the online version of Clearing Up, go to https://www.newsdata.com/clearing_up/

As a subscriber you have full access to digital content allowed by your subscription, once you've completed a simple registration process. Please visit https://www.newsdata.com/tutorial-create-a-login/video_bbd2af52-d02c-11e9-adfe-3fc4ba234b3c.html for information on how to register.

The Clearing Up website also features archives of past issues and links to other NewsData news and information services.

For the PDF version, click this link for this week's issue of Clearing Up:
https://grok.newsdata.com/cgi-bin/viewpdf.cgi?iss=cup1940&cid=IFJrjXxjxeiQ

You can also paste the link into your browser's address box and press Enter (or Return). The issue should appear after a moment.

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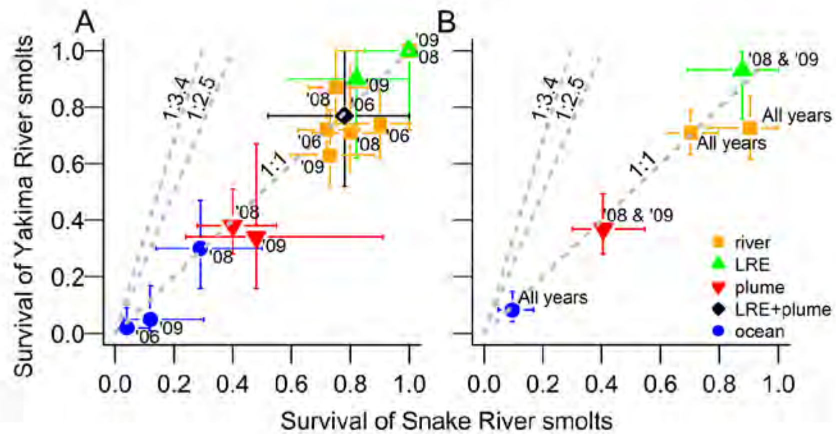

A
B
Survival of Yakima River smolts
Survival of Snake River smolts
1.0
0.8
0.6
0.4
0.2
0.0
1:3.4
1:2.5
1:1
'09
'08
'06
All years
'08 & '09
river
LRE
plume
LRE+plume
ocean

From: David Welch

Sent: Mon Feb 24 17:14:30 2020

To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Cc: Aswea Porter

Subject: [EXTERNAL] RE: Clearing Up, Issue 1940

Importance: Normal

Thank you!

We should touch base toward the middle of next week, once Aswea & Erin have had a chance to do a read through on the revised draft manuscript. A bit of a warning-- it is a very different manuscript from the earlier one because I (reluctantly) pruned out a lot of the material on the psychology of cognitive dissonance (which also explains the "selective ignorance" issue that you mention below). I did a lot of the cutting to make the paper more likely to pass through peer review, but I still shake my head at the obstinance of people refusing to change their minds and really ask whether "more of the same" is really going to work any better as a strategy. (As a friend of mine, who is a biomedical researcher quipped the other day when I described my frustration, that's the "more of the same strategy"... Couldn't possibly have been wrong with my original guess, so obviously we just need to do more of what hasn't been working to make things work the way we know they should!

(b)(5) [redacted]

David

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Monday, February 24, 2020 3:41 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Aswea Porter <Aswea.Porter@Kintama.com>

Subject: RE: Clearing Up, Issue 1940

Hi,
Here is the earlier part of the juvenile survival essay on page 4 For the PDF version, click this link for this week's issue of Clearing Up:
https://grok.newsdata.com/cgi-bin/viewpdf.cgi?iss=cup1939&cid=IFJrjXxjxeiQ

some of the policy makers have only been paying attention to some information. The NOAA model does have some functions which allow differential survival due to arrival timing or carryover effects of transportation. Bowles et al. are selectively ignoring NOAA and other studies.

Yes, there will be no 'new' monitoring this year, (and the Corps budget from DC looks even smaller), but this week we are trying to get organized to deliver gas bubble trauma and smolt injury monitoring data from the existing monitoring at the bypasses to the hydro operators who are supposed to respond as quickly as possible. The 2020 Flexible Spill Agreement has some rules, that they would drop down from 125% TDG to 120/115% TDG once a sample of anadromous or reservoir fish exceeded a certain level (Leah knows the limit better than I do). But there are some details to be worked out about how quickly they would return back to 125%, or delay time for getting the data. I guess everyone has their hypothesis for what will happen. In 2017 and 2018, flows were periodically very high due to snowmelt and precipitation but it was not constant for days at a time. Adult monitoring is only observational.

Christine

-----Original Message-----
From: David Welch <David.Welch@Kintama.com>
Sent: Friday, February 21, 2020 10:43 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] RE: Clearing Up, Issue 1940

Thanks for this-- very interesting.

(b)(5) [redacted]
Columbia River!

Here is the quote from Ed Bowles in Clearing Up:

"He told me one way to understand why latent mortality makes sense, even if the precise cause is not understood, is to compare adult fish returns (known as smolt-to-adult return ratios, or SARs) to Lower Granite Dam (the fourth dam on the Snake River) with adult returns to the John Day system in Oregon (the third dam up the Columbia River main stem).
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I would certainly agree with Scott Levy's quote:
"Millions of juvenile salmon are perishing in the lower Snake River and we should not be going into this next spill season unnecessarily blind," he said".

A couple of questions:

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To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Clearing Up, Issue 1940

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From: Pisces

Sent: Thu Feb 27 13:53:47 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users:

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Modifications to Land Acquisition Status report
- Support of new attachment type called “Manuscript”
- Display SOW Revision in breadcrumb navigation
- Allow bulk edit of Project RM&E priorities

- Stopping support for programmatic and NEPA public involvement

Several bugs have been fixed:

- Contract payment report does not support multiple account types
- "Protocol Name" criteria is not available for portfolio query
- Internal work milestone's completion data is not updated

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always...

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Yarman,Jennifer A (CONTR) - EW-4

Sent: Mon Mar 23 11:58:41 2020

Subject: Message to BPA's Fish & Wildlife Project Sponsors

Importance: Normal

Bonneville Contracts and Strategic Sourcing realizes we are all experiencing uncertain times. We want to share with you that we are doing everything to maintain business continuity within the region without jeopardizing the health and welfare of our co-workers or partners. Bonneville employees are working remotely during the week of March 23. We will continue to evaluate our response to the coronavirus and initiate changes as appropriate. We ask that before you stop, change, or limit the work for which you agreed to perform, please communicate with Bonneville's Contracting Officers (CO) or Contracting Officer Representatives (COR).

If you are able to do so and to the extent applicable, please maintain business continuity by working remotely. If you are not able to work remotely, please contact your CO or COR to facilitate any contract changes or reductions in project scope, schedule, and value. Thank you for your patience during this difficult time.

Respectfully,

Lynnial E. Trusty Jr.

Director | Contracts & Strategic Sourcing

BONNEVILLE POWER ADMINISTRATION

letrusty@bpa.gov | P (360) 418-8258 | C (b)(6) [redacted]

From: Greene,Jacqueline R (CONTR) - EW-4

Sent: Thu Mar 26 12:55:02 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users:

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Stop displaying "Last SOW Action" in red in Dashboard if conditions no longer met
- Provide change logs for project and contract contacts
- Add Attachment Types report link to Project and BPA-Internal-Work Documents pages
- Smart copy for Milestone Dates

- Raise photo's max file size from 2 MB to 4 MB
- Browse photos by project portfolio

Several bugs have been fixed:

- "Contact Role" is displayed as "Contact Type"
- SOW Validation displays identical "missing contact role" errors
- "Gemini" is the Pisces Web project code name but is referenced in work element definition

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org

- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: David Welch

Sent: Mon Mar 30 20:21:55 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: EiS comments

Importance: Normal

(b)(6) [redacted]

No photo description available.

I have just submitted the manuscript. Let's chat when you have time about the implications—a couple may shock you (& your colleagues).

David

(250) 756-7747

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Monday, March 30, 2020 5:56 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: EiS comments

Hi,

I haven't checked in, for a while.

There have been a lot of rapid decisions being made which will affect PIT tagging during the 125% TDG operation this spring which starts next week at Lower Granite. (I remember at the beginning of March, I was closely [redacted]

Anyway, it is against OSHA rules to make workers endure known hazards, without safety equipment. The agencies all made decisions for tasks that involved more than two people working within 6 feet. I believe the state fish and wildlife agencies have stopped wild trapping and some hatchery tagging. Most hatchery tagging and some parr tagging occurred last fall. NOAA was trying to add up the likely number of tagged smolts coming downstream in order to make a decision regarding their estuary trawl, which is necessary to get hydrosystem survival to Bonneville. They might use their new flexible cable which is pulled by two smaller skiffs. The Corps has blocked the crews doing all the tagging at the Lower Granite bypass and adult trap this spring. They will have the smaller number of PSMFC staff doing the smolt monitoring and GBT assessment. I think CRITFC is able to do their additional adult tagging at Bonneville.

It should be interesting. Lots of debate is likely at the TMT forum.

I have been listening to a couple of nights of the public comment period that was requested, because some don't prefer the written comments. The last day is tomorrow at 4pm. It was interesting to hear the spectrum of opinions – mostly there are only about 20-30 callers. Last Thursday there were several French people with a specific set of talking points regarding southern resident killer whales. There are a several new ideas, such as someone emphasizing brook trout outcompeting Chinook. Some of the common talking points are either 20 years out of date or totally misinformed. One is that there is 92% mortality through the hydrosystem or '8 million smolts killed'. It is also frequently stated that we are within 5 years of extinction and everything is getting worse and worse, or that there used to be a thriving recreational fishery in Idaho, but it is collapsed in the last decade. This is sort of fascinating because I go over to DART and look at the ladder time series for Bonneville or Ice Harbor, and it is clear that the count has increased a lot since 2000, however so many people share these impressions about availability of adults in streams from the 1970-90s vs right now. I do understand that there was a lot more harvest downstream of Bonneville 20-70 years ago, but that shouldn't influence people's perceptions. Are the hatchery fish getting scooped up, or there are just more people out there in the state? Redd counts of wild fish are definitely lower, but it was a group choice to add hatcheries.

Christine

---------- Forwarded message ----------
From: "Sullivan,Leah S (BPA) - EWP-4" <lssullivan@bpa.gov>

Cc:

If interested, CRSO DEIS public meetings will kick off today if you want to listen in (see website for additional information at https://www.nwd.usace.army.mil/CRSO/Submit-Your-Comment/#top).

Dates: March 17, 18, 19, 25, 26, 31

Dial: [redacted]

When prompted, press # to join as participant.

Participant access code: [redacted]

Happy St. Patrick's Day,

Leah

From: David Welch

Sent: Tue Mar 31 13:26:33 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] FW: Final Submitted Manuscript

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

From: David Welch
Sent: Tuesday, March 31, 2020 1:21 PM
To: Christine Petersen [redacted] (b) (6)
Subject: Final Submitted Manuscript

FISH and FISHERIES

Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)

Journal:	*Fish and Fisheries*
Manuscript ID	Draft
Wiley - Manuscript type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Welch, David; Kintama Research Services Ltd, Porter, Aswea; Kintama Research Services Ltd Rechisky, Erin; Kintama Research Services Ltd
Key terms:	Aquaculture, Columbia River, dams, delayed mortality, smolt-to-adults returns, Snake River
Abstract:	(b)(5) [redacted]

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[redacted]

From: David Welch

Sent: Wed Apr 01 10:37:28 2020

To: Fish & Wildlife Invoices

Cc: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/ $10,481.72

Importance: Normal

Attachments: 2020-003 BPA (20 March 2020).pdf

Hello-

Please find attached our final invoice for this contract, which closes out the agreed-upon work.

I confirm that we have submitted for peer-reviewed publication the document prepared summarizing the analysis and have provided a copy to Dr Peterson. You will see in the invoice that our effort on this contract went well beyond what was originally expected, but we have of course only billed for the remaining monies in the contract.

Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

4/1/2020

Bonneville Power Administration-PBL
ATTN: Program Analyst
PO Box 3621
Portland, OR 97208-3621

INVOICE #: 2020-003

Kintama Research Services Ltd
4737 Vista View Crescent, Nanaimo, BC, V9V 1N8, Canada

BPA Contract #: 81498

BPA Project #: 1996-017-00

Invoice Performance Period: *(for work actually performed)*

Note: *If the invoice performance period covers more than one budget period or BPA fiscal year [10/01/20xx-9/30/20xx], provide a sub-total of the costs attributable to each budget period or fiscal year.*

Invoice Billing Period: **10/1/2019--3/20/2020**
Contract Term: **02/11/2019 - 01/31/2020**
Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

Expenditures this invoice:

			hours	$/hr	$
512111 Wages	Personnel and fringe:				
		Welch	528.25	$150.00	$79,237.50
		Porter	341.50	$109.38	$37,353.27
		Rechisky	95.00	$109.38	$10,391.10
Miscellaneous			trips		
	Conference registration & associated travel				

Total contract budget amount:	$75,000.00
Previously invoiced expenditures	$64,518.28
Current expenditures this invoice period	$126,981.87
Current Request	**$10,481.72**
Balance remaining:	$0.00

Invoice Contact:

Name:	Dr David Welch
Title:	President
Telephone # (Toll Free):	+1-866-546-8262
Telephone (Cell):	(b)(6) [redacted]
E-mail address:	david.welch@kintama.com

Please route payment via: Canadian Imperial Bank of Commerce
Checking: (b)(4) [redacted]
Swift: (b)(4) [redacted]

K:\9. MANAGEMENT\Invoices\2020 Invoices\2020-003 BPA (31 March 2020).xls

From: Fish & Wildlife Invoices

Sent: Wed Apr 01 11:45:13 2020

To: erin.rechisky@kintama.com

Cc: Petersen,Christine H (BPA) - EWP-4

Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/ $10,481.72

Importance: Normal

Attachments: 2020-003 BPA (20 March 2020).pdf

Hi Erin,

We cannot process this Final invoice until the final status report has been submitted. Please submit and let us know when this has been taken care of.

Thank you,

Michele

From: David Welch
Sent: Wednesday, April 1, 2020 10:37 AM
To: Fish & Wildlife Invoices
Cc: Petersen,Christine H (BPA) - EWP-4 ; Erin Rechisky
Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hello-

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Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: (b)(6) [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

4/1/2020

Bonneville Power Administration-PBL
ATTN: Program Analyst
PO Box 3621
Portland, OR 97208-3621

INVOICE #: 2020-003

Kintama Research Services Ltd
4737 Vista View Crescent, Nanaimo, BC, V9V 1N8, Canada

BPA Contract #: 81498

BPA Project #: 1996-017-00

Invoice Performance Period: *(for work actually performed)*

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Contract Term: **02/11/2019 - 01/31/2020**
Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

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Invoice Contact:

Name:	Dr David Welch
Title:	President
Telephone # (Toll Free):	+1-866-546-8262
Telephone (Cell):	[redacted]
E-mail address:	david.welch@kintama.com

Please route payment via: Canadian Imperial Bank of Commerce
Checking: [redacted]
Swift: [redacted]

K:\9. MANAGEMENT\Invoices\2020 Invoices\2020-003 BPA (31 March 2020).xls

From: Fish & Wildlife Invoices

Sent: Wed Apr 01 11:45:15 2020

To: erin.rechisky@kintama.com

Cc: Petersen,Christine H (BPA) - EWP-4

Subject: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/ $10,481.72

Importance: Normal

Attachments: 2020-003 BPA (20 March 2020).pdf

Hi Erin,

We cannot process this Final invoice until the final status report has been submitted. Please submit and let us know when this has been taken care of.

Thank you,

Michele

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, April 1, 2020 10:37 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

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Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

4/1/2020

Bonneville Power Administration-PBL
ATTN: Program Analyst
PO Box 3621
Portland, OR 97208-3621

INVOICE #: 2020-003

Kintama Research Services Ltd
4737 Vista View Crescent, Nanaimo, BC, V9V 1N8, Canada

BPA Contract #: 81498

BPA Project #: 1996-017-00

Invoice Performance Period: *(for work actually performed)*

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Please route payment via: Canadian Imperial Bank of Commerce
Checking: [redacted]
Swift:

K:\9. MANAGEMENT\Invoices\2020 Invoices\2020-003 BPA (31 March 2020).xls

From: Fish & Wildlife Invoices

Sent: Wed Apr 01 11:59:33 2020

To: Erin Rechisky

Subject: RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Importance: Normal

Thank you!

Michele

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 1, 2020 11:51 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; David Welch <David.Welch@Kintama.com>
Subject: [EXTERNAL] RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Michelle,
I am working on the final status report right now. I've been corresponding with Christine.

I'll have the status report finished today or tomorrow and follow up with you.

Kind regards,

Erin

Erin Rechisky, PhD

Research Manager

kintama.com

755 Terminal Avenue North• Nanaimo BC V9S 4K1 • Canada

Cell: (b)(6) [redacted]

Email: erin.rechisky@kintama.com • Skype: erin_rechisky

From: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Sent: April 1, 2020 11:45 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

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Michele

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Sent: Wednesday, April 1, 2020 10:37 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

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Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: **http://kintama.com/media/videos/**

P Please consider the environment before printing this e-mail

From: Erin Rechisky

Sent: Wed Apr 01 11:59:37 2020

To: chpetersen@bpa.gov

Subject: [EXTERNAL] RE: Status Report Submitted

Importance: Normal

Hi Christine,
I meant to add a comment to the status report. Can you add this:
Final Jan-Mar 2020 (1/1/2020 - 3/31/2020) Submitter Comments

Our manuscript of the Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha) was submitted to Fish and Fisheries on March 30, 2020.
Abstract
(b)(5) [redacted]

Erin
-----Original Message-----
From: CBFish on behalf of support@cbfish.org <donotreply@cbfish.org>
Sent: April 1, 2020 11:55 AM
To: chpetersen@bpa.gov; Erin Rechisky <Erin.Rechisky@Kintama.com>

Subject: Status Report Submitted

To: Christine Petersen;Erin Rechisky
Cc:

The "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" report for contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been submitted by erin.rechisky@kintama.com. You may view the submitted report in Pisces.

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: David Welch

Sent: Wed Apr 01 12:27:45 2020

To: Erin Rechisky; Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Deliverable Marked Complete

Importance: Normal

Hi Christine--

I think getting wide distribution of the manuscript makes great sense. I have no problem with sending the paper out for information or comment.

David

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 01, 2020 11:49 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: David Welch <David.Welch@Kintama.com>
Subject: RE: Deliverable Marked Complete

Hi Christine,
Yes, you may share the paper. I've cc'd David in case he feels otherwise.
I've gone back in and selected "Pisces users" for access to the manuscript file.
I've marked travel complete and added that we did not travel.
I've marked contract admin complete and added a comment.
Looks like the final status report needs to be submitted before the invoice can be processed. I just have a couple more things to do in Pisces. Hopefully I can get them completed today but my workday is coming to a close since I am home schooling.
Erin

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 1, 2020 11:27 AM

To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Hi Erin,

Thank you very much for the paper. I spoke with David yesterday, and the figures really have a lot of implications if you understand and let it sink in. I need to read the full paper later this week.

(b)(5) [redacted]

In Pisces - you might select 'pisces users', but I am not sure what level would make the paper accessible via a web crawler such as google. My best understanding is that only the annual reports that Suzie Frye 'publishes' on the website end up being findable. Another element is that I believe the tech services project number for Bioanalyst might be accessible to contacts only, because this is the case for UW (Jim Anderson) so it wouldn't make a difference what option you pick.

You could check green for travel, and then add a note or comment.

For timely administration of contracting, you can also mark this complete.
I spoke with David briefly about next steps, but I need to talk to Jody and Kristen about setting up a time for you guys to possibly present or respond to questions. We can let several of them read the paper and I anticipate they will like to participate. I will raise the second data analysis that you halted with Jody, and David also spoke of a couple new ideas yesterday.

Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 1, 2020 11:03 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Deliverable Marked Complete

Hi Christine,
I've uploaded the SAR paper to Pisces. I was not sure who should have access? I selected "Contacts" from the drop down menu. Let me know if I should change that.
For the final status report of our contract, how do we handle "optional travel to conference"?
Also, can I mark the Deliverable for E:119 "Effective implementation management and timely contract administration" complete as of yesterday?

Thanks,
Erin

-----Original Message-----
From: CBFish on behalf of support@cbfish.org <donotreply@cbfish.org>
Sent: April 1, 2020 10:56 AM
To: chpetersen@bpa.gov; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Deliverable Marked Complete

To: Christine Petersen;Erin Rechisky
Cc:

The milestone "Deliverable: Produce Journal Article" for work element "B: 183. The coast-wide collapse in marine survival of North American Chinook salmon" on contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been marked complete on status report "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)".

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: CBFish on behalf of support@cbfish.org

Sent: Wed Apr 01 15:03:29 2020

To: chpetersen@bpa.gov; erin.rechisky@kintama.com

Subject: [EXTERNAL] Status Report Returned

Importance: Normal

To: Christine Petersen;Erin Rechisky
Cc:

The "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" report for contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been returned to erin.rechisky@kintama.com by the COTR for additional work.

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: David Welch

Sent: Wed Apr 01 15:37:24 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Fish Passage Center email...

Importance: Normal

Attachments: FPC Letter to Agencies on Kintama Request (1 October 2019).pdf

Christine—

Attached is the email Michelle de Hart sent out to various organizations after I formally requested she provide the data we needed. In it Michelle says that she will respond to Kintama, which we never received… she wrote to the agencies, but never back to Kintama. (*"The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables."*).

Do you know whether Michelle wrote back to BPA asking for the contract details? She certainly has never responded to me at all.

David

David Welch

From: Petersen,Christine H (BPA) - EWP-4 [chpetersen@bpa.gov]
Sent: Wednesday, October 02, 2019 9:12 AM
To: David Welch
Subject: FW: Kintama Letter
Attachments: KintamaLetter-091919.pdf

Hi David
I am heading back from Seattle this morning. I actually got an incoming call from FPC (b)(6) [redacted]
(b)(6) [redacted]

This letter may warrant no response, and may be the documentation needed to show we don't have access to hatchery to hatchery PIT based SARs. A little weird to CC all the agencies. I will talk with Jody Lando or maybe Ben Z tomorrow.

Christine

Sent from Workspace ONE Boxer

---------- Forwarded message ----------
From: Michele Dehart <mdehart@fpc.org>
Date: Oct 1, 2019 3:50 PM
Subject: [EXTERNAL] FW: Kintama Letter
To:
adam.j.storch@state.or.us,Erick.S.VanDyke@coho2.dfw.state.or.us,tucker.a.jones@state.or.us,lort@critfc.org,lotr@critfc.org,LESR@critfc.org,'Christine Golightly' <GOLC@critfc.org>,ED.Bowles@state.or.us,lance Hebdon
<lance.hebdon@idfg.idaho.gov>,tim.copeland@idfg.idaho.gov,Daniel.Rawding@dfw.wa.gov,tweitwmt@dfw.wa.gov,Michael.Garrity@dfw.wa.gov,Steve_Haeseker@fws.gov,David Swank
<david_swank@fws.gov>,ritche.graves@noaa.gov,jayh@nezperce.org,zpenney@critfc.org
Cc: Jerry McCann <jmccann@fpc.org>,Brandon Chockley <bchockley@fpc.org>,Erin Cooper <ecooper@fpc.org>,Gabriel Scheer <gscheer@fpc.org>,Bobby Hsu <bobbyhsu@fpc.org>,"Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>

Hello:
This is just a heads up, to pass along a recent certified letter received by the Fish Passage Center from David Welch, Kintama Research Services. This letter is related an article by Welch et al, developed under contract with BPA, submitted for publication in the online journal PLOS. The article titled, "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow moving catastrophe or deeper failure?". The article was posted on a biological sciences archive page, for non-peer reviewed articles, called bioRxiv. The analyses developed under BPA contract was attached to recommendations by Welch to the NW Power Planning Council amendment process.

The BPA COTR on this contract is Christine Petersen and Welch has copied her on this letter. Some of the statements by Welch in this letter, do not comport with the documentation of emails from Christine Petersen, BPA, to the Fish Passage Center in 2017, in which Ms. Petersen states that BPA is interested in SARs from release to uppermost dam for the 2017 Biological Assessment. SARs from point of release to upper most dam, are not a component of CSS analyses or study design. The FPC does not generate these SARs and Ms. Petersen was advised accordingly in 2017 and advised that this request would represent a significant amount of new work. When the FPC was asked to review the Welch analyses, 2019, the BPA contract, including deliverables and work elements was requested, to understand the hypotheses that BPA contracted Kintama to pursue. The Kintama contract, work elements, deliverables, was not provided.

The FPC provides all data and analyses completed in FPC, CSS and SMP projects to the public. SARs from point of release, traps, etc...are not generated as part of these projects. The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables.

Michele

From: CBFish on behalf of support@cbfish.org

Sent: Thu Apr 02 16:04:09 2020

To: chpetersen@bpa.gov; erin.rechisky@kintama.com

Subject: [EXTERNAL] Status Report Submitted

Importance: Normal

To: Christine Petersen;Erin Rechisky
Cc:

The "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" report for contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been submitted by erin.rechisky@kintama.com. You may view the submitted report in Pisces.

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Erin Rechisky

Sent: Thu Apr 02 16:28:09 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Deliverable Marked Complete

Importance: Normal

Managing....barely!

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 2, 2020 4:24 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Thank you very much, Erin,

(b)(5) [redacted]

There are various time consuming challenges in the next week, but I should think we would be prepared by 2-3 weeks from now. There have been some wild discussions of monitoring, and dramatic changes in the planned operation at the dams this spring. Exciting times!

(b)(6) [redacted]

Talk to you soon,
Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Thursday, April 2, 2020 4:05 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Deliverable Marked Complete

Done.
Just let us know when you are ready to discuss the SARs manuscript.

Erin

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 1, 2020 3:05 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Hi Erin,

I am able to return the status report, but it won't let me copy in your comment. Just enter it and return it to me.

Kristen suggests a discussion in 2-3 weeks when several of us have had a chance to read the manuscript?

Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 1, 2020 11:49 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: David Welch <David.Welch@Kintama.com>
Subject: [EXTERNAL] RE: Deliverable Marked Complete

Hi Christine,
Yes, you may share the paper. I've cc'd David in case he feels otherwise.
I've gone back in and selected "Pisces users" for access to the manuscript file.
I've marked travel complete and added that we did not travel.
I've marked contract admin complete and added a comment.
Looks like the final status report needs to be submitted before the invoice can be processed. I just have a couple more things to do in Pisces. Hopefully I can get them completed today but my workday is coming to a close since I am home schooling.
Erin

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 1, 2020 11:27 AM

To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Hi Erin,

Thank you very much for the paper. I spoke with David yesterday, and the figures really have a lot of implications if you understand and let it sink in. I need to read the full paper later this week.

(b)(5) [redacted]

In Pisces - you might select 'pisces users', but I am not sure what level would make the paper accessible via a web crawler such as google. My best understanding is that only the annual reports that Suzie Frye 'publishes' on the website end up being findable. Another element is that I believe the tech services project number for Bioanalyst might be accessible to contacts only, because this is the case for UW (Jim Anderson) so it wouldn't make a difference what option you pick.

You could check green for travel, and then add a note or comment.

For timely administration of contracting, you can also mark this complete.
I spoke with David briefly about next steps, but I need to talk to Jody and Kristen about setting up a time for you guys to possibly present or respond to questions. We can let several of them read the paper and I anticipate they will like to participate. I will raise the second data analysis that you halted with Jody, and David also spoke of a couple new ideas yesterday.

Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 1, 2020 11:03 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Deliverable Marked Complete

Hi Christine,
I've uploaded the SAR paper to Pisces. I was not sure who should have access? I selected "Contacts" from the drop down menu. Let me know if I should change that.
For the final status report of our contract, how do we handle "optional travel to conference"?
Also, can I mark the Deliverable for E:119 "Effective implementation management and timely contract administration" complete as of yesterday?

Thanks,
Erin

-----Original Message-----
From: CBFish on behalf of support@cbfish.org <donotreply@cbfish.org>
Sent: April 1, 2020 10:56 AM
To: chpetersen@bpa.gov; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Deliverable Marked Complete

To: Christine Petersen;Erin Rechisky
Cc:

The milestone "Deliverable: Produce Journal Article" for work element "B: 183. The coast-wide collapse in marine survival of North American Chinook salmon" on contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been marked complete on status report "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)".

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: CBFish on behalf of support@cbfish.org

Sent: Fri Apr 03 09:10:50 2020

To: chpetersen@bpa.gov; erin.rechisky@kintama.com

Subject: [EXTERNAL] Status Report Accepted

Importance: Normal

To: Christine Petersen;Erin Rechisky
Cc:

The "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)" report for contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been accepted by the COTR. You may view the accepted report in Pisces.

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Fish & Wildlife Invoices

Sent: Fri Apr 03 10:06:10 2020

To: Erin Rechisky; Fish & Wildlife Invoices

Cc: Petersen,Christine H (BPA) - EWP-4; David Welch

Subject: RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Importance: Normal

Thank you, Erin!

Michele

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Friday, April 3, 2020 9:23 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; David Welch <David.Welch@Kintama.com>
Subject: [EXTERNAL] RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Michelle,

I have submitted Kintama's final status report for our contract. Christine accepted it today.

Kind regards,

Erin

Erin Rechisky, PhD

Research Manager

kintama.com

755 Terminal Avenue North• Nanaimo BC V9S 4K1 • Canada

Cell: [redacted]

Email: erin.rechisky@kintama.com • Skype: erin_rechisky

From: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Sent: April 1, 2020 11:45 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Erin,

We cannot process this Final invoice until the final status report has been submitted. Please submit and let us know when this has been taken care of.

Thank you,

Michele

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, April 1, 2020 10:37 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hello-

Please find attached our final invoice for this contract, which closes out the agreed-upon work.

I confirm that we have submitted for peer-reviewed publication the document prepared summarizing the analysis and have provided a copy to Dr Peterson. You will see in the invoice that our effort on this contract went well beyond what was originally expected, but we have of course only billed for the remaining monies in the contract.

Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

From: Erin Rechisky

Sent: Fri Apr 03 12:06:27 2020

To: Fish & Wildlife Invoices

Subject: [EXTERNAL] RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Importance: Normal

No problem. Stand by. I'll forward David's e-mail.

From: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Sent: April 3, 2020 10:10 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Erin,

We've seem to misplace the invoice. Could you please resend?

Thank you,

Michele

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Friday, April 3, 2020 9:23 AM
To: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; David Welch <David.Welch@Kintama.com>
Subject: [EXTERNAL] RE: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Michelle,

I have submitted Kintama's final status report for our contract. Christine accepted it today.

Kind regards,

Erin

Erin Rechisky, PhD

Research Manager

kintama.com

755 Terminal Avenue North• Nanaimo BC V9S 4K1 • Canada

Cell: (b)(6) [redacted]

Email: erin.rechisky@kintama.com • Skype: erin_rechisky

From: Fish & Wildlife Invoices <FWInvoices@bpa.gov>
Sent: April 1, 2020 11:45 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: HOLD/3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hi Erin,

We cannot process this Final invoice until the final status report has been submitted. Please submit and let us know when this has been taken care of.

Thank you,

Michele

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, April 1, 2020 10:37 AM
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Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: 3482/Inv rec 04/01/20/net15/Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72

Hello-

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Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

From: Erin Rechisky

Sent: Fri Apr 03 12:06:50 2020

To: Fish & Wildlife Invoices

Subject: 3482/Inv rec 04/03/20/ Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/$10,481.72 final

Importance: Normal

Attachments: 2020-003 BPA (20 March 2020).pdf

From: David Welch <David.Welch@Kintama.com>
Sent: April 1, 2020 10:37 AM
To: BPA Invoices (fwinvoices@bpa.gov) <fwinvoices@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Entity: Kintama Research/contract 81498/Invoice Period 11.01.2019-3.20.2020/invoice #2020-003/ $10,481.72

Hello-

Please find attached our final invoice for this contract, which closes out the agreed-upon work.

I confirm that we have submitted for peer-reviewed publication the document prepared summarizing the analysis and have provided a copy to Dr Peterson. You will see in the invoice that our effort on this contract went well beyond what was originally expected, but we have of course only billed for the remaining monies in the contract.

Sincerely,

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

4/1/2020

Bonneville Power Administration-PBL
ATTN: Program Analyst
PO Box 3621
Portland, OR 97208-3621

INVOICE #: 2020-003

Kintama Research Services Ltd
4737 Vista View Crescent, Nanaimo, BC, V9V 1N8, Canada

BPA Contract #: 81498

BPA Project #: 1996-017-00

Invoice Performance Period: *(for work actually performed)*

Note: *If the invoice performance period covers more than one budget period or BPA fiscal year [10/01/20xx-9/30/20xx], provide a sub-total of the costs attributable to each budget period or fiscal year.*

Invoice Billing Period: **10/1/2019--3/20/2020**
Contract Term: **02/11/2019 - 01/31/2020**
Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

Expenditures this invoice:

			hours	$/hr	$
512111 Wages	Personnel and fringe:				
		Welch	528.25	$150.00	$79,237.50
		Porter	341.50	$109.38	$37,353.27
		Rechisky	95.00	$109.38	$10,391.10
Miscellaneous			trips		
	Conference registration & associated travel				

Total contract budget amount:	$75,000.00
Previously invoiced expenditures	$64,518.28
Current expenditures this invoice period	$126,981.87
Current Request	**$10,481.72**
Balance remaining:	$0.00

Invoice Contact:

Name:	Dr David Welch
Title:	President
Telephone # (Toll Free):	+1-866-546-8262
Telephone (Cell):	(b)(6) [redacted]
E-mail address:	david.welch@kintama.com

Please route payment via: Canadian Imperial Bank of Commerce
Checking: (b)(4) [redacted]
Swift: [redacted]

K:\9. MANAGEMENT\Invoices\2020 Invoices\2020-003 BPA (31 March 2020).xls

From: David Welch

Sent: Fri Apr 03 14:51:04 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Fish Passage Center email...

Importance: Normal

Thanks, Christine. No worries.

Have a good weekend, and let's catch up next week. I received an email from the journal confirming that they had received my email sending them two (of four) extra "Supplementary Info" sections that I had somehow failed to include the submitted document. (It seems I attached SI #1 & #2 twice, instead of SI # 1,2,3, & 4… sigh). J

Anyway, the journal does have it. My understanding is that the manuscript will undergo an initial review of potential fit with the journal before it goes out to the peer reviewers, but I am not sure if I will hear anything there (I think the paper is a pretty good fit). No idea on whether with COVID19 the review process will be faster or slower than normal.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Friday, April 03, 2020 1:56 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Fish Passage Center email...

Oh, sorry for slow response.

Yes – Michele asked for the contract details although I don't recall if there was a new letter or email asking for it, beyond the public email. My coworker Katie McDonald dug around and found the email where she had sent over a legally truncated version of the contract that omitted your personal info and also one or two work elements that weren't pertinent to what she was asking for. This had been sent January the year before and we had held a meeting with an attorney about it.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, April 1, 2020 3:37 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Fish Passage Center email...

Christine—

Attached is the email Michelle de Hart sent out to various organizations after I formally requested she provide the data we needed. In it Michelle says that she will respond to Kintama, which we never received… she wrote to the agencies, but never back to Kintama. (*"The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables."*).

Do you know whether Michelle wrote back to BPA asking for the contract details? She certainly has never responded to me at all.

David

From: Petersen,Christine H (BPA) - EWP-4

Sent: Thu Apr 16 17:09:31 2020

To: 'David Welch'; 'Erin Rechisky'

Subject: FW: CSS meeting tomorrow

Importance: High

Attachments: CSS 2020 Annual Meeting Agenda_FINAL.pdf

Hi,

This might not be a productive use of your morning, but they have the CSS presentations as a virtual meeting this year. The Lifecycle Model and cohort model were both used in the EIS, and they have some interesting contrasts, if you go down in the details.

Christine

From: Sullivan,Leah S (BPA) - EWP-4 <lssullivan@bpa.gov>
Sent: Thursday, April 16, 2020 2:01 PM
To: Al Giorgi <al.giorgi@bioanalysts.net>; Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: CSS meeting tomorrow
Importance: High

Just a quick note that tomorrow's annual CSS meeting has a limited amount of available lines. Please plan ahead and try to call in early, if feasible.

Leah

{message from FPC}

Please see attached for the 2020 CSS Annual Meeting Agenda

This meeting will be conducted remotely, please see the important access information attached in the agenda and below.

Date / time:

April 17, 2020 beginning at 8:30 AM

Place:

GoTo Meeting

https://global.gotomeeting.com/join/728423453

You can also dial in using your phone.

(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (646) 749-3122

- *One-touch:* tel:+16467493122,,728423453#

Access Code: 728-423-453

Conference is limited to 150 callers.

We ask that you please put your phones on mute and hold your questions until after the last presentation.

There is time allotted after the talks for extended discussions and questions.

Each presentation will have slide numbers for referencing back.

A 5 minute period after each presentation is provided for clarifying questions if needed.

Alex Saint – Fish Passage Center

Admin Assistant

503-833-3900

He/Him

Comparative Survival Study Annual Meeting (Webinar)

Date / time: April 17, 2020 beginning at 8:30 AM
Place: GoTo Meeting

https://global.gotomeeting.com/join/728423453
You can also dial in using your phone.
(For supported devices, tap a one-touch number below to join instantly.)

United States: +1 (646) 749-3122
- One-touch: tel:+16467493122,,728423453#

Access Code: 728-423-453

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There is time allotted after the talks for extended discussions and questions.
Each presentation will have slide numbers for referencing back.
A 5 minute period after each presentation is provided for clarifying questions if needed.

Time	Title	Presenter
8:30 AM	Introduction to CSS	Jerry McCann
8:50 AM	Juvenile survival, travel time, and the in-river environment	Steve Haeseker
9:10 AM	Bonneville Abundance Estimation	Adam Storch
9:30 AM	Annual SARs, TIR and D by study category	Brandon Chockley
10:00 AM	Upper Columbia River SARs	Dan Rawding
10:30 AM	Break 15 minutes	
10:45 AM	Delayed Mortality Review	Gabe Sheer
11:00 AM	SARs and Productivity	Tim Copeland
11:20 AM	CRSO-EIS Modeling – Summary y of Alternatives and Data Sets	Brandon Chockley
11:40 AM	CRSO-EIS Modeling – Life-cycle Model Results	Bob Lessard
11:55 AM	CRSO-EIS Modeling – Cohort Specific Model Results	Steve Haeseker
12:15 PM	Questions / Discussion	ALL

CSS has allotted time after the talks for extended discussions and questions, as needed.

From: David Welch

Sent: Mon Apr 20 10:36:45 2020

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] FW: Next steps?

Importance: Normal

Attachments: Distributions_early_survivals_v2.png

Hi Christine—

Erin corrected me on something I had written to you previously (see below for the email trail).

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

David

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Monday, April 20, 2020 9:06 AM
To: David Welch <David.Welch@Kintama.com>
Cc: Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Next steps?

Hi David,

(b)(5) [redacted]

[redacted]

You might want to forward this to Christine.

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: April 17, 2020 10:58 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Next steps?

Thanks. I just got back on to the CSS call as they broke for 5 minutes—[redacted] **(I caught part of the WTT & survival analysis before having to step off).**

(b)(5)

[redacted]

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Friday, April 17, 2020 9:35 AM
To: David Welch <David.Welch@Kintama.com>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Next steps?

I will talk to Jody. Also, John Skidmore (now our interim division manager) should probably considered essential to have at your presentation. He has a background with creel surveys, and he wishes to make tracking of harvest management forums/adult issues be part of the job description of an open listing here at BPA. The agency has typically had no role because harvest appears to be thoroughly outside of the domain of the Dept of Energy.

I am watching the CSS presentations. With several topics, you would need an opportunity to go to the blackboard and have a more prolonged discussion. It was interesting, that Steve Haeseker had slides on the topic of daily survival rates, which was the subject of your second data analysis. Except his 'mechanistic' model for the travel time + daily mortalities would be that the river is a geographic location of very high risk, while upstream habitat and estuary are very low risk. I would like very much for you to be able to finish this.

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To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
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Subject: [EXTERNAL] Re: Next steps?

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(b)(5) [redacted]

David

David Welch, Kintama Research

Tel: +1 (250) 729-2600 x223

Cell: [redacted]

Sent from my iPad

On Apr 16, 2020, at 17:22, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Hi,

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Let me see if I can get in touch with Jody Lando and see if she can see a time in late April that she would suggest.

Were you able to talk with Ben Zelinsky?

Christine

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Subject: [EXTERNAL] Next steps?

Hi Christine-

I wonder if we could organize a video conference to go over the key points of our paper with your colleagues, and talk about next steps?

(b)(5) [redacted]

Stay safe,

David

David Welch, Ph.D.

<image001.jpg>

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

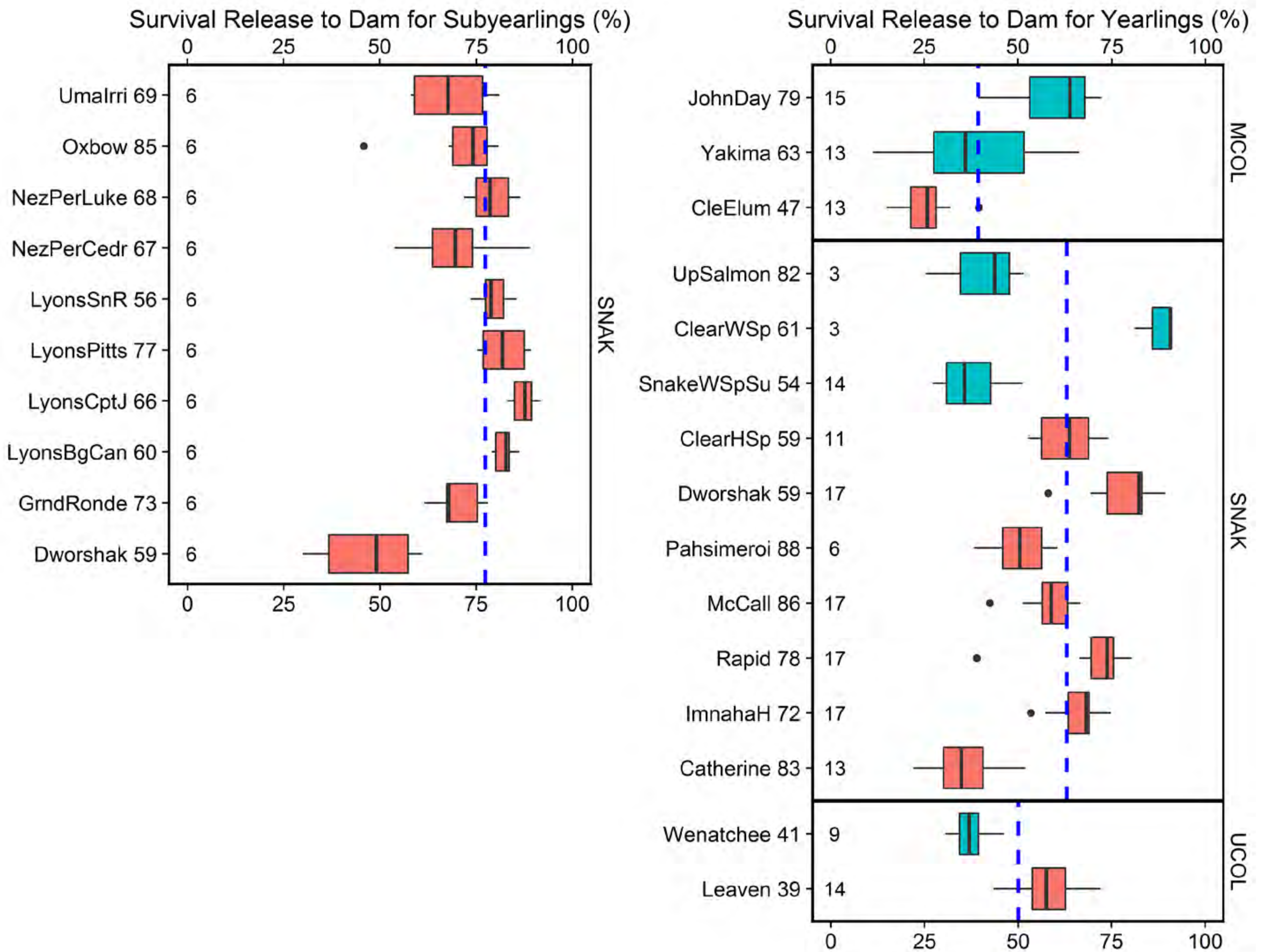
david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail


Survival Release to Dam for Subyearlings (%)
0
25
50
75
100
UmaIrri 69
6
Oxbow 85
6
NezPerLuke 68
6
NezPerCedr 67
6
LyonsSnR 56
6
LyonsPitts 77
6
LyonsCptJ 66
6
LyonsBgCan 60
6
GrndRonde 73
6
Dworshak 59
6
SNAK
Survival Release to Dam for Yearlings (%)
JohnDay 79
15
Yakima 63
13
CleElum 47
13
MCOL
UpSalmon 82
3
ClearWSp 61
3
SnakeWSpSu 54
14
ClearHSp 59
11
Dworshak 59
17
Pahsimeroi 88
6
McCall 86
17
Rapid 78
17
ImnahaH 72
17
Catherine 83
13
SNAK
Wenatchee 41
9
Leaven 39
14
UCOL

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed Apr 22 16:49:46 2020

To: 'David Welch'

Cc: Erin Rechisky; Aswea Porter

Subject: RE: Next steps?

Importance: Normal

Attachments: Schaller2020CompSRI.pdf

Hi,

Thank you very much.

(b)(5) [redacted]

(b)(5) [redacted]

Anyway, it is really challenging to identify a day for a presentation because half the folks I would like to include here, Jody Lando, Greg Smith and others, are blocking out two weeks at the start of May for focusing on the draft NOAA BiOp. I would also like to include John Skidmore and various members of the hydro team. I am looking at May 18th but I still need to ask if that works. Jody said that if you have any new ideas, it would be best to have handouts to circulate. I will try to get back to you soon regarding a time for a webex presentation.

Talk to you soon

Christine

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(b)(5) [redacted]

David

David Welch, Kintama Research

Tel: +1 (250) 729-2600 x223

Cell: + (b)(6) [redacted]

Sent from my iPad

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Stay safe,

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David Welch, Ph.D.

<image001.jpg>

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile:(b)(6) [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: **http://kintama.com/media/videos/**

Article type : Article

Achieving productivity to recover and restore Columbia River stream-type Chinook Salmon relies on increasing smolt-to-adult survival

Charles E. Petrosky, Idaho Department of Fish and Game – retired

Howard A Schaller, U.S. Fish and Wildlife Service – retired

Eric S. Tinus, Oregon Department of Fish and Wildlife - retired

Timothy Copeland*, Idaho Department of Fish and Game, Boise, ID 83707, USA

Adam J. Storch, Oregon Department of Fish and Wildlife, 17330 SE Evelyn Street, Clackamas, OR 97015, USA

*Corresponding author: tim.copeland@idfg.idaho.gov

Suggested running head: Salmon smolt-to-adult survival and productivity

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1002/NAFM.10449

Abstract

We analyze and compare productivity and survival rates of stream-type Chinook Salmon *Oncorhynchus tschawystcha* populations from the upper and middle ranges of their distribution in the Columbia River basin. These two groups of populations undergo vastly different exposures during migration through the Federal Columbia River Power System (FCRPS). Declines of the Snake River populations, listed as Threatened under the U.S. Endangered Species Act (ESA), have been associated with development and operation of the FCRPS. In contrast, John Day River stream-type Chinook Salmon populations, which were less affected by the FCRPS, have declined to a lesser extent and are not listed. Smolt-to-adult survival rates (SARs) accounted for a majority of the variation in life-cycle survival rates of Snake River Chinook Salmon. Productivity declined to 13% and 44% of historical productivity levels for Snake River and John Day River populations, respectively. A synthesis of previous studies contrasting anthropogenic impacts between the two regions supports the conclusion that FCRPS impacts explain the large difference in population productivity. Our results suggest that SARs of 4% would result in an expected productivity of up to 70% of historical levels (an SAR level consistent with regional restoration objectives). SARs have been shown to be highly influenced by conditions within the FCRPS (e.g., water velocity and passage through dam powerhouses). Marine conditions also influence SARs; however, meaningful management actions are only available to affect conditions within the FCRPS. Given the importance of SARs to overall life-cycle productivity, recovery and restoration strategies need to prioritize actions that have potential to substantially increase SARs by addressing the significant impacts of mainstem dams. This study highlights the importance of considering river management options in the face of increasingly variable and warming ocean conditions.

Overall life cycle survival and recruitment of Pacific salmon are regulated by conditions in both freshwater and marine environments (Bradford 1995; Bisbal and McConnaha 1998; Peterman et al. 1998; Lawson et al. 2004; Michel 2019). The relative importance of freshwater and marine factors is seldom quantified because a long time series of life-stage specific demographic data is required and often unavailable. Understanding the relative influence of these factors is critical to manage and craft actions that can restore depressed salmon populations (NPCC 2014).

Major anthropogenic changes have affected life cycle survival and recruitment of Columbia River basin stream-type Chinook Salmon *Oncorhynchus tschawystcha*. Large hydroelectric dams have been built in the Snake and Columbia River migration corridor (Figure 1) in the latter half of the 20th century (Raymond 1988; ISG 1999; Budy et al. 2002). Declines in Snake River life cycle survival, productivity and SARs coincident with completion and operation of the FCRPS have been well documented in the literature (Raymond 1988; Petrosky et al. 2001; Wilson 2003; Schaller et al. 2014). The number of dams encountered by smolts emigrating from the Snake River increased from two in the early 1950s to eight by 1975. One effect of reservoir impoundment has been a 10-fold reduction in water velocity. Managers have sought to mitigate the impacts of these projects by modifying the physical structures of dams, among other remedial actions. Freshwater habitat had also been altered in many Snake and mid-Columbia tributaries since European settlement, although several spawning and rearing areas of the Snake River basin remain in a relatively pristine condition (Thurow et al. 1997; Thurow 2000; Budy and Schaller 2007; NOAA 2017). Harvest of Columbia River basin salmon stocks has been reduced or eliminated as many have been listed under the ESA. Consequently, a large hatchery system, which includes the Lower Snake River Compensation Plan, has been built to mitigate for lost harvest and to supplement wild populations. Individual populations may be managed with any combination of these four basic approaches: hydrosystem actions, habitat remediation, harvest limits or hatchery inputs. How effective each management approach has been to improve life cycle survival and recruitment has been debated vigorously.

Mitigation programs (e.g., Fish and Wildlife Program under Northwest Power Act; NPCC 2014) and ESA management actions (e.g., NOAA Biological Opinions and Recovery Plans; NMFS 2000; NOAA 2014, 2017) have provided incremental improvements in FCRPS passage and survival, but much of the focus remains on restoring tributary habitat. However, tributary habitat restoration projects require adequate numbers of spawning adult salmon to realize benefits. A program has been implemented over the last 25 years that increases the proportion of water discharge that is spilled over the FCRPS dams to reduce the numbers of smolts that pass through the powerhouses (bypass and turbine routes). That action has been associated with higher levels of SARs for both Snake River stream-type and ocean-type Chinook Salmon (Buchanan et al. 2011; Haeseker et al. 2012, Schaller et al. 2014, CSSOC 2017). Despite these incremental efforts, both SARs and full life cycle survival rates have remained very low. A focus on key limiting factors is crucial for success of all restoration activities (Budy & Schaller 2007; NPCC 2014).

ESA recovery and broad-scale rebuilding (stable populations supporting harvest) goals have been formulated over the last several years (e.g., NOAA 2017; CBPTF 2019; IDFG 2019). The Interior Columbia Technical Recovery Team developed viability criteria to achieve ESA recovery (low or very low risk of population extinction; ICTRT 2007). The Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program identified mainstem survival objectives (SARs in the range of 2%-6% and averaging 4%) for listed salmon populations (NPCC 2014) to achieve sufficient survival rates to recover ESA-listed populations and progress towards broad-scale rebuilding goals.

The purpose of this paper is to examine the historical SARs, productivity values and annual life cycle survival rates of Columbia River basin stream-type Chinook Salmon and to use this information to guide our present understanding of how survival rates in the smolt-to-adult life stage can influence the overall productivity of these populations. We accomplish this by updating a long time-series of spawner-recruit data reported in Schaller et al. (2014) and comparing those data with SARs to determine how much variation in life cycle survival rates is explained by SAR values. The smolt-to-adult life stage in this paper includes mortality during seaward migration and in the marine environment. We also synthesize the work of previous peer-reviewed studies to identify potential management actions for improving SARs.

Our study advances Schaller et al.'s (2014) investigation of spatial and temporal lines of evidence to assess the decline of Snake River stream-type Chinook Salmon populations in response to development and operation of the FCRPS. We compare and contrast populations in Idaho and

Oregon over time to relate the effects of past management approaches on life cycle survival and recruitment. We analyze and compare productivity and survival rates of stream-type Chinook populations from two regions of the Columbia River basin that undergo vastly different exposures during migration through the FCRPS. That analysis provides insight into broad-scale SAR rebuilding objectives and their consistency with achieving ESA viability for abundance and productivity goals. Declines in abundance and productivity of Snake River stream-type Chinook Salmon over the latter half of the 20th century are associated with development and operation of the FCRPS (Schaller et al. 2014); these populations have been listed as Threatened under ESA since 1992. In contrast, productivity of Mid-Columbia stream-type Chinook Salmon declined to a lesser extent over this period and those populations remain unlisted. Populations from the two regions experience a diverse variety of anthropogenic impacts to tributary spawning and rearing habitats and from hatchery programs and harvest management. Finally, the results of these analyses and our synthesis of the literature help to provide focus for management and restoration activities that have the potential to increase SARs to achieve ESA viability criteria and progress towards broad scale population goals. This comprehensive approach could to be applied broadly to other river systems by: (1) prioritizing, the restoration actions for a population based on biological considerations and (2) informing the allocation of limited financial resources effectively to recover and rebuild the populations.

Methods

We evaluated life cycle survival rates and SAR patterns for stream-type Chinook Salmon populations from the Snake and John Day rivers and synthesized findings from peer review literature in the context of environmental and management changes that have occurred over the past 70 years. Stream-type Chinook Salmon from both regions have similar life history characteristics (Schaller et al. 2007), producing yearling smolts that migrate seaward in April and May and return as adults in spring and early summer after spending two or three years at sea; a small fraction of males return after a single year (i.e., jacks). Ocean fishery exploitation of both ESUs is negligible (Schaller et al. 2000; PFMC 2011). The number of federal dams encountered by emigrating juvenile salmon increased during the study period from two to eight for Snake River populations and from two to three for John Day River populations. Most of the additional dam construction occurred in the late 1960s and early 1970s. The geomorphology and habitat quality of the populations' freshwater spawning and rearing habitat are diverse within the Snake River basin and some, like the Grande Ronde and Imnaha, have very similar attributes to those in the John Day River basin. The John Day and Middle Fork Salmon rivers have no hatcheries, but the Middle Fork Salmon River has more high quality habitat. Historically, all populations supported mainstem Columbia River harvest rates exceeding 50% as well as substantial tributary harvest. Recently, mainstem harvest rates have been constrained greatly under the U.S. v. Oregon Fisheries Management agreement. No directed non-tribal harvest on wild fish occurs in the Snake River basin, while the John Day populations experience limited terminal harvest under certain conditions (U.S. v Oregon 2018).

Subject populations

Study populations include 18 populations from four Major Population Groups (MPGs) of the Snake River spring/summer Chinook Salmon Evolutionarily Significant Unit (ESU) and three populations from the John Day MPG of the mid-Columbia spring Chinook Salmon ESU (Figure 1). Freshwater spawning and rearing habitat quality varies among the populations. Budy and Schaller (2007) calculated habitat quality scores and defined habitat quality ratings for Snake River stream-type Chinook Salmon populations using NMFS (2004) habitat impairment ratings (Table 1). Habitat quality for study populations in the Middle Fork Salmon MPG were consistently rated high quality. The majority of the Middle Fork Salmon River and tributaries lies within the Frank Church River of No Return Wilderness Area or within adjacent federal lands and the habitat is relatively pristine, diverse and connected (Thurow 2000; NOAA 2017). Habitat quality was rated as medium in the South Fork Salmon MPG populations. The habitat is largely under federal jurisdiction and portions are high quality habitat. However, several areas have been degraded by road construction, timber harvest and domestic livestock grazing (NOAA 2017). Populations in the Upper Salmon and Grande

Ronde/Imnaha MPGs have a mix of habitat quality ratings ranging from low to high. Federal lands, including wilderness, dominate the upper elevations of the Upper Salmon MPG, with lower elevations and valley bottoms often in private ownership; habitat quality impacts include irrigation withdrawals, grazing, timber harvest and mining (NOAA 2017). While the Grande Ronde/Imnaha MPG has experienced habitat degradation, some of the habitat today is in good condition; the Minam and Wenaha river populations inhabit wilderness and the Imnaha River also has high quality habitat. The Upper Mainstem Grande Ronde River, Catherine Creek, and Wallowa/Lostine River populations experience altered hydrology, reduced habitat quality and complexity (NOAA 2017). Impacts to habitat quality for the John Day populations include altered hydrology, irrigation withdrawals, grazing, timber and mining. Using the Budy and Schaller (2007) approach and NMFS (2004) habitat impairment ratings, we estimated that habitat quality was rated as low for the three John Day populations. The John Day River and the Grande Ronde/Imnaha MPGs share the dominant geology and biome of the Blue Mountain ecoregion (Table 1).

The potential influence of hatchery fish varies widely across the study populations (Table 1). No hatchery Chinook Salmon are released within the Middle Fork Salmon and John Day MPGs. Hatchery programs for Chinook Salmon in the other three MPGs include the South Fork Salmon River Mainstem, Upper Salmon River Mainstem, and Grand Ronde/Imnaha River populations, except the Minam and Wenaha rivers, to mitigate for FCRPS impacts to salmon productivity and lost harvest opportunity losses (Table 2). Supplementation programs have been implemented within some Snake River populations with the goal of maintaining or increasing natural abundance while maintaining the long-term productivity (Venditti et al. 2018). Examples include Johnson Creek in Idaho and the Lostine/Wallowa, upper Grande Ronde, Catherine Creek, and Imnaha River mainstem populations in Oregon (Feldhaus et al. 2017).

We updated the spawner and recruit (SR) data compiled and analyzed by Schaller et al. (2014) with six more brood years (Figure 2). We summarized natural spawner abundance of Snake River populations relative to the Minimum Abundance Threshold (MAT) viability criterion (ICTRT 2007) for a recent period (1998-2010) that coincides with FCRPS management actions undertaken in NOAA

Biological Opinions (NMFS 2000, 2004; NOAA 2014). Monitoring and evaluation emphasizing placement of passive integrated transponder (PIT) tags in emigrating juveniles to track passage and survival through the FCRPS increased during this period. Comparable SAR metrics based on PIT tags exist for both Snake River and John Day River populations in the recent period (McCann et al. 2017).

We updated the series of data that relates abundance of parents to their progeny using the methods and definitions of spawners and recruits described in Schaller et al. (2014). Numbers of spawners and spawning ground recruits for Snake River populations were estimated through brood year 2009 or 2010 by state and tribal fisheries agencies for the NOAA Fisheries ESA five-year review process (NFSC 2015). The Big Sheep Creek (Imnaha River tributary) population was functionally extirpated in the recent period and SR data were updated only through brood year 2004. We expanded estimates of spawning ground recruits to pre-harvest recruits to the Columbia River mouth (Figure 2; Table 2). We updated the John Day River SR data from spawner redd counts and Columbia River harvest estimates maintained by U.S. v. Oregon Technical Advisory Committee (unpublished data). The age composition and hatchery fractions from Bare et al. (2016) are used to estimate the abundance of adult recruits to the Columbia River mouth.

Survival rate index

We applied a survival rate index (SRI) to characterize annual changes in life-cycle survival rates (Schaller et al. 1999) and compared index values with population recruitment during a baseline period, before most of the current dams were built, to survival rates during the smolt-to-adult life-stage. The SRIs are deviations from observed recruits/spawner, accounting for density-dependent effects for the period preceding the completion of the FCRPS (Schaller et al. 1999, 2014; Schaller and Petrosky 2007). We classified the SR data for each population into two periods (pre-1970 and post-1974) defined by FCRPS development and operations affecting the threatened Snake River populations following the methods and definitions of Schaller et al. (1999). The two periods provide a contrast of mainstem river conditions before and after completion of the final two Snake River dams. During the post-1974 period, smolts were collected and transported around dams in barges and trucks, turbines were screened, and other management actions were implemented to improve passage at the dams (Raymond 1979; Budy et al. 2002). Population status during the historical base period was generally considered by managers as healthy and harvestable (CBPTF 2019; IDFG 2019), while the post-1974 period was characterized by major population declines, ESA-listings and multiple FCRPS mitigation actions. Populations experienced wide variations in sea surface temperatures in both periods, as indicated by the Pacific Decadal Oscillation index (PDO; Mantua et al. 1997). While PDO values averaged lower in the historical base period than in the post-1974 period, salmon in both periods experienced warm and cool marine conditions and the annual PDO values overlapped considerably between periods (http://research.jisao.washington.edu/pdo/PDO.latest.txt).

We used the updated SR data to estimate productivity, defined in Schaller et al. (1999), as the natural logarithms of the ratio of recruits to spawners (ln(R/S)) in the absence of density-dependent mortality. The SR data were fit to the Ricker recruitment function (Ricker 1975). Critical to the application of this approach is the expectation a temporal change in density-independent mortality, such as that imposed by development and operation of hydroelectric dams, or an oceanic regime shift, will be reflected primarily in the intercept (Ricker "a") rather than in the slope (β) of the regressions. Evidence of non-stationarity is well established in the fisheries literature (Walters 1987; Zhang et al. 2017; Litzow et al. 2019). We examined non-stationarity in the recruitment functions (Hilborn and Walters 1992; Ruggerone et al. 2003; Litzow et al. 2019; Zhang et al. 2017) by updating analysis of covariance (ANCOVA) presented in Schaller et al. (1999, 2014) and Schaller and Petrosky (2007) to quantify differences in the intercepts (Schaller et al. 2014 – equation 2) that would represent the period effect on productivity. Updated model fits were estimated in the R programing environment (R Core Team 2018).

Smolt-to-adult survival rates

Estimates of SARs for the Snake River and John Day River populations were obtained from McCann et al. (2017, 2018). Snake River SARs from brood years 1962-2010 (smolt migration years 1964-2012) represented smolts arriving at the uppermost Snake River dam (Lower Granite since 1975) and adults and jacks returning to the Columbia River mouth (Petrosky and Schaller 2010). These values represent pre-harvest SARs because (as noted above) ocean exploitation of these populations is negligible. The smolt-to-adult life stage includes mortality during seaward migration and in the marine environment. Snake River SARs were based on PIT tag estimates from 1994 forward and run reconstruction methods in prior years; no SARs were available for 1985-1993 due to insufficient marking during those years (Petrosky et al. 2001). We use this combination of historical run reconstruction SARs and the recent PIT-based SARs as the primary data set. Historical run reconstruction SAR estimates for Snake River populations encompass survival variations that can be compared to historical changes in management practices and variation in the freshwater and marine environment. For the recent period we use the PIT tag SAR estimates that are the basis of contemporary and future monitoring programs in the Columbia River basin on PIT tags to estimate SARs and survival rates at multiple life stages for discrete demographic units. John Day SARs based on PIT tag estimates for brood years 1998-2010 represent smolts arriving at John Day Dam and adults and jacks returning to the Columbia River (McCann et al. 2017, 2018). Run reconstruction estimates of SAR prior to the onset of PIT tagging are unavailable for the John Day.

SRI versus SAR

We examined the influence of freshwater migratory and ocean survival rates (i.e., SARs) on scaled life-cycle survival rates (i.e., SRIs) by evaluating how much of the variation in SRIs could be explained by SAR values. Snake River overall average SRI was regressed against ln(SAR) for brood years 1962-2010 (Equation 1) and plotted by decade of smolt migration to examine temporal patterns.

(1) $SRI_j = \alpha + \beta \cdot ln(SAR_j) + \varepsilon_j,$

where α is the intercept, β is the regression slope, j is the brood year and ε_j is the normally distributed residual.

We also examined the relation of average SRI and ln(SAR) for each MPG to assess spatial patterns within the Snake River ESU. Average SRIs for the John Day populations were regressed against ln(SAR) for brood years 1998-2010. We assessed the relation between SRI against ln(SAR) for a combined John Day River and Snake River data set. Finally, we examined the predicted SRI at different levels of SAR to evaluate the efficacy and general applicability of the NPCC 2%-6% SAR objectives to recover and rebuild those populations.

Run reconstruction sensitivity analysis

PIT-tag based SARs for the Snake River populations have averaged about 70% of those based on run reconstruction (McCann et al. 2018). Therefore, we conducted a sensitivity analysis to examine the robustness of conclusions from our primary data set. For this purpose we used the Snake River SARs estimated both with run reconstruction methods and PIT tag marking and subsequent detections (Camacho et al. 2018; McCann et al. 2018). We expanded the run reconstruction-based SARs (calculated for adult returns to Lower Granite Dam) to the Columbia River mouth using the annual ratios of run reconstruction-based SAR to PIT tag-based SAR (McCann et al. 2018) and regressed the aggregate Snake River SRI against run reconstruction-based ln(SAR) for brood years 1962-2010 to bound the expected response between SAR and SRI. We then examined the predicted SRI at different levels of run reconstruction-based SAR compared to predictions from the PIT tag-based method. This sensitivity analysis was only possible for the Snake River aggregate for these brood years.

Results

Population summary statistics

Average spawner abundance of the Snake River populations during the recent period was about one-third that of the baseline, prior to full FCRPS development (Table 2), despite decreases in Columbia River fishery exploitation, modifications to passage at the dams and a mass juvenile fish transportation program. Recruitment of Snake River populations declined five-fold to 19% of the base period. Snake River natural-origin spawner abundance during brood years 1998-2010 averaged 40% of the MAT, well less than ESA abundance delisting criterion. Hatchery-origin spawners comprised a variable proportion of total spawners in Snake River populations, ranging from 0% to 79%.

John Day River spawner abundance increased in recent years (1998-2010) relative to the base period (Table 2), due in part to reductions in Columbia River fishery exploitation following FCRPS development and juvenile passage improvements at John Day Dam. Recruitment increased relative to the base period for two populations and declined for the third population. Hatchery strays comprised an estimated 3% of total spawners in the John Day River populations during 1998-2010.

Survival rate index

Average productivity and survival rates declined more for Snake River than for John Day River populations following FCRPS completion. Average productivity declined from the pre-1970 baseline by 2.04 for Snake River populations and 0.82 for John Day River populations for brood years 1975-2010 (Table 3; Figure 2, top panel). In other words, expected R/S declined to 13% ($e^{-2.04}$) and 44% ($e^{-0.82}$) of the historical productivity level for Snake River and John Day River populations, respectively. Although the magnitude of decline differed between Snake and John Day populations, the SRIs were highly correlated (r = 0.68) over the entire time series. Within the Snake River populations, the average decline in productivity was similar for populations in high and low-quality habitat (-2.23 and -2.36, respectively; Table 3).

Snake River populations with >10% hatchery fractions on the spawning grounds experienced declines in productivity similar to those with lower hatchery fractions (-1.99 and -2.17, respectively; Table 3).

Smolt-to-adult survival rates

Snake River pre-harvest SARs decreased from about 4% in the 1960s to about 1% in the post-1974 period (Figure 2, bottom panel). Snake River SARs in the post-1974 period have varied widely, ranging as low as 0.3% (2003 brood year) to a high of 4.3% (2006 brood year). In recent brood years (1998-2010), the geometric mean of Snake River SARs was 1.1%. SARs were less than 2% in ten of 13 years and less than 1% in five years. In contrast, recent John Day River SARs ranged from 0.9% to 11.4%, averaging 3.9% and exceeding 2% in 12 of 13 years (Figure 2). Although differing in magnitude, the ln(SAR) values of Snake and John Day populations were highly correlated ($r = 0.77$) in recent years.

SRI versus SAR

Migratory and ocean survival explained much of the variation in recruitment of Chinook Salmon in all of the study populations. A large portion of the variation (80%) in Snake River SRIs was explained by ln(SAR) for brood years 1962-2010 (Table 4). SARs in the 1960s (1964-1969 smolt migrations) ranged from 3.5% to 6.5%, while parental spawner levels resulted in pre-harvest recruitments within the expected range (by definition) for the base period. Both SARs and SRIs declined in the 1970s and remained depressed in subsequent decades (Figure 3). The relation between SRI and SAR appears very consistent across the decades. The prediction line indicates that a pre-harvest SAR of 2% is associated with 35% of base-period productivity; pre-harvest SARs of 4% and 6% are associated with 70% and 106% of base-period productivity, respectively (Table 5).

The pattern of SRIs and SARs is quite similar across the geographic range of the four Snake River MPGs (Table 4; Figure 4). The slope of the regression for the South Fork Salmon MPG is less than for the other MPGs, however. Historical levels of productivity are associated with SARs approaching 5-6% for all ESA-listed Snake River MPGs upstream of Lower Granite Dam (Table 5).

The pattern of John Day SARs and SRIs is generally similar to that in the Snake River (Table 4; Figure 4), although the John Day sample size (13) was limited. The John Day prediction line indicates that a pre-harvest SAR of 2% is associated with 45% of base-period productivity; pre-harvest SARs of 4% and 6% are associated with 67% and 85% of base-period productivity, respectively (Table 5). A regression of combined Snake River and John Day River SAR data explained a high degree of variation in SRIs (82%) and indicates a pre-harvest SAR of 2% is associated with 34% of base-period productivity; pre-harvest SARs of 4% and 6% are associated with 66% and 98% of base-period productivity, respectively (Table 5; Figure 5).

Run reconstruction sensitivity analysis

Our results are robust to the alternative SAR method. A large portion of the variation (66%) in Snake River SRIs was explained by ln(SAR) for brood years 1962-2010 using run reconstruction-based SARs (Figure 6). The SRI versus SAR relation based solely on run reconstruction SARs produced a similar but somewhat lower expectation of life cycle productivity at regional management objectives compared to the primary method. The prediction line indicates that a pre-harvest SAR of 2% is associated with 25% of base-period productivity; pre-harvest SARs of 4% and 6% are associated with 49% and 74% of base-period productivity, respectively (Figure 6). Our sensitivity analysis shows that both methods yield SARs that fall well short of levels needed to recover and rebuild Snake River Chinook Salmon populations.

Discussion

Our study results indicate that achieving productivity objectives for Columbia River stream-type Chinook Salmon populations will require improvements to survival in the smolt-to-adult life stage. Our conclusions are robust to the change in measurement of SARs from run reconstruction to PIT tags. SARs are a function of smolt migration conditions and the marine environment (Petrosky and Schaller 2010; Haeseker et al. 2012; Schaller et al. 2014; Michel 2019). Survival from smolt to adult stage accounted for a majority (about 80%) of the variation in complete life cycle survival rates of Snake River Chinook Salmon. The pattern of the relationship between SRI and SAR in the John Day River was similar to that in the Snake River. A single model fit to SARs of combined Snake and John Day data explained a large majority (82%) of the variation in SRIs. The high degree of life cycle survival variation explained by SARs shows that reliance on off-site mitigation (tributary habitat improvement) for FCRPS impacts is unlikely to achieve regional goals.

We found that historical levels of life cycle productivity for Snake River and mid-Columbia River stream-type Chinook Salmon are associated with SARs approaching 6%. The NPCC (2014) identified SAR objectives for listed salmon populations in the range of 2% to 6% and average 4%. Our results suggest that SARs of 4% would result in a productivity near 70% of the historical baseline levels. Our observations of the relation between SARs and life cycle survival rates are consistent with those from earlier analyses (Marmorek et al 1998; Peters and Marmorek 2001). Snake River SARs have declined substantially from about 4% in the latter portion of the base period to an average of about 1% in recent years. In contrast, John Day River populations exhibited higher recent life cycle survival compared to the Snake River populations that migrate through five additional dams. The recent John Day SARs have averaged about 4%, similar to historical levels for the Snake, and the recent John Day SRIs are relatively closer to their historical levels.

Poor SARS are also related to the marine environment when the PDO and sea surface temperatures are warmer and the nearshore upwelling volumes are less. Salmon populations experienced wide variations in PDO in both the base period and the post-1974 period. The top models in Schaller et al. (2014) identified September PDO as the most influential marine variable in explaining variation in SRI. However, Snake River SRI declines began in the early 1970s (while the PDOs were still low) and SRIs remained depressed when Snake River salmon experienced cooler ocean conditions in the late 1990s and mid 2000s (Schaller and Petrosky 2007 and Figure 2).

Snake River populations experience substantial delayed mortality in the marine environment as a result of their outmigration experience through the FCRPS (Williams et al. 2005; Buchanan et al. 2011; Marmorek et al. 2011; Schaller et al. 2014). The outmigration experience results in an accumulation of injuries, multiple stress events, and alteration of estuary arrival timing: mechanisms that may explain delayed mortality (Budy et al. 2002; Muir et al. 2006; Scheuerell et al. 2009; Rechisky et al. 2012). Decreased water velocity and increased number of powerhouse passages have been related to large increases in the time required for juveniles to migrate to sea and reductions in SRI, SAR and marine survival rates for Snake River Chinook Salmon (Petrosky and Schaller 2010; Buchanan et al. 2011; Haeseker et al. 2012; Schaller et al. 2014). The avoidance of powerhouse passages has been assessed by directly evaluating spill levels (Haeseker et al. 2012), or through calculating powerhouse passages, which are the compliment of spill levels (Petrosky and Schaller 2010; Schaller et al. 2014). John Day populations have fewer powerhouse encounters than Snake River populations and hence are impacted less by the FCRPS.

John Day and Snake River populations have many similar characteristics. Populations in the John Day and Grande Ronde/Imnaha MPGs share a dominant geology and biome. Impairment of spawning and rearing habitat quality for John Day populations is similar to that of the Lostine/Wallowa, Catherine Creek, and upper Grande Ronde ESA-listed populations (Table 1), yet the relative population performance is vastly different. Performance of the John Day populations, with uniformly impaired habitat quality, exceeds that of Snake River populations within the Middle Fork Salmon MPG, which have high quality habitat (Table 1). Stray hatchery influence is low in the John Day River populations and Snake River populations in the Minam and Wenaha rivers; Middle Fork Salmon MPG; the Secesh population; and three populations in the Upper Salmon River (Table 2). Survival and productivity of the Snake River populations with minimal hatchery influence have decreased compared to the John Day populations despite their generally better habitat and lower harvest pressure.

Our results are consistent with previous studies of the relative influences of tributary habitat and hatcheries on life cycle survival of Snake River Chinook Salmon. Budy and Schaller (2007) concluded that a “large gap remains between how much survival improvement is needed vs. what is likely to occur” in Snake River spawning and rearing habitats. Venditti et al. (2018) found that hatchery supplementation had no apparent lasting influence on adult-to-adult productivity in Snake River populations.

Managers are unlikely to restore productivity of Snake River stream-type Chinook Salmon without major increases in SARs. Incremental improvements in FCRPS passage to date have been insufficient to achieve SAR goals for Snake River salmon. A recent court order (Simon 2016) has compelled FCRPS managers and regulators to evaluate the feasibility and efficacy of spill and Snake River dam removal through an Environmental Impact Statement (EIS) under the National Environmental Policy Act. The potential benefits of actions such as spill and dam removal to ameliorate FCRPS impacts are being evaluated for increasing SARs (CSSOC 2017; USACE 2020). Decreasing the time required for smolts to migrate downstream through the FCRPS and reducing the number of times they are forced to encounter powerhouses should increase SARs for Snake River stream-type Chinook Salmon, and for salmonids from other natal rivers of the Columbia River basin. Evaluation of approaches to experimental spill management (CSSOC 2017) estimated that increasing spill for fish passage within safe limits (125% total dissolved gas) had a high probability of improving SARs. We acknowledge there are uncertainties surrounding the efficacy of spill and researchers have varying interpretations of data underlying arguments for the benefit of avoiding powerhouse encounters (e.g., Faulkner et al. 2019). However, meaningful management actions are only available to affect conditions within the FCRPS that have a potential to increase SARs. The current basinwide marking of representative groups of juvenile salmon will allow evaluation of the spill program (CSSOC 2017).

Regional management goals emphasize the restoration of healthy and harvestable salmon populations (NPCC 2014; CBPTF 2019) in the face of variable marine conditions. Projected climate changes that warm oceans and increase variability in environmental conditions suggest that Columbia River basin salmon may face less favorable future marine survival conditions (Lijing et al. 2019). Those predictions emphasize the need to greatly improve migration conditions through the FCRPS in concert with other actions being implemented to protect and improve freshwater spawning and rearing habitats, improve hatchery practices, and maintain harvest regulations. Our study, including the synthesis of past studies, highlights the importance of considering river management options in the face of increasingly variable and warming ocean conditions.

Natural spawner abundance levels of Snake River Chinook Salmon populations are far below ESA abundance thresholds (Table 2) and the Big Sheep population became functionally extirpated by the early 2000s. The low abundance and perpetuation of low SARs, due in large part to FCRPS configuration and operations, pose both genetic and demographic risks that lead to a high extirpation risk (McElhany et al. 2000; ICTRT 2007; Thompson et al. 2019) to Snake River stream-type Chinook Salmon. The NPCC SAR objectives provide a readily measured metric that gauges whether life cycle survival rates can achieve ESA recovery goals and make progress toward broad-scale salmon restoration efforts (ISAB 2018).

Abundant stream-type Chinook Salmon populations are important socially, culturally, and legally to the Columbia region, to provide tribal, sport and commercial fishing. Restored, healthy stream-type Chinook Salmon populations provide essential services to the ecosystem through the delivery of critical marine nutrients and a food source for wildlife (ISG 1999). Restoring the ecosystem function requires a consistent increased level of returning adults to the Snake and Columbia River stream-type Chinook Salmon populations affected by the FCRPS. Restoration activities should be focused where there is the greatest potential to increase productivity and where the level of risk to meet population recovery and rebuilding goals is lowest -- an approach consistently supported in the peer-reviewed literature from scientific investigations of ecology (Crouse et al. 1987; Mangel et al. 2006; Budy and Schaller 2007).

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Table 1. Study populations of Chinook salmon by major population group with selected habitat and hatchery characteristics.

Major Population Group	Population[1]	Abbreviation[1]	Adult Life History Type[1]	Ecoregion[2]	Weighted Habitat Quality Score[3]	Habitat Rating[4]	First Year of Hatchery Return[5]
Upper Salmon (USR)	Lemhi R.	SRLEM	SPRING	MR	7.80	low	NA
	Upper Salmon R. Mainstem	SRUMA	SPRING	IB	5.55	med	1985
	East Fork Salmon R.	SREFS	SPR/SUM	MR/ IB	3.50	high	1984
	Valley Cr.	SRVAL	SPRING	IB	5.20	med	NA
Middle Fork Salmon (MFS)	Big Cr.	MFBIG	SPR/SUM	IB	2.00	high	NA
	Bear Valley Cr.	MFBEA	SPRING	IB	1.50	high	NA
	Marsh Cr.	MFMAR	SPRING	IB	2.00	high	NA
	Sulphur Cr.	MFSUL	SPRING	IB	3.00	high	NA
South Fork Salmon (SFS)	South Fork Salmon R. Mainstem	SFMAI	SUMMER	IB	4.70	med	1982
	East Fork South Fork Salmon R.	SFEFS	SUMMER	IB	4.40	med	2002
	Secesh R.	SFSEC	SUMMER	IB	4.25	med	NA
Grande Ronde/Imnaha (GRIM)	Imnaha R. Mainstem	IRMAI	SPR/SUM	BM	2.95	high	1986
	Big Sheep Cr.	IRBSH	SPRING	BM	4.60	med	1993
	Wenaha R.	GRWEN	SPRING	BM	3.35	high	NA
	Lostine R.	GRLOS	SPRING	BM	8.95	low	2004
	Minam R.	GRMIN	SPRING	BM	3.75	high	NA

	Catherine Cr.	GRCAT	SPRING	BM	13.00	low	1987
	Upper Grande Ronde R. Mainstem	GRUMA	SPRING	BM	9.05	low	1987
John Day (JDA)	John Day R. Upper Mainstem	JDUMA	SPRING	BM/CP	13.05	low	NA
	Middle Fork John Day R.	JDMFK	SPRING	BM/CP	11.70	low	NA
	North Fork John Day R.	JDNFK	SPRING	BM/CP	10.90	low	NA

[1] Source: ICTRT (2007)

[2] U.S. Environmental Protection Agency ecoregion captures the dominant geology and biome; CP= Columbia Plateau, BM= Blue Mountains, IB= Idaho Batholith, MR=Middle Rockies

[3] Source: NMFS (2004) and Budy and Schaller (2007), a higher score indicates a greater probability of degradation

[4] Habitat quality for Snake River ESU from Budy and Schaller (2007); Habitat quality for John Day populations applied the methods of Budy and Schaller(2007) in this study.

[5] First year in which adult (age >4) Chinook Salmon returned from hatchery program(s) operating within a population. NA = not applicable.

Table 2. Summary statistics for recent period (brood years 1998-2010) for Snake River and John Day River stream-type Chinook Salmon populations.

Region, MPG	Population	Brood Years	Fraction of hatchery spawners post 1997	Minimum Abundance Threshold (MAT)	Natural Origin Spawners (NOS) post 1997	NOS as % MAT	NOS as % pre-1970 spawners	Recruits post 1997	Recruits as % pre 1970
Snake River									
USR	SRLEM	1957-2010	0.00	1000	164	16%	10%	270	4%
	SRUMA	1957-2010	0.36	1000	473	47%	35%	812	12%
	SREFS	1957-2010	0.01	1000	365	37%	20%	690	12%
	SRVAL	1957-2010	0.00	500	119	24%	17%	243	12%
MFS	MFBEA	1957-2010	0.00	750	518	69%	32%	937	15%
	MFMAR	1957-2010	0.00	500	272	54%	27%	582	12%
	MFSUL	1957-2010	0.00	500	74	15%	22%	148	11%
	MFBIG	1957-2010	0.00	1000	237	24%	38%	371	17%
SFS	SFMAI	1957-2009	0.38	1000	824	82%	34%	1672	30%
	SFEFS	1957-2009	0.37	1000	355	36%	42%	743	30%
	SFSEC	1957-2009	0.04	750	658	88%	99%	1247	83%

GRIM	IRMAI	1949-2010	0.61	1000	528	53%	24%	1036	15%
	IRBSH	1964-2004	0.79	500	20	4%	3%	42	2%
	GRWEN	1949-2010	0.04	750	431	57%	29%	711	11%
	GRLOS	1949-2009	0.41	1000	373	37%	44%	1046	22%
	GRMIN	1954-2010	0.02	750	467	62%	46%	877	25%
	GRCAT	1953-2010	0.44	1000	135	14%	12%	392	8%
	GRUMA	1956-2009	0.37	1000	46	5%	11%	211	10%
John Day River									
JDA	JDUMA	1959-2010	0.03	NA	926	NA	495%	1826	269%
	JDMFK	1960-2010	0.03	NA	716	NA	439%	1241	180%
	JDNFK	1959-2010	0.03	NA	1751	NA	102%	2621	43%

Table 3. Analysis of covariance results for Ricker recruitment functions that used period (treatment) and spawners (covariate) for stream-type Chinook salmon Major Population Groups (MPG) and populations from the Snake River and John Day River regions, brood years 1950s-2010.

Region, MPG	Population	Brood Years	Intercept pre1970	Intercept post1974	Intercept difference	Intercept p-value	Slope	Slope p-value	R^2	Slope homogeneity p-value

Snake River										
USR	SRLEM	1957-2010	2.62	0.62	2.01	<0.01	-0.0008	<0.01	0.24	<0.01
	SRUMA	1957-2010	2.95	1.17	1.78	<0.01	-0.0010	<0.01	0.48	0.71
	SREFS	1957-2010	2.99	0.84	2.15	<0.01	-0.0010	<0.01	0.26	0.10
	SRVAL	1957-2010	3.05	0.86	2.19	<0.01	-0.0027	<0.01	0.35	<0.01
MFS	MFBEA	1957-2010	3.91	1.11	2.80	<0.01	-0.0016	<0.01	0.34	0.11
	MFMAR	1957-2010	3.87	0.93	2.94	<0.01	-0.0023	<0.01	0.39	0.06
	MFSUL	1957-2010	3.69	0.96	2.73	<0.01	-0.0066	<0.01	0.39	0.05
	MFBIG	1957-2010	2.99	1.15	1.84	<0.01	-0.0029	<0.01	0.30	<0.01
SFS	SFMAI	1957-2009	1.75	0.64	1.11	<0.01	-0.0004	<0.01	0.28	<0.01
	SFEFS	1957-2009	2.45	1.03	1.42	<0.01	-0.0016	<0.01	0.38	0.25
	SFSEC	1957-2009	1.60	1.17	0.43	0.09	-0.0012	<0.01	0.26	0.02
GRIM	IRMAI	1949-2010	2.39	0.66	1.73	<0.01	-0.0006	<0.01	0.57	<0.01
	IRBSH	1964-2004	1.65	-0.81	2.46	0.09	-0.0009	0.32	0.23	0.92
	GRWEN	1949-2010	2.51	0.46	2.05	<0.01	-0.0008	0.01	0.38	0.16
	GRLOS	1949-2009	3.21	1.07	2.14	<0.01	-0.0018	<0.01	0.54	0.54
	GRMIN	1954-2010	2.41	0.80	1.60	<0.01	-0.0010	<0.01	0.45	0.08
	GRCAT	1953-2010	2.74	0.23	2.50	<0.01	-0.0009	<0.01	0.40	0.36
	GRUMA	1956-2009	3.40	0.59	2.81	<0.01	-0.0036	<0.01	0.53	0.21
John Day River										
JDA	JDUMA	1959-2010	1.86	1.08	0.78	<0.01	-0.0008	<0.01	0.36	<0.01
	JDMFK	1960-2010	1.89	1.43	0.47	0.17	-0.0017	<0.01	0.44	0.02
	JDNFK	1959-2010	2.66	1.45	1.22	<0.01	-0.0007	<0.01	0.61	0.41

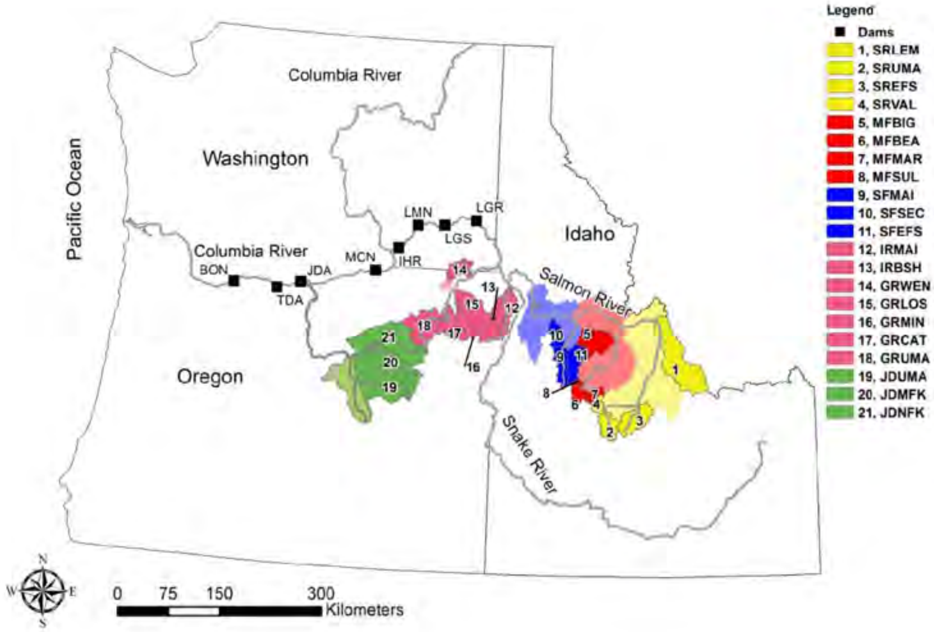
Table 4. Regression results for SRI vs. ln(SAR) for Snake River populations, Snake River and John Day River major population groups (MPGs) and for combined Snake River and John Day River data.

Population Group	n	a	SE(α)	P(α)	β	SE(β)	P(β)	R^2
Snake River								
USR	41	3.2350	0.5151	<0.0001	1.0816	0.1174	<0.0001	0.69
MFS	41	3.5162	0.6024	<0.0001	1.2699	0.1373	<0.0001	0.69
SFS	41	1.9981	0.3510	<0.0001	0.6647	0.0800	<0.0001	0.64
GRIM	41	2.6846	0.4458	<0.0001	0.9583	0.1016	<0.0001	0.70
All Snake MPGs	41	2.8907	0.3504	<0.0001	1.0082	0.0799	<0.0001	0.80
Mid-Columbia								
JDA	13	1.4417	0.5187	0.0179	0.5720	0.1569	0.0038	0.55
All MPGs	54	2.6536	0.2600	0.0000	0.9516	0.0626	<0.0001	0.82

Table 5. Predicted percent of historical productivity (95% prediction interval) at different SAR levels for Snake River populations, Snake River and John Day River MPGs, and for combined Snake River and John Day River data. Predicted productivity is estimated from the regression parameters for SRI vs. ln(SAR) for the population groups (Table 4).

	SAR level				
Population Group	1%	2%	4%	6%	8%
Snake River					
USR	18%	37%	78%	121%	165%
	(5%-60%)	(11%-127%)	(22%-275%)	(34%-436%)	(45%-608%)
MFS	10%	23%	57%	95%	136%
	(2%-41%)	(5%-99%)	(13%-246%)	(21%-42%)	(30%-624%)
SFS	35%	55%	87%	114%	138%
	(15%-80%)	(24%-127%)	(37%-205%)	(48%-272%)	(57%-334%)
GRIM	18%	35%	67%	99%	130%
	(6%-52%)	(12%-100%)	(23%-199%)	(33%-300%)	(42%-402%)
All Snake MPGs	17%	35%	70%	106%	141%
	(8%-40%)	(15%-81%)	(30%-165%)	(44%-252%)	(58%-342%)
Mid-Columbia					
JDA	30%	45%	67%	85%	100%
	(12%-75%)	(20%-102%)	(31%-146%)	(38%-187)%	(44%-226%)
All MPGs	18%	34%	66%	98%	128%
	(8%-41%)	(15%-78%)	(29%-152%)	(42%-226%)	(55%-299%)

List of Figures



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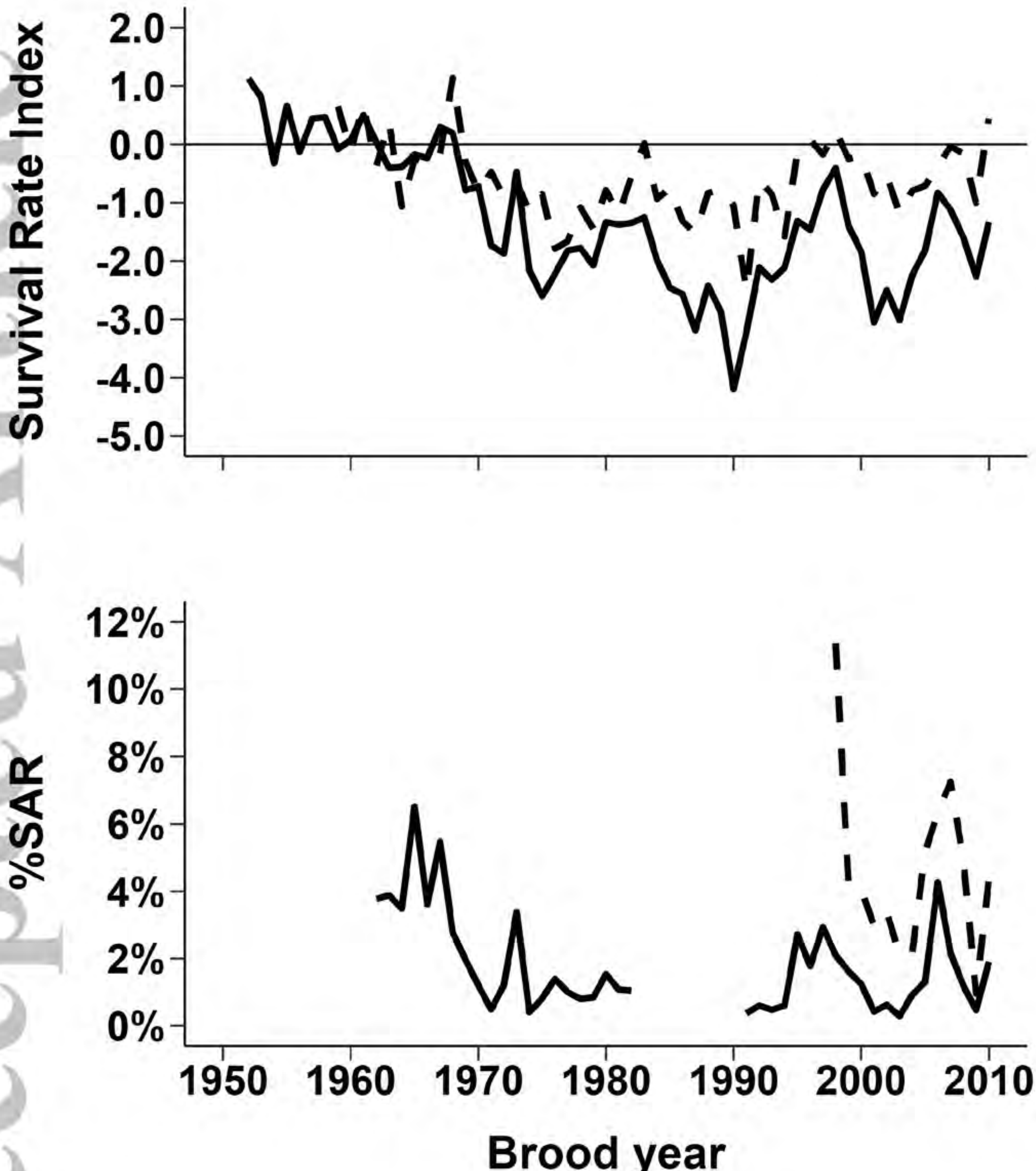

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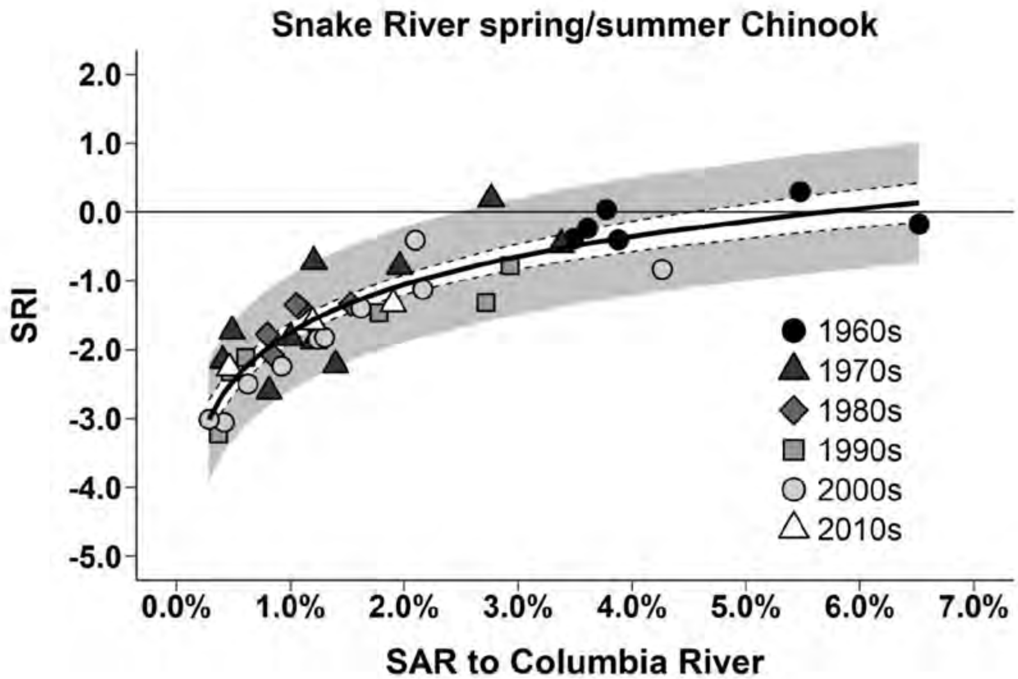

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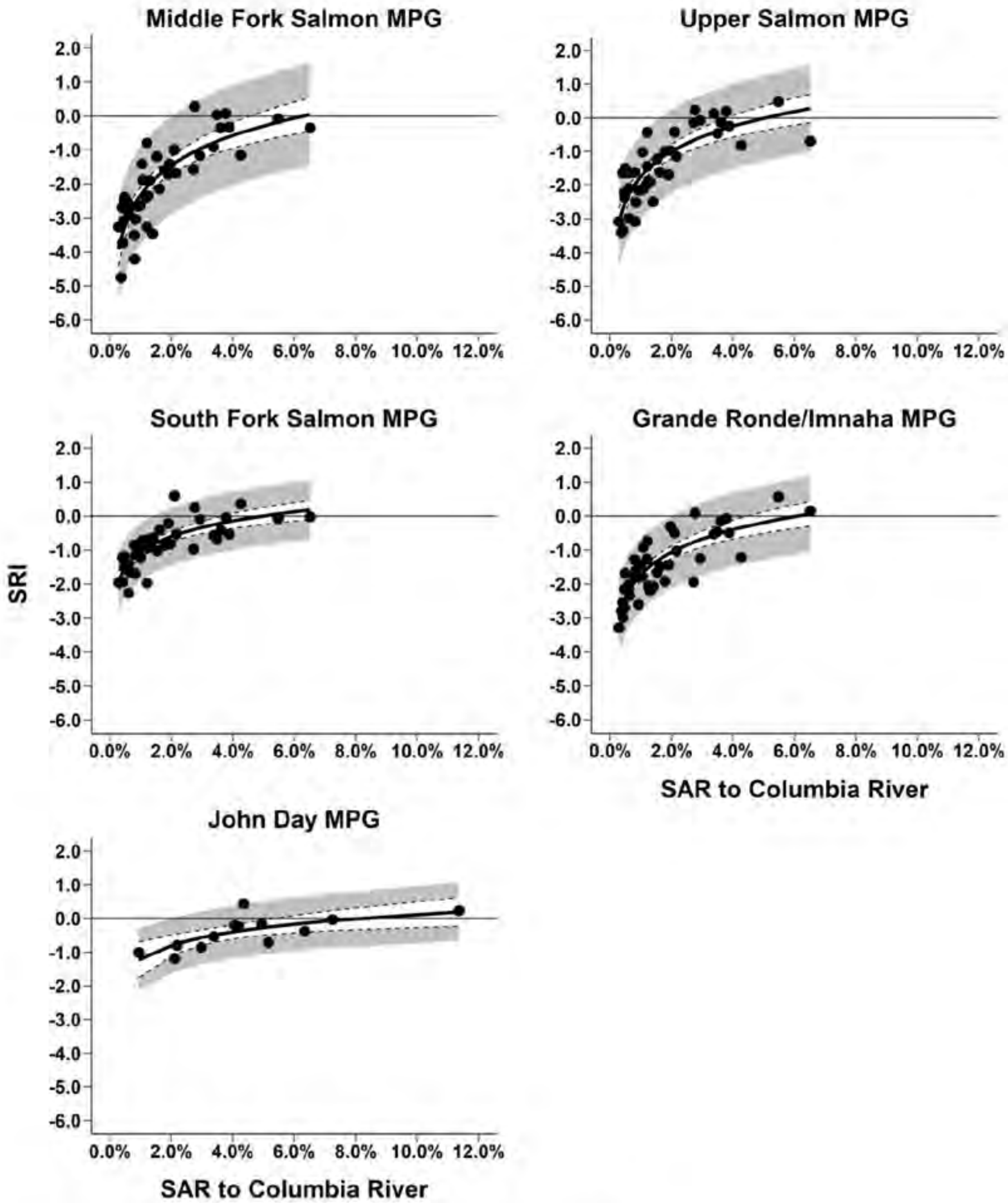

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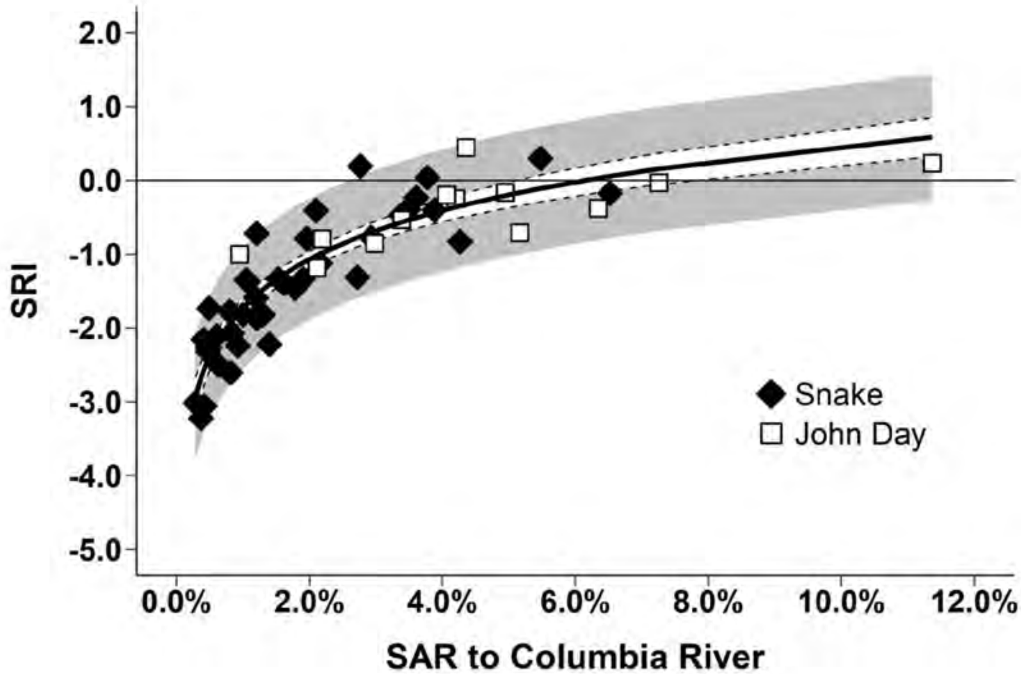

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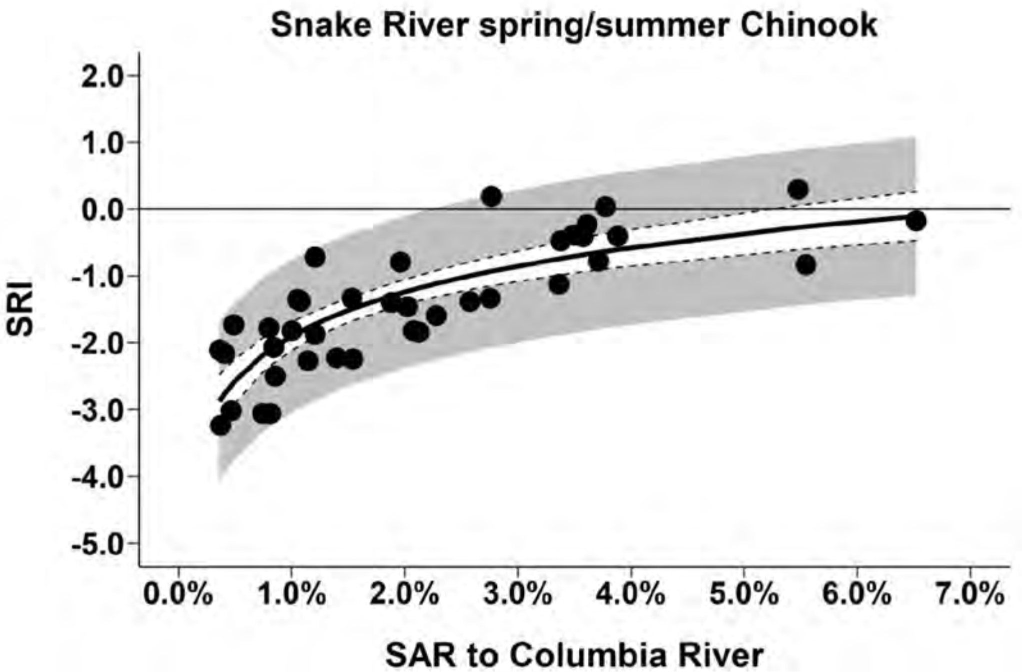

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From: Erin Rechisky

Sent: Thu Apr 23 14:29:10 2020

To: David Welch; Petersen,Christine H (BPA) - EWP-4

Cc: Aswea Porter

Subject: [EXTERNAL] RE: Next steps?

Importance: Normal

I believe they cited our paper as an example of early arrival to the estuary as a mechanism for delayed mortality.

Christine, can you send an example of a handout?

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: April 22, 2020 5:27 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Next steps?

Thanks. I had heard that Charlie's paper was going to come out soon, but I hadn't seen it. I did have a good laugh in quickly skimming it just now—for perhaps the first time ever they have cited one of our delayed mortality papers! However, here is the (only) citation: "*The outmigration experience results in an accumulation of injuries, multiple stress events, and alteration of estuary arrival timing: mechanisms that may* *explain delayed mortality (Budy et al. 2002; Muir et al. 2006; Scheuerell et al. 2009; Rechisky et al. 2012).***".**

So, it is nice to be cited (I suppose), but they have apparently felt compelled to cite us in a way that suggests we support that claim. Of course, we don't. The explicit test we did refuted the claim that there would be lower survival, which they don't say… and the paper they cite (deliberately?) was one comparing survival of transported and in-river migrants, not the one assessing the effect of multiple dams on survival. I don't think anyone from the Columbia cites our PNAS paper that found no difference in below Bonneville survival or the subsequent MEPS paper that expanded that result to smaller smolts (and more groups).

May 18th works. With luck we will have emerged from most of our social distancing by then, if only for a few months.

You mentioned Jody suggested handouts to present new ideas. We can certainly do this (and have lots of ideas), but a discussion about what would be most helpful to BPA staff would be useful… some of the work we were proceeding with until the contract was re-focused on the relative SAR comparison? The re-analysis of the spill vs SAR (TDG) projections?

(b)(5)

[redacted]

My calendar is open the rest of this week apart from two Friday calls at 12-1 and 4-5 pm.

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Wednesday, April 22, 2020 4:50 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Next steps?

Hi,

Thank you very much.

(b)(5) [redacted]

Anyway, it is really challenging to identify a day for a presentation because half the folks I would like to include here, Jody Lando, Greg Smith and others, are blocking out two weeks at the start of May for focusing on the draft NOAA BiOp. I would also like to include John Skidmore and various members of the hydro team. I am looking at May 18th but I still need to ask if that works. Jody said that if you have any new ideas, it would be best to have handouts to circulate. I will try to get back to you soon regarding a time for a webex presentation.

Talk to you soon

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, April 20, 2020 10:37 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] FW: Next steps?

Hi Christine—

Erin corrected me on something I had written to you previously (see below for the email trail).

(b)(5) [redacted]

(b)(5) [redacted]

David

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Monday, April 20, 2020 9:06 AM
To: David Welch <David.Welch@Kintama.com>
Cc: Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Next steps?

Hi David,

(b)(5) [redacted]

You might want to forward this to Christine.

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: April 17, 2020 10:58 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Next steps?

Thanks. I just got back on to the CSS call as they broke for 5 minutes—[redacted] (I caught part of the WTT & survival analysis before having to step off).

(b)(5) [redacted]

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Friday, April 17, 2020 9:35 AM
To: David Welch <David.Welch@Kintama.com>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Next steps?

I will talk to Jody. Also, John Skidmore (now our interim division manager) should probably considered essential to have at your presentation. He has a background with creel surveys, and he wishes to make tracking of harvest management forums/adult issues be part of the job description of an open listing here at BPA. The agency has typically had no role because harvest appears to be thoroughly outside of the domain of the Dept of Energy.

I am watching the CSS presentations. With several topics, you would need an opportunity to go to the blackboard and have a more prolonged discussion. It was interesting, that Steve Haeseker had slides on the topic of daily survival rates, which was the subject of your second data analysis. Except his 'mechanistic' model for the travel time + daily mortalities would be that the river is a geographic location of very high risk, while upstream habitat and estuary are very low risk. I would like very much for you to be able to finish this.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, April 16, 2020 6:03 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] Re: Next steps?

I did. Ben was intrigued and was going to touch base with you, but I'm not sure of his time line there.

I think that any time in May would still be extremely early for expecting reviewer comments back... journals typically give 2 to 3 months and then often have to repeatedly cajole the reviewers for further weeks or months. For us to "successfully" get it through peer review is realistically the fall, unless this COVID-19 issue makes the process much more responsive than it has been in the past.

[redacted]

David

David Welch, Kintama Research

Tel: +1 (250) 729-2600 x223

Cell: +[redacted]

Sent from my iPad

On Apr 16, 2020, at 17:22, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Hi,

I was just prompting some coworkers to suggest a good time for this. Basically, they are forecasting being extremely busy in the first two weeks of May when they receive the NOAA draft BiOp and need to respond to it. So we would need to choose either before this, or later in May. [redacted] But we might also want to wait a bit longer.

Managers here wanted your paper to successfully get through review, and we might be at that stage in May, and better able to talk about planning additional work at that point. (b)(6) [redacted]
(b)(6) [redacted]

Let me see if I can get in touch with Jody Lando and see if she can see a time in late April that she would suggest.

Were you able to talk with Ben Zelinsky?

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, April 16, 2020 3:21 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] Next steps?

Hi Christine-

I wonder if we could organize a video conference to go over the key points of our paper with your colleagues, and talk about next steps?

(b)(5) [redacted]

Stay safe,

David

David Welch, Ph.D.

<image001.jpg>

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: (b)(6) [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

From: David Welch

Sent: Tue Apr 28 19:38:28 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] FW: PINKS: "Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology"

Importance: Normal

Attachments: FPC Letter to Agencies on Kintama Request (1 October 2019).pdf; Kintama Letter to Fish Passage Center (18 Sept 2019).pdf

FYI—my comments to Greg Ruggerone. I had hoped that the journal would have asked him to be one of the reviewers because I think he is both very knowledgeable about the Columbia issues and very balanced (as well as bright!).

David

From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, April 28, 2020 7:02 PM
To: Greg Ruggerone <gruggerone@nrccorp.com>
Subject: RE: PINKS: "Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology"

Well, with luck the manuscript is not sitting at the journal and has actually gone out for review!

Too bad you weren't asked—I was hoping that they will get some deeply knowledgeable reviewers from the Columbia that don't have a particular axe to grind as reviewers, thus my suggestion that you would make a good one. (The harvest rate issue I alluded to last autumn is likely going to be explosive—if I am right, the problem is even more serious than what I outlined to you at dinner).

I attach Michelle deHart's email to others (18 outside folks and 5 FPC staff!) informing them that I had asked for their SAR data, but with the above-dam smolt survival added back in (hardly a difficult task). She took the time to send an email to all these people telling them that I had made this request (also attached), but never actually responded to me. I guess that is pretty typical- I sent the request by both email and registered mail to make sure it wouldn't be ignored.

I find the FPC really problematic for the Columbia—they attack work they don't like by putting their reviews of these studies up on their website, where they are very difficult to effectively refute (where do I put my response? On Kintama's website, and start a little war of non-interacting memos?). But the really difficult problem I discovered was that when we tried to recreate the FPC's work we realized we couldn't—there wasn't enough data to really know what data they were selecting…so the region is essentially critically dependent on the FPC/CSS objectively selecting and analysing all of the data, and not excluding data that doesn't fit their preconceptions—a tall order.

From: Greg Ruggerone <gruggerone@nrccorp.com>
Sent: Tuesday, April 28, 2020 2:34 PM

To: David Welch <David.Welch@Kintama.com>
Subject: Re: PINKS: "Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology"

Hi David.

I have not seen it. FYI, my term limits on the ISAB and RP have expired. Some of us were brought back this winter for hatchery and resident fish reviews but those reviews are essentially over.

Greg

Sent from my iPad

> On Apr 28, 2020, at 11:58 AM, David Welch <David.Welch@kintama.com> wrote:
>
> **Nice! Congrats.**
>
> **I have our SARs paper submitted and strongly suggested you as one of the reviewers given your knowledge of the Columbia River basin issues.**

I assume that it has gone out for review (submitted a month ago), but now we are in waiting mode.

David

From: Greg Ruggerone <gruggerone@nrccorp.com>
Sent: Tuesday, April 28, 2020 11:20 AM
To: Sonia Batten (PICES) <sonia.batten@pices.int>; David Welch <David.Welch@Kintama.com>
Subject: Fwd: PINKS: "Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology"

FYI, See attached.

Also, We have a new paper just accepted by CJFAS on the impacts of pink salmon And SST on productivity of 47 sockeye populations.

Also, a new paper by Neala Kendall on the impacts of pinks on survival of Chinook in Salish Sea.

Hope all is well.

Greg

From: Greg Ruggerone <GRuggerone@nrccorp.com>
Date: April 28, 2020 at 11:03:08 AM PDT
To: Randall Peterman <peterman@sfu.ca>, Brendan Connors <Brendan.Connors@dfo-mpo.gc.ca>
Subject: PINKS: "Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology"

FYI, Greg

Brendan, I wonder if you could slip this into the page proof? FYI, last year a paper by M Baker suggested sandlance in the Salish Sea area may be impacted by pinks. But his evidence was weaker than this evidence from Atka mackerel.

Sent from my iPad

Elsevier

Estuarine, Coastal and Shelf Science

Available online **24 April 2020**, 106775

Estuarine, Coastal and Shelf Science

Competition-driven growth of Atka mackerel in the Aleutian Islands ecosystem revealed by an otolith biochronology

Mary ElizabethMatta[a]

Kimberly M.Rand[b]

Morgan B.Arrington[c]

Bryan A.Black[d]

a

Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

b

Lynker Technologies, LLC, 202 Church Street SE #536, Leesburg, VA, 20175, USA

c

School of Aquatic and Fishery Sciences, University of Washington, 1122 Boat Street, Seattle, WA, 98195, USA

d

Laboratory of Tree-Ring Research, University of Arizona, 1215 E. Lowell Street, Tucson, AZ, 85721, USA

Received 19 December 2019, Revised 14 April 2020, Accepted 16 April 2020, Available online 24 April 2020.

https://doi.org/10.1016/j.ecss.2020.106775Get rights and content

Highlights

- A **28**-year growth record was developed from otolith annulus measurements.
- Growth varied cyclically, being higher in even years and lower in odd years.
- Growth was positively related to copepod abundance, a favorite prey item.
- **The otolith growth chronology showed evidence of competition with pink salmon.**

Abstract

Fish otolith increment biochronologies can reveal factors contributing to growth. These annually resolved, multi-decadal biochronologies have been used to identify temporal and spatial patterns in growth variability. Here, we used a linear mixed modeling approach to determine the relative importance of intrinsic factors (e.g., sex, age) and extrinsic factors (e.g., temperature, abundance of con-specifics and competitors) to growth of Atka mackerel (*Pleurogrammus monopterygius*), a commercially important groundfish dominant in the Aleutian Islands ecosystem. A yearly alternating pattern of wide and narrow increments was observed, and was negatively correlated with abundance of pink salmon (*Oncorhynchus gorbuscha*), suggesting possible competition over shared food resources such as large copepods (which were positively correlated with the otolith biochronology). There was no detectable effect of temperature on otolith growth, which could be a result of relative stability in water temperatures at the study site. We also contrast the otolith biochronology with a body condition index to examine the relationship between otolith and somatic growth. This represents the first otolith biochronology developed in the Aleutian Islands and provides insight into potential species interactions and their impacts on growth within this highly dynamic and productive ecosystem.

Graphical abstract

Image 1

David Welch

From: Petersen,Christine H (BPA) - EWP-4 [chpetersen@bpa.gov]
Sent: Wednesday, October 02, 2019 9:12 AM
To: David Welch
Subject: FW: Kintama Letter
Attachments: KintamaLetter-091919.pdf

Hi David
I am heading back from Seattle this morning. I actually got an incoming call from FPC [redacted]

This letter may warrant no response, and may be the documentation needed to show we don't have access to hatchery to hatchery PIT based SARs. A little weird to CC all the agencies. I will talk with Jody Lando or maybe Ben Z tomorrow.

Christine

Sent from Workspace ONE Boxer

---------- Forwarded message ----------
From: Michele Dehart <mdehart@fpc.org>
Date: Oct 1, 2019 3:50 PM
Subject: [EXTERNAL] FW: Kintama Letter
To:
adam.j.storch@state.or.us,Erick.S.VanDyke@coho2.dfw.state.or.us,tucker.a.jones@state.or.us,lort@critfc.org,lotr@critfc.org,LESR@critfc.org,'Christine Golightly' <GOLC@critfc.org>,ED.Bowles@state.or.us,lance Hebdon
<lance.hebdon@idfg.idaho.gov>,tim.copeland@idfg.idaho.gov,Daniel.Rawding@dfw.wa.gov,tweitwmt@dfw.wa.gov,Michael.Garrity@dfw.wa.gov,Steve_Haeseker@fws.gov,David Swank
<david_swank@fws.gov>,ritche.graves@noaa.gov,jayh@nezperce.org,zpenney@critfc.org
Cc: Jerry McCann <jmccann@fpc.org>,Brandon Chockley <bchockley@fpc.org>,Erin Cooper <ecooper@fpc.org>,Gabriel Scheer <gscheer@fpc.org>,Bobby Hsu <bobbyhsu@fpc.org>,"Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>

Hello:
This is just a heads up, to pass along a recent certified letter received by the Fish Passage Center from David Welch, Kintama Research Services. This letter is related an article by Welch et al, developed under contract with BPA, submitted for publication in the online journal PLOS. The article titled, "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow moving catastrophe or deeper failure?". The article was posted on a biological sciences archive page, for non-peer reviewed articles, called bioRxiv. The analyses developed under BPA contract was attached to recommendations by Welch to the NW Power Planning Council amendment process.

The BPA COTR on this contract is Christine Petersen and Welch has copied her on this letter. Some of the statements by Welch in this letter, do not comport with the documentation of emails from Christine Petersen, BPA, to the Fish Passage Center in 2017, in which Ms. Petersen states that BPA is interested in SARs from release to uppermost dam for the 2017 Biological Assessment. SARs from point of release to upper most dam, are not a component of CSS analyses or study design. The FPC does not generate these SARs and Ms. Petersen was advised accordingly in 2017 and advised that this request would represent a significant amount of new work. When the FPC was asked to review the Welch analyses, 2019, the BPA contract, including deliverables and work elements was requested, to understand the hypotheses that BPA contracted Kintama to pursue. The Kintama contract, work elements, deliverables, was not provided.

The FPC provides all data and analyses completed in FPC, CSS and SMP projects to the public. SARs from point of release, traps, etc...are not generated as part of these projects. The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables.

Michele

KINTAMA
Technology that Provides Answers

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Revenue Canada Business Number: 85245 0519 RT0001
DUNS: 247365385

18 Sept 2019

Re: Provision of CSS SARs data

Dear Ms DeHart:

As you will be aware, the FPC's published CSS studies report annual survival primarily from the topmost dam back to the topmost dam. This excludes smolt survival in the migration segment from hatchery release or upstream tagging site to the topmost dam for most populations (and particularly the Snake River). Over the past several years Kintama has requested three or four separate times via Dr Christine Petersen (our BPA Contracting Officer) that the FPC provide smolt to adult survival data (SARs) for the entire life history.

To date there has been no provision of this survival data, although your staff indicated several times that they will look into the request.

The FPC criticized a recent manuscript of ours partly because of the apples to oranges nature of the comparison of SARs calculated using PIT tags in the Columbia River basin and CWTs used elsewhere on the west coast of North America. This is problematic for my group because although you have criticized this difference, it is the mainly the lack of data from the CSS on upstream survival that is one of two major causes of discrepancy between the CWT and PIT tagging methods. (The other being lack of harvest data in PIT tag SAR estimates). As a result it is the PIT tag estimates that are anomalous because of the exclusion of upstream smolt and adult survival.

Your staff suggested to Dr Petersen that our request would be a lot of work. It is unclear why this would be so troublesome. We had initially planned to simply do the extractions ourselves, but found that there is insufficient detail in the CSS reports for us to know exactly what tagging groups the CSS use and exclude in creating their SAR estimates. As a result, if we simply do the SAR estimation ourselves the criticism may then simply shift that we have failed to exactly replicate what tagging groups your group uses.

As a result, I am requesting that the FPC provides the SAR data directly, using the data filters you use for the CSS report. Specifically, we are looking for SARs estimates that span the complete migration history from smolt release (from the hatcheries or traps) back to the hatchery or spawning grounds as adults for all the populations that have 'Overall' SARS reported in the CSS annual reports (Appendix B in the 2016 version, specifically Tables B1-B49, B51-100, B103-105). The data we need are for hatchery and wild steelhead, and yearling and subyearling hatchery and wild Chinook from the Snake and upper and mid Columbia rivers.

The SARS currently reported in the CSS reports are from dam to dam so tributary mortality above the dams is excluded for both smolts and returning adults. Our goal here is to capture and credit to freshwater as much of the survival losses as is practicable. If the FPC only has survivals from smolt release until adult return to the most upriver dam (i.e. excluding mortalities of returning adults from the top dam to hatchery &/or spawning ground), we will use those instead.

We note that the FPC has some limited portions of the data we are seeking publically available on their website, but it would be much cleaner for our analysis to have the entire dataset from one source. We will also need a citation for the data source so that we can publish it (a "personal communication" from you or a senior member of your staff will be fine if necessary).

This request is being sent via email and registered letter.

Sincerely,

David Welch, Ph.D.
KINTAMA
President, Kintama Research Services Ltd.
david.welch@kintama.com

c.c. Dr Christine Petersen, BPA

From: Petersen,Christine H (BPA) - EWP-4

Sent: Thu Apr 30 11:58:05 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; 'David Welch'; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Subject: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

[redacted] (internal)

[redacted] (external)

[redacted] (toll free)

ID: [redacted]

We would like to invite David, Aswea and Erin to present on their revised and submitted manuscript. While they maintain their focus on patterns of West Coast SARs for yearling and subyearling Chinook, they have developed some new material on CWT and PIT based SARs, and the significance of the harvest component.

We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc. Will provide a Webex link later.

It was challenging to find a good time when we're all available this month. Please alert me if this is just not going to work because of the BiOp review or any other reason. We can add a few more participants later

FISH and FISHERIES

Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)

Journal:	*Fish and Fisheries*
Manuscript ID	Draft
Wiley - Manuscript type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Welch, David; Kintama Research Services Ltd, Porter, Aswea; Kintama Research Services Ltd Rechisky, Erin; Kintama Research Services Ltd
Key terms:	Aquaculture, Columbia River, dams, delayed mortality, smolt-to-adults returns, Snake River
Abstract	(b)(5) [redacted]

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From: David Welch

Sent: Thu Apr 30 12:37:29 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: Erin Rechisky

Sent: Thu Apr 30 13:37:27 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Deliverable Marked Complete

Importance: Normal

Hi Christine,
Thanks. I won't make any changes in Pisces.
I'll mention the handout to David again.

Erin

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 30, 2020 12:17 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Oh - the first part of this probably doesn't make sense. The email from our invoicer somehow came to the top of my inbox and I didn't check the date so it looked as though she had just sent it again. Please disregard.

Christine

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4
Sent: Thursday, April 30, 2020 12:13 PM
To: 'Erin Rechisky' <Erin.Rechisky@Kintama.com>
Subject: RE: Deliverable Marked Complete

Weird - I just saw that our invoicer put a hold, because she cannot see the final status report.
I would initially list Pisces users, but project contacts is fine.

You can check optional travel as green, because it was optional. You did present at AFS though, didn't you? Just not the funded trip as discussed?

You can also mark 119 green.

It is a real challenge picking a day for you guys to present. I know David preferred earlier. Half of us are really stressed out with the expected NOAA biop arriving today and blocked off the entire month as unavailable, but I think they should welcome the break, plus it could be very important to discuss the themes in your paper with NOAA. NOAA has a separate harvest BiOp. They are probably addressing the Council SAR goals and density dependence in the document somewhere.

Also - as far as a handout for new ideas... when I was talking to Jody, she thought that it would be easiest to consider any potential new work, or taking up the second data analysis concerning above/within/below hydrosystem daily survival rates, if you could make a document for people to peruse beforehand or afterwards. I am not sure if there is a suggested format exactly. I can say that it would be easiest from a contracting perspective to reinitiate the second study because we already have the sole source justification, but this is just one consideration.

Christine

-----Original Message-----
From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, April 1, 2020 11:03 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Deliverable Marked Complete

Hi Christine,
I've uploaded the SAR paper to Pisces. I was not sure who should have access? I selected "Contacts" from the drop down menu. Let me know if I should change that.
For the final status report of our contract, how do we handle "optional travel to conference"?
Also, can I mark the Deliverable for E:119 "Effective implementation management and timely contract administration" complete as of yesterday?

Thanks,
Erin

-----Original Message-----
From: CBFish on behalf of support@cbfish.org <donotreply@cbfish.org>
Sent: April 1, 2020 10:56 AM
To: chpetersen@bpa.gov; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Deliverable Marked Complete

To: Christine Petersen;Erin Rechisky
Cc:

The milestone "Deliverable: Produce Journal Article" for work element "B: 183. The coast-wide collapse in marine survival of North American Chinook salmon" on contract #81498 under project #1996-017-00 ("Technical and Analytical Support for ESA Activities/Issues") has recently been marked complete on status report "Final Jan-Mar 2020 (1/1/2020 - 3/31/2020)".

If you feel this email has reached you in error, please contact the assigned COTR for this contract, Christine Petersen (chpetersen@bpa.gov).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Thu Apr 30 14:13:31 2020

To: Monroy Flores,Luisa F (BPA) - EWB-4

Subject: Position Posted: Fish and Wildlife Administrator, GS-0480-13, EWM – Portland, OR

Importance: Normal

Hello,

A Fish and Wildlife Administrator position just opened in the Idaho and Montana Implementation group (EWM). The Land Lead position leads internal and external teams in the planning, execution, and monitoring of land acquisitions and conservation easements throughout the Columbia River Basin.

Announcement #: DOE-BPA-20-13995-MP

Position Title: Fish and Wildlife Administrator, GS-0480-13, EWM – Portland, OR

Opening Date: 04/30/2020

Closing Date: 05/09/2020

USAJOBS Link: https://www.usajobs.gov/GetJob/ViewDetails/567086600

Individuals that are eligible to apply are:

- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Military Spouses
- Peace Corps & AmeriCorps Vista
- Specials Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

Bonneville Power Administration
bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

Facebook-Icon_31x31_v3Flickr-Icon_31x31Instagram-Icon_31x31LinkedIn-Icon_31x31Twitter_31x31YouTube_31x31

From: Erin Rechisky

Sent: Thu Apr 30 16:40:15 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: Aswea Porter

Sent: Thu Apr 30 16:40:51 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: David Welch

Sent: Tue May 05 14:39:25 2020

To: Erin Rechisky

Cc: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Important...

Importance: Normal

Attachments: Karier(Perspectives_ Independent Science Needed in Fish-Recovery Strategy _ NW Fishletter 2020).com.pdf

(b)(5) [redacted]

I copy Christine for her comments.

David

P.S. Christine, no doubt you have seen Tom Karier's article, but I attach it here in case you haven't. I pointed this out to Erin & Aswea because I am currently working up precisely that proposal to explicitly test the TDG effects of higher spill. If Tom is calling for "independent science needed", then you can't get much more independent than Kintama! J

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Tuesday, May 05, 2020 2:18 PM
To: David Welch <David.Welch@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Important...

Really good article.

This was surprising:

(b)(5) [redacted]

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: May 5, 2020 2:02 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Important...

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Tuesday, May 05, 2020 1:52 PM
To: David Welch <David.Welch@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Important...

I can't access the NewsData Fishletters anymore.

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: May 5, 2020 12:35 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: Important...

This is a very interesting read on the politics and the science. If you haven't a;ready read it, take the time in the next few days to do so:

https://www.newsdata.com/nw_fishletter/perspectives-independent-science-needed-in-fish-recovery-strategy/article_0c582fe4-8e30-11ea-be82-d3f89c05343a.html

David Welch, Ph.D.

kintamav_RGB

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fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

https://www.newsdata.com/nw_fishletter/perspectives-independent-science-needed-in-fish-recovery-strategy/article_0c582fe4-8e30-11ea-be82-d3f89c05343a.html

Perspectives: Independent Science Needed in Fish-Recovery Strategy

Tom Karier
May 4, 2020

By Tom Karier, Eastern Washington University economics professor and former Northwest Power and Conservation Council member.

The recent release of the draft environmental impact statement for the Columbia River hydropower system seems like a familiar episode in the endless debate about breaching the four lower Snake River dams: Feds support dams, enviros do not.

But science in the draft EIS makes this more interesting. This time the feds threw a curveball, by supporting a different underlying science for their preferred alternative. This abrupt change highlights the need for independent science to help identify the best strategy to recover endangered fish populations.

An obvious solution to the dam debate is to follow the science because in the end, nature—not federal agencies, environmental groups or courts—will determine whether we did the right thing to save salmon. So, whose science do we follow?

Until recently, BPA and other federal agencies relied on analysis by the National Marine Fisheries Service, presumably because they trusted the work. NMFS also found relatively weaker benefits to fish from spill and dam breaching, results that were consistent with existing federal policy.

Then things changed. Federal agencies in 2018 successfully negotiated with Northwest states and tribes a compromise flexible spill operation that increased spill to 16 hours a day in exchange for eight hours of increased power generation. It was popular with state and tribal fishing agencies and not particularly expensive for BPA. Lost generation during two-thirds of the day could be offset by generation during the one-third of the day when electricity prices were high. Flexible spill was a great political compromise and easily rose to the top in the draft EIS as the preferred alternative

But even a great political compromise doesn't guarantee biological success. The question remains, will it save salmon?

NMFS doesn't seem to think so. When the agency ran the preferred alternative through its forecasting model for the draft EIS, it found survival (smolt-to-adult returns) for Snake River spring Chinook, a bellwether species, fell 7.5 percent compared to doing nothing. If NMFS is correct, a small direct benefit from additional spill is likely to be swamped by steep reductions in transport of juvenile fish. Barging fish downriver was once controversial, but now often beats the survival of fish left in river. Because the preferred operation makes it impossible to put as many juveniles in barges, the overall survival of the run actually decreases.

Rather than choose a different operation, Bonneville chose a different science, one that it found at the Fish Passage Center. According to the FPC, the preferred alternative should increase survival of the same species by 35 percent. In a remarkable reversal, the draft EIS elevates the status of the Fish Passage Center to the level of NMFS science, if not higher.

All this shopping around for the right science should be a wake-up call for the region. How, after decades of experimenting with higher levels of spill, do we still not know whether it harms or helps fish? And if federal agencies accept FPC estimates for flexible spill, do they also accept the center's estimate for dam breaching, which shows a 170 percent improvement in survival?

Competing analyses of spill and dam breaching revolve around a single issue—latent mortality. The Fish Passage Center has advocated for this hypothesis for years with the claim that each powerhouse passage by fish leads to a significant reduction in ocean survival. The evidence was based on a reduction in fish survival after completion of the Snake River dams and the perception that fish from downriver hatcheries had a higher survival rate than those from upriver hatcheries with more powerhouse encounters. An important corollary to this hypothesis is that fish that pass dams by spill are largely exempt from this effect. NMFS included latent mortality in its analysis, but only to demonstrate that it accounted for most of the difference between its results and those of the FPC.

In 2007 the Independent Science Advisory Board reviewed this hypothesis and said, "The ISAB concludes that the hydrosystem causes some fish to experience latent mortality, but strongly advises against continuing to try to measure absolute latent mortality. Latent mortality relative to a damless reference is not measurable." There were simply too many alternative explanations for ocean mortality that the Fish Passage Center attributed to latent mortality. And yet in the new draft EIS, the FPC uses its estimates of latent mortality to calculate fish survival without Snake River dams. This doesn't mean that FPC estimates are necessarily wrong, but being based on unmeasurable estimates, they warrant some healthy amount of skepticism.

What about the reduction in latent mortality associated with spill? That relationship was not deemed unmeasurable and lies at the heart of the current discrepancy over the preferred alternative. The ISAB addressed this issue in 2012. By that time, most juvenile fish were either being spilled or bypassed, with relatively few going through the turbines. Because additional spill would take more fish from the bypass systems (with high survival rates) than from the turbines, the expected net benefit was very small. In other words, no matter how much you liked spill, there appeared to be no mechanism for more spill to significantly improve survival.

However, there was a catch. Although juvenile fish using the bypass system had high survival at the dams, they had lower returns as adults. This suggested latent mortality from bypass systems and created, at least in theory, potential benefits of shifting bypassed fish to the spillways. However, there was another catch. It was observed that smaller fish were disproportionately attracted to the bypass system and if that was the case, then there may not be any latent mortality. Smaller juvenile fish typically have lower adult returns and simply pulling them from the bypass to the spillway would have little to no benefit. In 2012, the ISAB said this was measurable and in fact should be measured.

The latest installment in this drama is research cited in the draft EIS. A 2019 study by James Faulkner and his colleagues at NMFS demonstrated "size selective tendencies at many of the bypass systems in the [Columbia River System] which would potentially reduce the benefit of increased spillway passage shown by the [Fish Passage Center's Comparative Survival Study] model." And the big headline from NMFS, "The finding raises questions about whether spilling additional water past dams to carry more fish through spillways instead of bypass systems will substantially increase their survival in the ocean and the number that return to rivers as adults."

So, just as the evidence appears to be shifting in favor of NMFS, BPA and the other federal agencies (U.S. Army Corps of Engineers and Bureau of Reclamation) decided to jump ship for the Fish Passage Center model in the draft EIS.

All this indicates that science is making progress, but not fast enough. BPA is close to embarking on a salmon recovery strategy that may reduce survival of endangered fish by 7.5 percent. If this occurs, we need to know results sooner rather than later, and this requires a more active role for independent science.

The ISAB should not wait this time until someone asks it a question. It needs to take the initiative and design operations that can determine if higher spill is helping or harming fish. For example, is it better to alternate spill hourly as in the preferred alternative, or over longer intervals? Are we collecting all the necessary data? Drug trials work because they are carefully designed to secure information with the least amount of cost and risk. We may not be able to achieve that standard in the Columbia Basin, but we should seek the best possible experimental design.

We have more than 20 years of testing different spill levels in the Columbia Basin that have proven inconclusive. Let's not do that again. Why not task the independent science panel to develop an experimental design that will efficiently determine if the preferred alternative is expanding salmon populations or reducing them? The natural world cares little about our good intentions.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed May 06 17:05:42 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; 'David Welch'; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Cc: Lando,Jody B (BPA) - EWP-4

Subject: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

Note: Changing the time to Friday May 29th to allow greater attendance.

[redacted](internal)

[redacted] (external)

[redacted](toll free)

ID: [redacted]

We would like to invite David, Aswea and Erin to present on their revised and submitted manuscript. While they maintain their focus on patterns of West Coast SARs for yearling and subyearling Chinook, they have developed some new material on CWT and PIT based SARs, and the significance of the harvest component.

We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc. Will provide a Webex link later.

It was challenging to find a good time when we're all available this month. Please alert me if this is just not going to work because of the BiOp review or any other reason. We can add a few more participants later

From: David Welch

Sent: Wed May 06 19:24:29 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: Erin Rechisky

Sent: Wed May 06 21:15:07 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: Greene,Jacqueline R (CONTR) - EW-4

Sent: Thu May 07 16:16:45 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Increased the maximum file size allowed for Design document type from 50 MB to 150 MB
- CO and COTR assignment changes are now logged in Contract Contact Change Log
- Added an alert to COR to remove the SOW of a canceled CCR
- Added call-outs to the Location Summary map layer features

- Identify Work Sites locations is now set to placeholder location (i.e. organization headquarters) instead of actual work location
- Added edit functionality to photos and converted existing photos for consistency
- Created new "QC Review" document type
- Created new MOU/MOA grid
- Vocabulary terms updated to stay consistent with MonitoringResources.org

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Aswea Porter

Sent: Fri May 08 15:21:04 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: Revised West coast SARs paper, Kintama

Importance: Normal

From: David Welch

Sent: Sat May 09 10:27:57 2020

To: Erin Rechisky; Aswea Porter

Cc: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] FW: "Survival of migrating salmon smolts in large rivers ..." - new citations

Importance: Normal

(b)(5) [redacted]
the west coast. I can't access the paper yet off Sci-Hub, and I don't want to pay for purchase of the full article right now. However, the figures are free to view and the abstract is quite interesting.

Note how much lower the Sacramento smolt survival is than the Columbia River hydropower system survival for the same species. I'm not sure right now as I don't have access to the full paper, but I suspect these are independent datapoints from the paper we cited by Cyril Michel for the same area.

I copy Christine for her info—survival in California is 0-9% versus ca. 50% for the Snake River to Astoria.

d

From: Google Scholar Alerts <scholaralerts-noreply@google.com>
Sent: Saturday, May 09, 2020 5:30 AM
To: David Welch <David.Welch@Kintama.com>
Subject: "Survival of migrating salmon smolts in large rivers ..." - new citations

1. Historic drought influences outmigration dynamics of juvenile fall and spring-run Chinook Salmon

GP Singer, ED Chapman, NA Fangue, DD Colombano...

Riverine ecosystems around the world have undergone extensive anthropogenic alterations, often to the detriment of native aquatic biodiversity. Migratory fishes are particularly vulnerable to habitat fragmentation and degradation. For example ...

Save

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"Survival of migrating salmon smolts in large rivers with and without dams" - new citations

Cancel alert

This alert is sent by Google Scholar. Google Scholar is a service by Google.

From: David Welch

Sent: Mon May 25 11:54:42 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Revised West coast SARs paper, Kintama

Importance: Normal

Hi Christine—

I am currently preparing the PowerPoint for this review. A question: Will I be able to share my screen and step through the Powerpoint from my end, or will you need to control the presentation as the organizer?

I ask because if I don't have full control over the presentation I won't add a lot of little animations to make it easier for the attendees to follow the various points we want to make on individual slides.

We should probably have a brief coordination call to discuss the presentation prior to the actual time. I (b)(5) [redacted]

-----Original Appointment-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Thursday, April 30, 2020 11:58 AM
To: Petersen,Christine H (BPA) - EWP-4; Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; David Welch; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4
Cc: Lando,Jody B (BPA) - EWP-4
Subject: Revised West coast SARs paper, Kintama
When: Friday, May 29, 2020 1:30 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: [redacted]

Note: Changing the time to Friday May 29th to allow greater attendance.

[redacted] (internal)

[redacted] (external)

[redacted] (toll free)

ID: [redacted]

We would like to invite David, Aswea and Erin to present on their revised and submitted manuscript. While they maintain their focus on patterns of West Coast SARs for yearling and subyearling Chinook, they have developed some new material on CWT and PIT based SARs, and the significance of the harvest component.

We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc. Will provide a Webex link later.

It was challenging to find a good time when we're all available this month. Please alert me if this is just not going to work because of the BiOp review or any other reason. We can add a few more participants later

From: David Welch

Sent: Tue May 26 15:13:16 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Weds

Importance: Normal

Hi-

Anytime tomorrow is fine, so long as we can wrap up by 3:45. Vancouver Island (population ~1 million) hasn't had a diagnosed case of COVID 19 for 11 days now, and the province as a whole is down to (almost) single digits for new cases each day. I'm now allowed to visit small groups of friends with moderate precautions, and that's what happens tomorrow afternoon.

We have gotten off lucky with the first wave, although what happens with the second wave is anyone's guess at this point.

I'm just sending Aswea the ppt to review first, then Erin tomorrow (she needs to review and get back to me on the changes to the draft paper first). Would you like to see it before the Friday presentation? I can send it to you as well.

d

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, May 26, 2020 2:22 PM
To: David Welch <David.Welch@Kintama.com>
Subject: Weds

Hi

Tomorrow would be a good time for a call, as I don't have meetings and a lot of the BiOp stuff is on someone else's desk.

I am about to send out the webex and add a few invitees.

Christine

Sent from Workspace ONE Boxer

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed May 27 09:56:30 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; 'David Welch'; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Cc: Lando,Jody B (BPA) - EWP-4

Subject: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

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[redacted] (internal)
[redacted] (external)
(toll free)
ID: [redacted]

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We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc. Will provide a Webex link later.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed May 27 12:50:32 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; David Welch; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Cc: Lando,Jody B (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - E-4; Scranton,Russell W (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; Allen,Brady (BPA) - EWP-4; Eagan Moody,Maura (BPA) - EWP-4; Karnezis,Jason P (BPA) - EWL-4

Subject: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

- Use **Join Meeting** link and the WebEx Audio **Call Me** feature
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We would like to invite David, Aswea and Erin to present on their revised and submitted manuscript. While they maintain their focus on patterns of West Coast SARs for yearling and subyearling Chinook, they have developed some new material on CWT and PIT based SARs, and the significance of the harvest component.

We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc.

From: David Welch

Sent: Wed May 27 13:03:20 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Emailing: Comment on McMichael et al 2013 -- 9 Dec2013.docx, Figure 1_Comparative area plot.pdf

Importance: Normal

Attachments: Comment on McMichael et al 2013 -- 9 Dec2013.docx; Figure 1_Comparative area plot.pdf

Nice to talk with you Christine.

Here is the commentary we submitted on Geoff McMichael's study. Unfortunately, the editors decided not to publish it, but I thought our comments were reasonable.

david

Your message is ready to be sent with the following file or link attachments:

Comment on McMichael et al 2013 -- 9 Dec2013.docx
Figure 1_Comparative area plot.pdf

Note: To protect against computer viruses, e-mail programs may prevent sending or receiving certain types of file attachments. Check your e-mail security settings to determine how attachments are handled.

Scale affects interpretation of movement patterns in juvenile salmon

Trawl-based studies have demonstrated that juvenile salmon emigrating from the Columbia River largely migrate north once they enter the ocean [1-5]. These findings are the basis for the assumption in coastal acoustic telemetry studies using the POST (Pacific Ocean Shelf Tracking) array that similar proportions of smolts migrate north after ocean entry [6-11]. Recently, McMichael et al. [12] reported detections of acoustic-tagged smolts on JSATS (Juvenile Salmon Acoustic Telemetry System) receivers south of the Columbia River mouth during the 2010 migration, and suggested that northward behavioural migration at ocean entry cannot be assumed. The discrepancy should serve as yet another reminder that the spatial and temporal scale at which we make our measurements may determine the patterns we observe and should inform our interpretations [13].

I contend that what has been observed in trawl surveys and on the POST acoustic tracking array is marine behavioral migration, whereas observations from the JSATS array are probably the result of powerful, but localized, tidal currents that should not be interpreted as marine migratory behavior. Results from JSATS may differ from results of POST and earlier trawl-based surveys, but they should be viewed as supportive rather than conflicting. For instance, 70% of yearling smolts were detected for one day or less on the JSATS array [12], which is consistent with the northward migration speeds recorded on the POST subarray to the north [14].

The plume receivers of the POST array extended across the continental shelf at Willapa Bay, WA, approximately 40 km north of the Columbia River mouth (Figure 1). JSATS plume receivers were placed in a north-biased box that bounded the river mouth with an along-shelf terminal subarray part way across the shelf approximately 15 km east of the river mouth, and cross-shelf lines of receivers north and south of the river mouth [12; cross-shelf receiver positions estimated from figures therein].

The Columbia River plume is not a homogeneous oceanographic feature. Conditions near the river mouth are vastly different from those found off Willapa Bay. Horner-Devine et al. [15] describe a useful salinity-based anatomy of the plume that includes a tidal plume, a re-circulating plume, and a far-field plume. McMichael et al.'s plume array lies within the region affected by the tidal plume, a lens of estuarine water flushed from the river on the ebbing tide that exhibits strong horizontal surface current velocities (sometimes exceeding 3 m s^{-1}) and can extend to a depth of approximately 10 m [15, 16]. The tidal plume has strong westward flow, and in the presence of southward flowing coastal surface currents, may extend 35 km from the river mouth, but when current flow is northward, the tidal plume may dissipate within 10-20 km [16]

The tidal plume flows over and mixes with the re-circulating plume, which consists of water from previous tidal plumes that has been on the shelf between 0.5 and 4 days, has a cross-shelf extent up to approximately 40 km, and reduced currents [15]. Beyond the recirculating plume lies the far-field plume - waters that are no longer directly affected by the momentum of the river's discharge and are in the final stages of mixing with the ocean [15]. Depending on the orientation and duration of surface winds, the POST array off Willapa Bay may lie in far-field waters or across the boundary of the re-circulating plume [17]. The operational definition of the plume used by POST authors, i.e., between receiver arrays at Astoria Bridge or Sand Island and Willapa Bay, thus encloses the significant features of the plume (Figure 1).

The placement of the JSATS array within the bounds of the tidal plume (with a northward bias relative to the river mouth) and the observation in McMichael et al. [12] and Emmett et al. [18] that most smolts apparently depart the river on the ebb tide, make it likely that the detection patterns observed on the JSATS array were influenced by strong currents in the tidal plume rather than the migratory behaviour of the tagged smolts or weaker ocean currents. The critical swimming speed of juvenile Chinook and steelhead has been measured at approximately 0.5 to 0.75 m s-1 [19, 20]. These are 1/4th to 1/6th of the maximum horizontal plume current speeds and comparable to velocities sampled behind the tidal plume front by Horner-Devine et al. [15, see their Figure 13b]. They are also greater than the ambient summer coastal ocean flow of approximately 0.1 $m\ s^{-1}$ [21]. Thus the strength of the currents in the tidal plume can obscure most of the behavioural signal in the patterns of smolt movement.

McMichael et al. [12] report a greater proportion of detections on the southern terminus of the JSATS array when southerly ocean currents were generally dominant, and the opposite pattern when currents were reversed. However, the greatest proportion of their detections when they measured southerly currents appears to occur almonst directly west of the river mouth. Thus, their finding may be more consistent with extended westward propagation of the tidal plume under southern coastal flow conditions [16] than an effect of weaker coastal ocean currents. Conversely, if smolt migration had primarily taken place during periods of northern coastal flow, a northward trend in detections on the JSATS array may have been prevalent.

A few southward migrating smolts have been reported in previous migration studies [1, 3, 4, 8, 10]. McMichael et al. [12] reference two smolts detected on the POST array at Cascade Head, OR, in 2009 (reported in [8]) in their argument for southward migration at ocean entry. In addition, six smolts were detected on this array in 2011 [10]. Seven of these smolts were never detected again, but one was detected migrating north rapidly, first on the Willapa Bay array, and then at the north end of Vancouver Island, Canada. This is clearly behavioural migration and it suggests that even extended southward excursions can be reversed.

In summary, McMichael et al. have reported interesting observations, but their suggestion that they challenge previous findings and assumptions is tenuous. The limited scale of their array relative to the geographic features under consideration and the limited observation period (one migration year) precludes making these conclusions. The spatial extent of their plume array and powerful local currents that substantially exceed smolt swimming speeds must be considered when interpreting movement patterns near the river mouth. The migration patterns clearly evident at larger spatial scales support the general assumption of northward migration once smolts are beyond the tidal plume.

References

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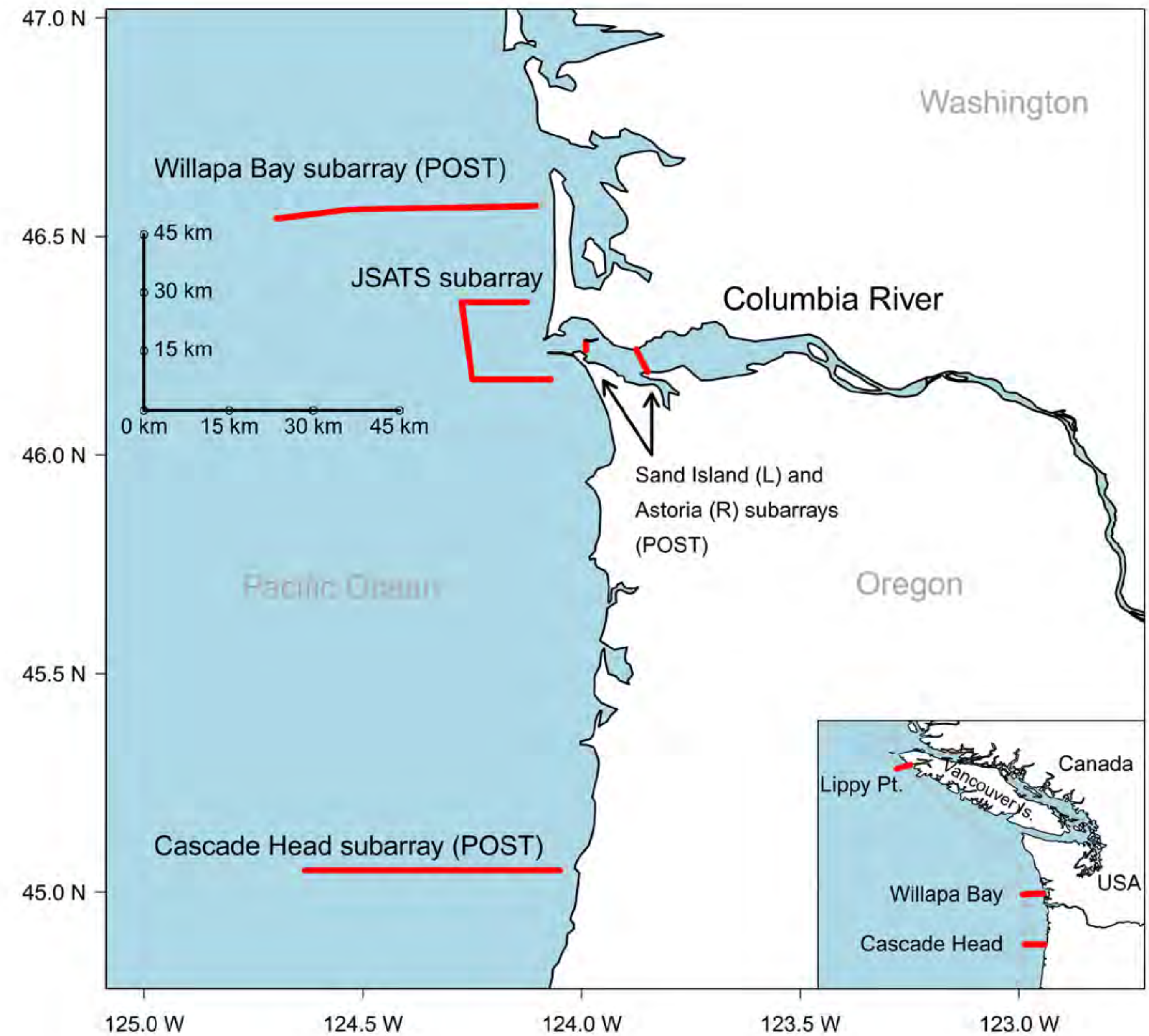
Figure 1. Positions of POST estuary, plume and coastal subarrays and the JSATS plume subarray (all denoted by red lines).

[FIGURE ATTACHED TO E-MAIL]



47.0 N
46.5 N
46.0 N
45.5 N
45.0 N
125.0 W
124.5 W
124.0 W
123.5 W
123.0 W
Washington
Willapa Bay subarray (POST)
45 km
30 km
15 km
0 km
15 km
30 km
45 km
JSATS subarray
Columbia River
Sand Island (L) and
Astoria (R) subarrays
(POST)
Pacific Ocean
Oregon
Canada
Lippy Pt.
Vancouver Is.
USA
Willapa Bay
Cascade Head
Cascade Head subarray (POST)

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed May 27 16:09:00 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; David Welch; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Cc: Lando,Jody B (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - E-4; Scranton,Russell W (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; Allen,Brady (BPA) - EWP-4; Eagan Moody,Maura (BPA) - EWP-4; Karnezis,Jason P (BPA) - EWL-4

Subject: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

Hi everyone- sorry to push thia forward again, but it looks like at least 4 people involved with the BiOp review could not attend, who would like to be involved. I will cancel for Friday, and look on the calendars for a better time.

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We would like to invite David, Aswea and Erin to present on their revised and submitted manuscript. While they maintain their focus on patterns of West Coast SARs for yearling and subyearling Chinook, they have developed some new material on CWT and PIT based SARs, and the significance of the harvest component.

We should try to shoot for an hour presentation, but I am setting aside 90 minutes for optional discussion etc.

___________________________[X]

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed May 27 16:09:07 2020

To: Sullivan,Leah S (BPA) - EWP-4; Jule,Kristen R (BPA) - EWP-4; David Welch; Erin Rechisky; Aswea Porter; Skidmore,John T (BPA) - EWL-4; Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4

Cc: Lando,Jody B (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - E-4; Scranton,Russell W (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; Allen,Brady (BPA) - EWP-4; Eagan Moody,Maura (BPA) - EWP-4; Karnezis,Jason P (BPA) - EWL-4

Subject: Canceled: Revised West coast SARs paper, Kintama

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

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From: Greene,Jacqueline R (CONTR) - EW-4

Sent: Thu May 28 13:46:02 2020

To: Pisces

Bcc: hadondy-kaplan@bpa.gov; ddknapp@bpa.gov; cmclark@bpa.gov; jmmccloud@bpa.gov; jcwilson@bpa.gov; mballen@bpa.gov; dwwelch@bpa.gov; induran@bpa.gov; ktwolfe@bpa.gov; esgresh@bpa.gov; cjmatthew@bpa.gov; kcgrange@bpa.gov; chpetersen@bpa.gov; krjule@bpa.gov; dldocherty@bpa.gov; ezolmajd-haghighi@bpa.gov; sldonahue@bpa.gov; kmcampbell@bpa.gov; rkeanini@bpa.gov; mmomalley@bpa.gov; djkaplowe@bpa.gov; rwshull@bpa.gov; jepeterson@bpa.gov; ejleitzinger@bpa.gov; pmgillespie@bpa.gov; kpmote@bpa.gov; spmarsh@bpa.gov; tatrinh@bpa.gov; cdmcclory@bpa.gov; jpkarnezis@bpa.gov; jwlane@bpa.gov; clread@bpa.gov; rdgeorge@bpa.gov; slfrye@bpa.gov; sdgrant@bpa.gov; mlteoh@bpa.gov; chfurey@bpa.gov; jklord@bpa.gov; tepansky@bpa.gov; amcreason@bpa.gov; ahcummings@bpa.gov; bmdick@bpa.gov; baguirre@bpa.gov; ermcomie@bpa.gov; rcguiao@bpa.gov; jayarman@bpa.gov; aemai@bpa.gov; safife@bpa.gov; jacleveland@bpa.gov; memoody@bpa.gov; allheureux@bpa.gov; jtskidmore@bpa.gov; rwscranton@bpa.gov; lldexter@bpa.gov; gmcclintock@bpa.gov; stbiegel@bpa.gov; gmsmith@bpa.gov; cjhamel@bpa.gov; jwconnor@bpa.gov; makavanagh@bpa.gov; smlopez@bpa.gov; spwelch@bpa.gov; MLJanssen@bpa.gov; ckbrown@bpa.gov; tlhauser@bpa.gov; sggray@bpa.gov; mthaight@bpa.gov; dagambetta@bpa.gov; rxmazaika@bpa.gov; vlwatts@bpa.gov; uvmohan@bpa.gov; ptlofy@bpa.gov; potoole@nwcouncil.org; pci@nwi.net; keith@sitkatech.com; Andrew.Murdoch@dfw.wa.gov; james.r.ruzycki@state.or.us; jayh@nezperce.org; cbrun@hrecn.net; ireland@kootenai.org; emmitt@nezperce.org; brej@yakamafish-nsn.gov; butlerc@yakamafish-nsn.gov; clec@yakamafish-nsn.gov; lamr@yakamafish-nsn.gov; rogb@yakamafish-nsn.gov; dlindley@ykfp.org; brianm@exelearn.com; amy.hines@osc.idaho.gov; laura.tesler@state.or.us; steve.elam@idfg.idaho.gov; EBerntsen@kalispeltribe.com; michael@sitkatech.com; john.vivio@sitkatech.com; soults@kootenai.org; kelly.e.reis@state.or.us; kweist@nwcouncil.org; lawrence.schwabe@grandronde.org; droix@columbialandtrust.org; Daniel.Bertram@osc.idaho.gov; Amy.Cassel@idwr.idaho.gov; Abbie.Gongloff@osc.idaho.gov; bobminton@hotmail.com; egalloway@sbtribes.com; cswcd@custertel.net; patrick.murphy@idfg.idaho.gov; jessica.buelow@idfg.idaho.gov; clwood@tu.org; scampbell@sbtribes.com; KELD@critfc.org; ijezorek@usgs.gov; elaine@ykfp.org; CWheaton@psmfc.org; t.k.iverson@comcast.net; dawanderson@mt.gov; john.arterburn@colvilletribes.com; cyndi.baker@ctwsbnr.org; mike_banach@psmfc.org; katie.barnas@noaa.gov; jbayer@usgs.gov; bbosch@yakama.com; Evan.brown@idfg.idaho.gov; colettecoiner@ctuir.org; aconley@ybfwrb.org; ldenny@sbtribes?com; mfritsch@nwcouncil.org; galp@critfc.org; gepl@critfc.org; jennifer.graham@ctwsbnr.org; tracy.hillman@bioanalysts.net; shorton@nwcouncil.org; brad.houslet@ctwsbnr.org; siltis@uw.edu; beckyj@nezperce.org; greer.maier@ucsrb.org;

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Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Updated Data Repository guidance on RM&E
- Improved rules on when a SOW should be locked or unlocked
- Added more columns to the Excel export of My Contracts grid on the Dashboard page
- Reflected Monitoring Resources vocabulary changes in CBFish
- Converted old photos to documents of type Photo
- Introduced photo tagging functionality
- Improved document upload to support slower Internet connection
- Updated the Help Center with a new look and feel to align with Pisces Web
- During a CCR initialization, if the contract start or end date has changed, the Status Report Milestone Wizard will be automatically invoked
- SOW Validation Guide misses a case where there's no status report milestone covering a new contract start date

Several bugs have been fixed:

- Contract amount in SOW report now includes pending, amended amount
- Grid stretcher overlays vertical scroll bar when all grid columns are shown

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: David Welch

Sent: Wed Jun 03 17:11:56 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: NOAA tech memo

Importance: Normal

Got it—thank you!

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Wednesday, June 03, 2020 3:23 PM
To: David Welch <David.Welch@Kintama.com>
Subject: NOAA tech memo

This is the Zabel Jordan tech memo – I hope this actually goes through due to size.

Christine

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Jun 09 13:07:00 2020

To: Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4; 'David Welch'; Skidmore,John T (BPA) - EWL-4; Lando,Jody B (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - E-4; Creason,Anne M (BPA) - EWL-4; Erin Rechisky; Aswea Porter

Subject: West Coast SARs presentation

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

Let's reschedule David/Aswea/Erin's presentation for June 29th. Please respond if this time will work for you.

(b)(5) [redacted]

We should try to shoot for 60 minutes, but I am scheduling 90 minutes for optional extended discussion.

Will update with Webex later

From: David Welch

Sent: Tue Jun 09 14:56:12 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: West Coast SARs presentation

Importance: Normal

From: Erin Rechisky

Sent: Tue Jun 09 15:29:56 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: West Coast SARs presentation

Importance: Normal

From: Ball,Crystal A (BPA) - EW-4

Sent: Mon Jun 22 16:11:28 2020

Subject: Letter to Sponsors from BPA Fish & Wildlife Executive Manager Crystal Ball

Importance: Normal

Attachments: Ltr to Region on FY21 Budgets sent via Email_06222020.pdf

Dear Project Sponsor:

I am reaching out at this time to communicate about the Fiscal Year 2021 (FY21) budget process. This message comes during an unprecedented pandemic, so let me start with a simple message of hope that you, your employees and colleagues, and families and friends are healthy, safe, and have the resources needed to weather this event.

Bonneville values its partnerships in implementing the Fish and Wildlife Program. Project sponsors help us fulfill our mitigation responsibilities and improve the natural environment. To that end, we want to inform you about our planned direction for FY21 budgets. Bonneville will hold the overall Fish and Wildlife Program budget steady for FY21. We have developed the FY21 start of year budgets for your project(s) and they have recently been uploaded into the contract management system, cbfish.org (aka Pisces Web). Bonneville staff will be reaching out to sponsors and contractors to discuss budgets for projects.

The budget planning process is an important milestone every year because it sets expectations regarding Bonneville funding for projects and contracts that will be developed in the upcoming fiscal year. Given the impacts of COVID-19 on operations, we will continue to be as flexible as possible to help manage the implementation of the Program. During this timeframe, if adjustments need to be made to contracts where work must be deferred to FY21, please work with your Contracting Officer's Representative (COR) and Contracting Officer (CO) to make the necessary adjustments.

As you may have heard by now, Bonneville has initiated some changes to its contracting process through revisions to the Bonneville Purchasing Instructions (BPI) and creation of the Bonneville Financial Assistance Instructions (BFAI). These changes allow the Fish and Wildlife Program to transition from Intergovernmental Contracts (IGCs) to Cooperative Agreements and Grants. These revisions place Bonneville in alignment with other federal, state, and local government entities and copies of both the most recent versions of the BPI and BFAI can be downloaded from Bonneville's website. In the following months, Bonneville's procurement office will be contacting you to provide more details in regards to the transition from the current IGCs to Cooperative Agreements and Grants.

I appreciate the opportunities I've had to meet with many of you and I look forward to connecting with other project sponsors, too. It has been an educational year for me – seeing projects in the field and learning about the history of the Fish and Wildlife Program. Given the challenges of navigating through this pandemic, I want you to know that I am as committed as ever to continuing to build the strong partnerships that support our shared goals.

Sincerely,

Crystal Ball

Executive Manager

Fish and Wildlife Program

(Please note that the text above is a duplicate of the attached letter)

Department of Energy

Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

ENVIRONMENT, FISH AND WILDLIFE

June 22, 2020

In reply refer to: EW-4

Dear Project Sponsor:

I am reaching out at this time to communicate about the Fiscal Year 2021 (FY21) budget process. This message comes during an unprecedented pandemic, so let me start with a simple message of hope that you, your employees and colleagues, and families and friends are healthy, safe, and have the resources needed to weather this event.

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I appreciate the opportunities I've had to meet with many of you and I look forward to connecting with other project sponsors, too. It has been an educational year for me – seeing projects in the field and learning about the history of the Fish and Wildlife Program. Given the challenges of navigating through this pandemic, I want you to know that I am as committed as ever to continuing to build the strong partnerships that support our shared goals.

Sincerely,

CRYSTAL BALL Digitally signed by CRYSTAL BALL Date: 2020.06.22 15:13:11 -07'00'

Crystal Ball
Executive Manager
Fish and Wildlife Program

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed Jun 24 13:47:36 2020

To: Bettin,Scott W (BPA) - EWP-4; Smith,Gregory M (BPA) - EWP-4; 'David Welch'; Skidmore,John T (BPA) - EWL-4; Lando,Jody B (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - E-4; Creason,Anne M (BPA) - EWL-4; Erin Rechisky; Aswea Porter; Jule,Kristen R (BPA) - EWP-4; Scranton,Russell W (BPA) - EWP-4

Cc: Sullivan,Leah S (BPA) - EWP-4

Subject: West Coast SARs presentation

Importance: Normal

Attachments: Submitted Manuscript Proof-Welch et al--Fish & Fisheries (30 March 2020).pdf

Updating with Webex Link.

David, Aswea and Erin will present their revised and submitted West Coast SARs study.

(b)(5) [redacted]

We should try to shoot for 60 minutes, but I am scheduling 90 minutes for optional extended discussion.

Please call in via the Webex conference call number, or have the program call your home number. We find this works better than using a separate conference line.

Monday, June 29, 2020

1:30 pm | (UTC-07:00) Pacific Time (US & Canada) | 2 hrs 30 mins

Join meeting

Join by phone

Tap to call in from a mobile device (attendees only)

[redacted] US Toll

Global call-in numbers

Join from a video system or application

(b)(2) [redacted]

Join using Microsoft Lync or Microsoft Skype for Business

(b)(2) [redacted]

From: David Welch

Sent: Wed Jun 24 18:59:56 2020

To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] RE: Monday

Importance: Normal

Thanks. It sounds like you have things covered. One minor potential hiccup is that WebEx could balk at calling a Canadian (foreign) number, but given that the two countries share one country code (1) I suspect it will be seamless.

If not, will fall back on using the audio and microphone on my computer.

Thanks you!

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Wednesday, June 24, 2020 4:03 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Monday

Hi,

Webex has become substantially easier than a couple of years ago – we used to need to request a link from IT a week ahead of time, and submit which outside users would be involved because there was some security concern that someone could find a way to hack into the government computer network. I typically would ask Russell Scranton to borrow his webex subscription number, that he had because he uses them so often.

The zoom and Google/Microsoft Teams links have the complication of jumping between whoever is talking. Jeff Fryer did use this for his recent presentation on the Bonneville adult facility that he made to 60 people, where they switched controls to someone showing the trap with a video camera.

Anyway, more recently, Webex comes paired with a phone number, and in the first step, it asks the person whether they want to have the program call their phone number (easiest), or you would use the audio and microphone in your computer.

Leah has her name on this webex link, and she got it started at 1:30, even though we will meet at 2. I think it should be straightforward to pass the control to one of you for the powerpoint.

Looking forward to it -

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, June 24, 2020 2:00 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>

Subject: [EXTERNAL] RE: Monday

Thanks, Christine—

I am a bit confused. If I, as presenter, use the WebEx phone number how do I manage the PowerPoint presentation? I had assumed that I would logon using the link (not the phone number) and then share my screen as I step through our points.

Sorry if I am being obtuse here, but its better to be clear rather than trying to sort it out at the time of the presentation!

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Wednesday, June 24, 2020 1:52 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>; David Welch <David.Welch@Kintama.com>
Subject: Monday

Hi,

I hope everything is going well with you, in the start of summer.

Leah and I are going to try to record your presentation on Monday, because Kristen Jule (policy manager) will be out. We have never done this before, but hopefully it is as simple as pressing ‘record’ as an option. [redacted] so I am hoping that she and John Skidmore will either or both be available.

Also, we want to go with the Webex phone number because we find that in cases where we post a regular conference number but someone posts a skype or webex link as a backup, just in case someone wants to show slides, than half the group will call this separate number.

Talk to you soon,

Christine

From: Aswea Porter

Sent: Thu Jun 25 05:25:09 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: Accepted: West Coast SARs presentation

Importance: Normal

From: David Welch

Sent: Mon Jun 29 11:25:50 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] BPA-Kintama Check in (29 June 2020).pptx

Importance: Normal

Attachments: BPA-Kintama Check in (29 June 2020).pptx

Hi Christine-

I am assuming that I will be able to control the PowerPoint presentation from my end, but am sending this copy along to you so that you have a backup.

In the event that I ***cannot*** control the presentation and step through it sequentially from my end, it would be good to confirm that now—I have a lot of animated circles and arrows on several of the screens which are designed to try to keep everyone focused as I step through the presentation. However, if I can't activate those steps with a keystroke from my end it would be a disaster if you had to try to do It to coordinate with my voice, because we would quickly fall out of synch.

Looking forwards to the discussion. There are only 17 slides that I intend to show, but I have two additional slides at the end of the presentation held as backup in case people want to discuss some of the broader issues. The final slide that I plan to end on (#17) is a discussion/review of next steps that Kintama could take for BPA. With your colleagues working flat out on the BiOP amidst the COVID-19 pandemic this spring a discussion of whether further work by Kintama will be supported has slipped quite a bit. If that discussion is inappropriate for your broader audience just let me know and I will remove it from this presentation.

I hope you and your family have been well these past few weeks.

Regards, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: (b)(6) [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

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Comparative SAR Analysis- Study Update

- Revised manuscript resubmitted to F&F 3 June.
- We substantially revised the writing of the Discussion & Conclusions.
- Sent out for re-review.
- Of the 3 initial original reviews, two said paper well written, one said poorly written.
- None had substantial technical criticisms—almost all the comments were on presentation & interpretation

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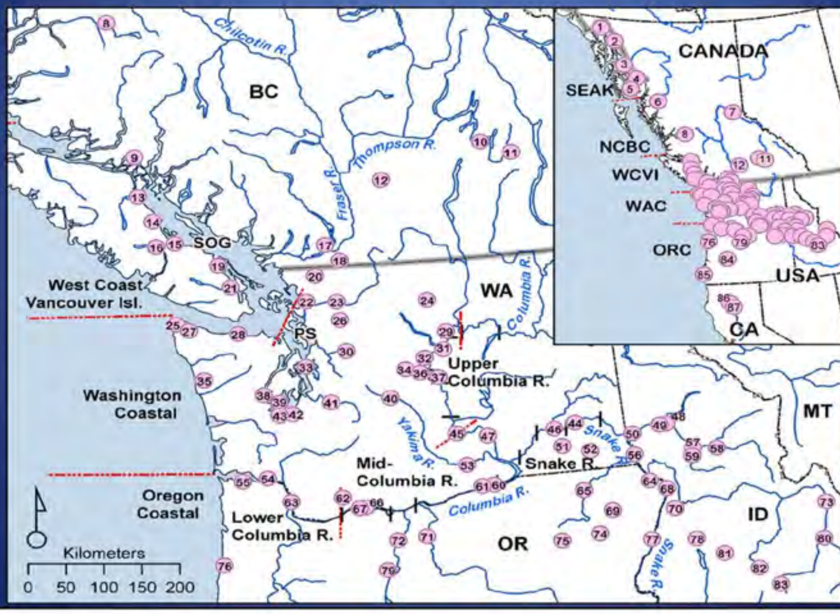
The Study Area



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Differences between Old (PLoS ONE) & New (Fish & Fisheries) Manuscripts

OLD

- Chinook & Steelhead
- Alaska to Oregon
- Combined tagging methods (CWT & PIT)
- Combined H&W
- Conclusions:

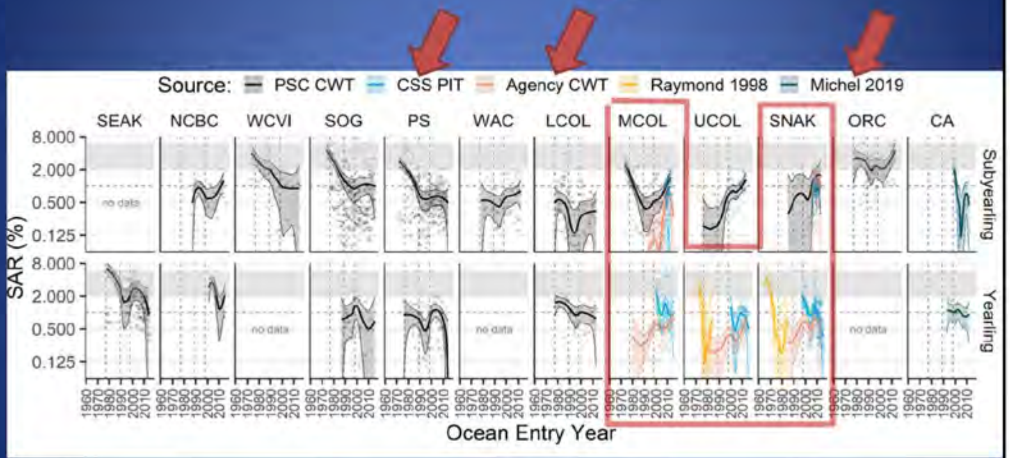
1) SARs have fallen to "about" the same level
2) No delayed mortality

NEW

- Chinook (Only)
- Added California
- Separated tagging methods
- Separated H&W
- Conclusions:

1) Same
2) Same
3) PIT-based SARs deeply flawed

Chinook SAR Data Broken Out by Methodology



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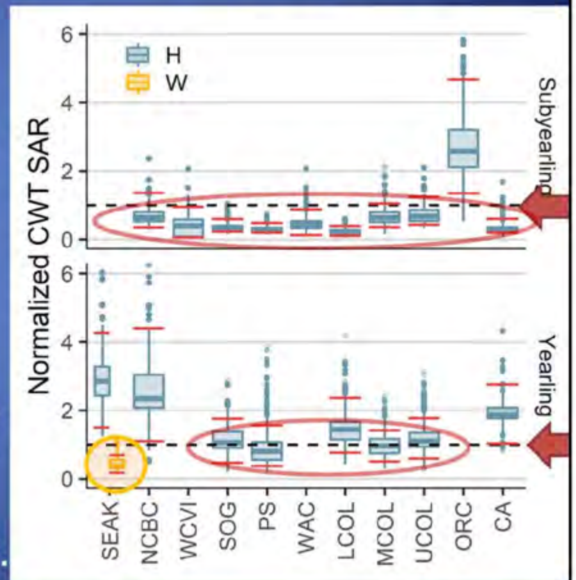
The Bottom Line: SARs 2010-2014

- Used CWT-based SAR estimates ***only***
- Restricted comparison to most recent 5 years
- Used a resampling scheme, normalizing against median Snake River SAR (see MS)
- Most regional SARs are worse (subyearling) or indistinguishable (yearling) from Snake R.



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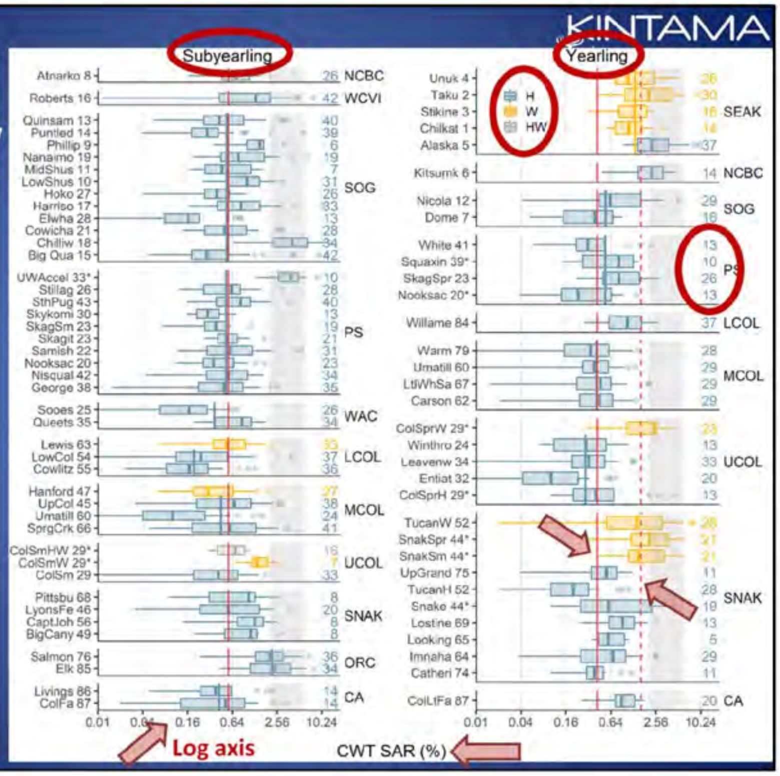
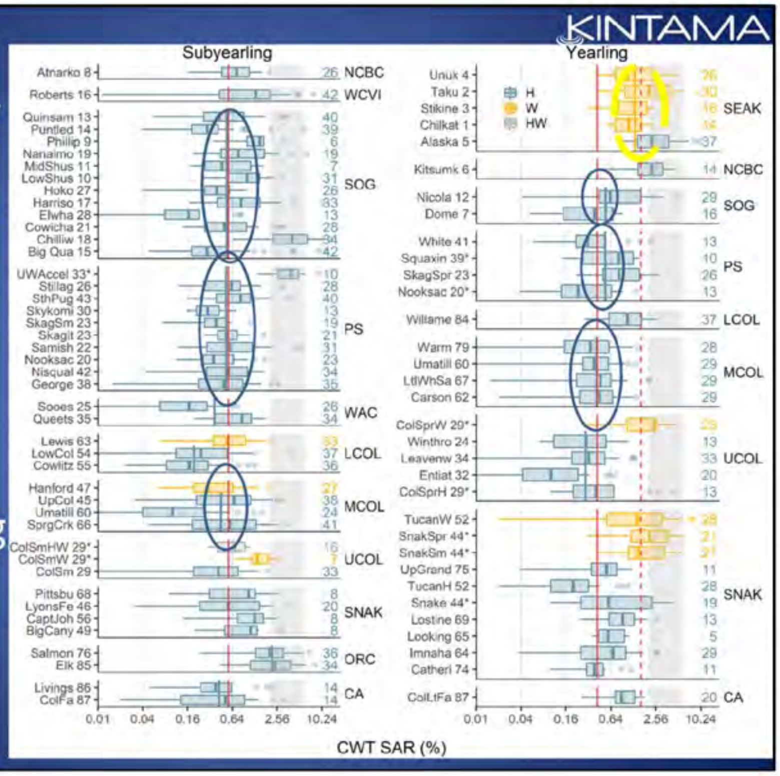
Delayed Mortality -CWTs



Delayed Mortality

- CWT SARs
- All available years
- No DM evident comparing MCOL (or anywhere else!)



Delayed Mortality -PIT Tags

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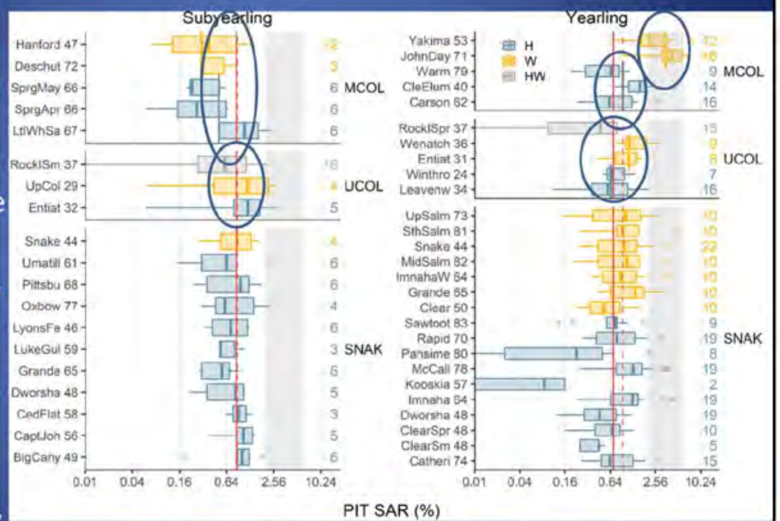
- All available years
- Generally same conclusion– NO DELAYED MORTALITY for most comparisons
- ***Only*** Yakima & John Day wild stocks have higher than expected SARS.



- Claims of delayed mortality underly most conservation arguments for how the FCRPS should be operated. However, only one of multiple possible comparisons actually supports that view—most contradict it.

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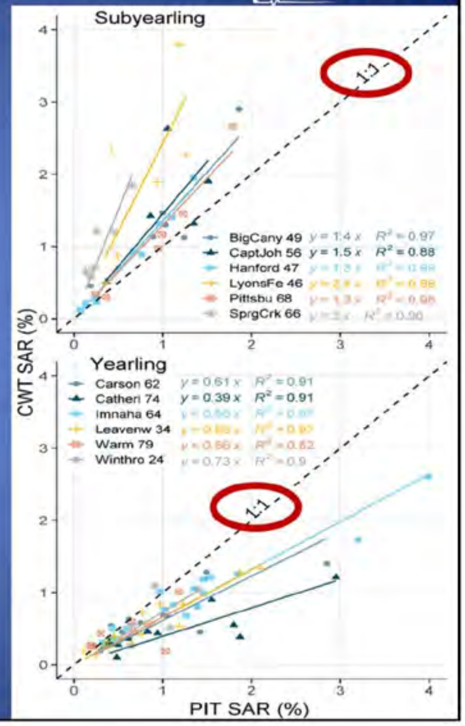
CWT Vs PIT Tag SARs

- Much time spent finding Columbia River basin hatcheries with CWT & PIT data for the same years
- ***Subyearling (Fall) Chinook:*** CWT SAR estimates are consistently ***higher***
- ***Yearling (Spring) Chinook:*** CWT SAR estimates are consistently ***lower***
- Hatchery-specific regression estimates have high R^2
- Regression slopes clearly not transferrable between hatcheries/stocks
- *➔No magic "one size fits all" conversion possible*

- There needs to be a coast-wide workshop designed to set SAR standards and align best practices (we explicitly called for this in paper)
- In correspondence with Dworshak NFH, Aswea encountered a new term we had never heard before: SAS (Smolt to Adult Survivals), as opposed to SARs (Returns).
- To quote verbatim: "**All harvest, including below LGR, is used to calculate SAS (smolt-to-adult survival). Though not presented in this report it will be in future reports".**



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Effect of Excluding Harvest on PIT SARs

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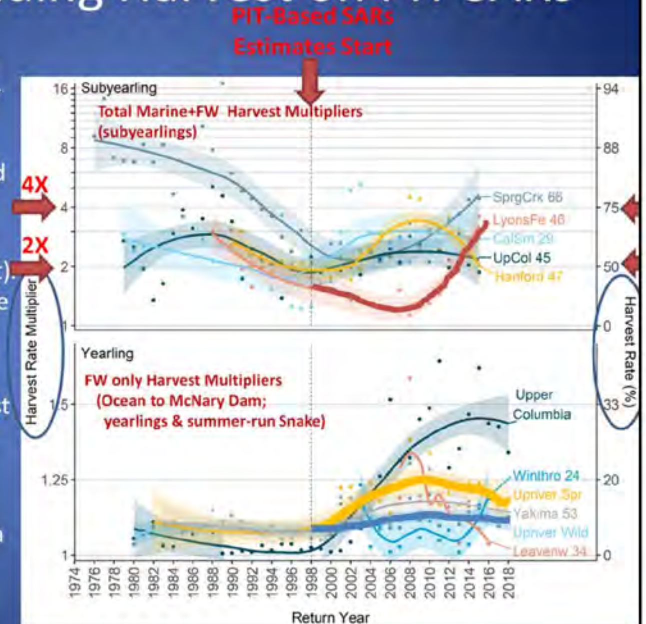
- The influence of fisheries harvest on the return of adult Chinook to the Columbia River is highly variable by year and between stocks!! ☹
- Y-axis shows multiplier needed in a given year to convert PIT tag based SARs to actual survival. (PIT SARs only available from 1998 to present).
- For example, if the harvest rate is 50%, the CSS' SAR must be doubled to account for adults intercepted in fisheries
- The upshot is excluding harvest when calculating PIT Tag SARs seriously distorts survival estimates.
- Different populations have different harvest patterns, so a simple inference of the consequences are unclear.



** data sources are documented in an appendix to the paper*

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The Pacific Salmon Treaty & The FCRPS

- PIT tag SARs came on-line in 1998
- Renegotiated treaty signed in 1999
- Treaty commits managers to abundance-based harvest management for Chinook
  - When abundance is low, harvest rates are reduced
  - When abundance is high, harvest rates are increased
- Because PIT tag SARs measure <u>returns</u>, not <u>survival</u>, they are measuring *<u>escapement from the fisheries</u>*

1) The fisheries get the benefit of improved hydrosystem conditions (increased catch) & Columbia R biologists aren't accounting for it
2) If managers are good at their jobs, escapement will be constant & freshwater improvements to survival will be hidden. Almost all of the Columbia River debate is around the role of the dams on *<u>adult returns</u>*, not smolt #s exiting the river.

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The Current Use of PIT tag SARs

- ***First***, even though people in the Columbia River basin know that catches are ***not*** routinely included in PIT tag SARs, they still think of SARs as measuring survival!

- ***SARs measure escapement from the fisheries-the survivors.***
  - This should be viewed as a major problem
  - Under the terms of the US-Canada Salmon Treaty, SAR improvements achieved at great cost are simply absorbed by fisheries—none of the additional harvest gets credited to hydrosystem changes.

- ***Second***, variation in harvest rates have large impacts on SARs.
  - Statistical analyses (spill, TDG…) using PIT tags are misleading.
  - Annual harvest rate variations of even 10~20% are as big as any expected improvements anticipated from hydropower modifications.
  - Because PIT tag-based SARs are used to calibrate ***all*** Columbia basin model analyses, harvest variability compromises findings.
  - We see no evidence modelers/policy people recognize this.

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For Example: CRSO Ecological Models Independent External Peer Review* (IEPR) Include

- NOAA Fisheries Comprehensive Passage (COMPASS) Model
- NOAA Fisheries Interior Columbia Basin Life-Cycle Models (LCM)
- Fish Passage Center Comparative Survival Study (CSS) Model
- University of Washington (UW) Columbia Basin Research Total Dissolved Gas (TDG) Model

All calibrated using PIT Tags

*Battelle. (2020). *Final Report For The Model Independent External Peer Review Columbia River System Operations (CRSO) Ecological Models. Battelle Memorial Institute, 4 May 2020.*


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Implications
• Battelle (2020):
– "Both sets of models, COMPASS/LCM and CSS, are sensible and credible, and allow for flexibility over a range of inputs that will be helpful for modeling future conditions.".
• But both models are calibrated using PIT tag-based SARs, *which exclude harvest.*
• So both models are similarly distorted
• It will take multiple years to sort out the impact of harvest on Columbia River models.
Ref: Battelle. (2020). *Final Report For The Model Independent External Peer Review Columbia River System Operations (CRSO) Ecological Models.*

Tom Karier's Editorial (Clearing Up-1 May 2020; NW Newsletter-4 May 2020)

- "Competing analyses of spill and dam breaching revolve around a single issue—latent mortality" (p. 5).
- "How, after decades of experimenting with higher levels of spill, do we still not know whether spill harms or helps fish?" (p. 3)

Tom Karier's Editorial (Clearing Up-1 May 2020; NW Newsletter 4 May 2020)

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- Our current paper addresses the latent mortality issues
  - Even the FPC's own broader SAR data ***doesn't support*** their own theory—only the original Yakima/John Day comparison does.
  - ***None*** of the Columbia basin CWT data sets support the belief that Snake River dams cause latent mortality
  - So we get to the same conclusions as our earlier telemetry studies delivered: There is no meaningful latent mortality, so events at sea are not substantively influenced by dam passage ("independent").

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Next Steps?

Complete paper on ocean vs freshwater survival rates. (Key point: Transport/Spill isn't effective because survival rates are similar—you don't change survival, just where the salmon die).

(b)(5) [redacted]

Complete proposal for a large-scale experimental test of TDG effects on survival in the field. Tailor budget to encompass different environments (lower river, plume, coastal ocean, different size smolts →$$$).

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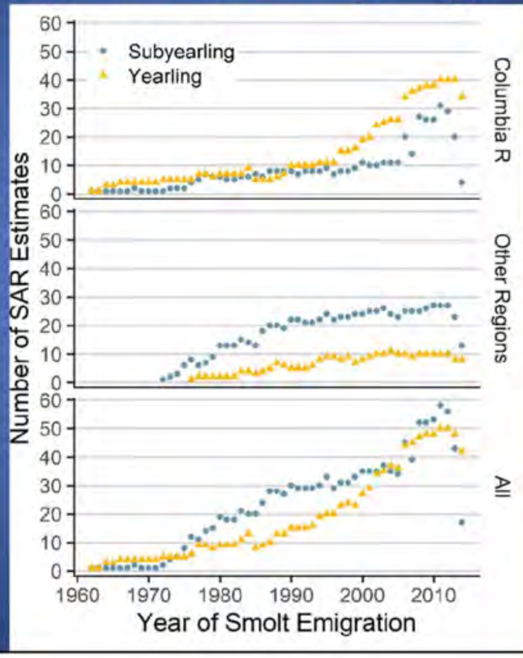
Coast-Wide SARs Sampling Effort



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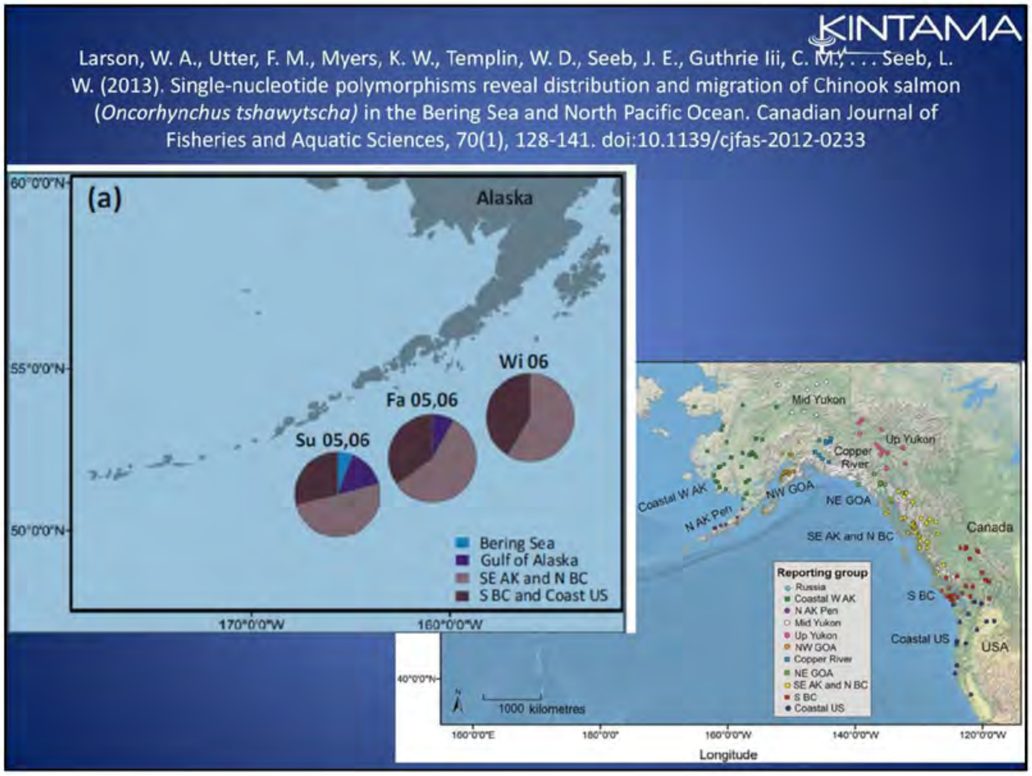
Larson, W. A., Utter, F. M., Myers, K. W., Templin, W. D., Seeb, J. E., Guthrie Iii, C. M., . . . Seeb, L. W. (2013). Single-nucleotide polymorphisms reveal distribution and migration of Chinook salmon (*Oncorhynchus tshawytscha*) in the Bering Sea and North Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences, 70(1), 128-141. doi:10.1139/cjfas-2012-0233



From: Petersen,Christine H (BPA) - EWP-4

Sent: Mon Jun 29 11:52:50 2020

To: 'David Welch'; Erin Rechisky; Aswea Porter

Subject: RE: Afternoon

Importance: Normal

Ben Zelinsky just confirmed too – you talk to him fairly often. Our organizational structure is a little hard to understand because we have the primary fish and wildlife program with various managers who often are most strongly focused on habitat and hatchery projects, but they created Ben's specialist policy position to be a liaison with NOAA and to do some strategic thinking. Those of us on our 'hydro team' such as Scott Bettin, Jason Sweet, Leah Sullivan are often spending half of our time working outside with the Corps and with staff who actually do things at the dams.

I will log in early- I trust it should be easy to pass the cursor control over to you, but Leah might need to enter her password first in order to do that.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, June 29, 2020 11:27 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] RE: Afternoon

All set. I just sent you an email on the presentation 2 minutes after you sent yours.

Let me know when you are going to be active on the WebEx and we can step through a few slides to make sure everything is working prior to the main group logging in at 2 pm.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Monday, June 29, 2020 11:21 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch <David.Welch@Kintama.com>
Subject: Afternoon

Hi,

Are you all set for this afternoon? Leah and I will record it for Kristen Jule (if the technology works).

You should try to finish the presentation in an hour, but I am hoping we could continue the discussion with everyone who is available to stay on the call for as long as we need afterwards.

John Skidmore was on our morning call, and so I hope he will attend has some things to say regarding harvest and our policy emphasis on this.

Christine

From: David Welch

Sent: Mon Jun 29 12:42:49 2020

To: Ben Zelinsky

Subject: [EXTERNAL] A time to catch up?

Importance: Normal

Hi Ben-

Christine emailed to say that you will be joining the presentation—I'm glad to hear it.

My talk will really lay out the evidence for three major differences in how the Columbia River basin currently does its business of salmon restoration. Perhaps the most important of these is really the one that I never even imagined that we would find when we set out on this effort 3+ years ago—the PIT tag system produces massively flawed "survival" estimates for reasons that I will outline. This belated discovery should have happened years before the current BiOP was developed, but if Michelle Dehart hadn't stonewalled my request to get the FPC's SAR data direct from them we probably never would have realized just how flawed their estimates (& NOAA's) really are.

I will leave further discussion for the broader group. However, there are some major potential developments on the Canadian side of the border that I would like to highlight for you, and this isn't really appropriate for today's discussion. However, it might be possible to resurrect the coast-wide telemetry array concept, which could have big implications for BPA.

Tuesday is probably a write-off for me, as is Wednesday 10-12. However, my schedule for the rest of the week is otherwise open. Is there a time that might work for you?

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

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fisheries work on-line: **http://kintama.com/media/videos/**

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From: Petersen,Christine H (BPA) - EWP-4

Sent: Mon Jun 29 13:21:19 2020

To: 'David Welch'

Subject: RE: Afternoon

Importance: Normal

Leah said she will open the Webex at 1:45.

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, June 29, 2020 11:27 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] RE: Afternoon

All set. I just sent you an email on the presentation 2 minutes after you sent yours.

Let me know when you are going to be active on the WebEx and we can step through a few slides to make sure everything is working prior to the main group logging in at 2 pm.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Monday, June 29, 2020 11:21 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch <David.Welch@Kintama.com>
Subject: Afternoon

Hi,

Are you all set for this afternoon? Leah and I will record it for Kristen Jule (if the technology works).

You should try to finish the presentation in an hour, but I am hoping we could continue the discussion with everyone who is available to stay on the call for as long as we need afterwards.

John Skidmore was on our morning call, and so I hope he will attend has some things to say regarding harvest and our policy emphasis on this.

Christine

From: Petersen,Christine H (BPA) - EWP-4
Sent: Mon Jun 29 13:54:02 2020
To: 'David Welch'
Importance: Normal

Hi David – I think with these Webexes, you have to both unmute yourself on your phone, and via the little icon on the computer.

I can see you.
Lcah should bc hcrc soon

From: Greene,Jacqueline R (CONTR) - EW-4

Sent: Thu Jul 02 15:07:21 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- View Milestone Changes to WSEs on the SOW Review page
- CR SOW initialization: Display helpful text while the Save button is disabled
- Improve document upload form to retain field values when switching file type or on validation error
- New SOW validation rule to 'require' a new Line Item Budget document for a CCR

- Display project unallocated expense budgets in Portfolio WorkingBudgets view
- Extend photo tagging to Portfolio photos
- Update Progress Reports - Draft (30 to 180 days old)
- Remove auto-populated milestone dates for BPA-internal WE-5
- Move all help related options from "Explore" to the Help menu
- Add Help Center to Help menu

Important bug fixes include:

- Portfolios: People view returns too much data
- SOW report does not fully report RM&E information
- WE Name and Title are not displayed in WE location pop-up
- Pisces does not consider using the Project EC Lead when sending Workflow emails

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: David Welch

Sent: Tue Jul 07 09:48:21 2020

To: Petersen,Christine H (BPA) - EWP-4; Aswea Porter; Erin Rechisky

Subject: [EXTERNAL] RE: final draft

Importance: Normal

Attachments: Submitted F&F Manuscript (3 June 2020).pdf

Hi Christine—

No problem. Here is the revised manuscript that was sent out for further review.

It would be good to have a call at some point where we could discuss BPA's interest in still funding the other work that we had proposed.

Best, David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, July 07, 2020 9:39 AM
To: Aswea Porter <Aswea.Porter@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch

<David.Welch@Kintama.com>
Subject: final draft

Hi,

Thank you so much for your presentation last week. Kristen Jule and others have the recording to view.

Ben Zelinsky asked if it was okay to send the latest draft to partners at the Corps (labeled that it isn't to be circulated further). Would this be okay with you, and do you have a version with any minor edits based on your interaction with the journal? (I distributed the copy internally that you sent a few months ago).

I hope everything is going well with all of you

Christine

FISH and FISHERIES

Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)

Journal:	*Fish and Fisheries*
Manuscript ID	Draft
Wiley - Manuscript type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Welch, David; Kintama Research Services Ltd, Porter, Aswea; Kintama Research Services Ltd Rechisky, Erin; Kintama Research Services Ltd
Key terms:	dams, delayed mortality, smolt-to-adult return, Snake River, productivity, survival
Abstract:	(b)(5) [redacted]

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From: David Welch

Sent: Sun Jul 19 10:42:12 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Kintama next steps...

Importance: Normal

Hi Christine-

I wonder if we could set up a call (Zoom?) to discuss likely next steps on the "habitat" survival rate analysis and timing? (No word as yet on the status of the second review).

I am tied up from 4 pm on Tuesday and all day Thursday (b)(6) [redacted] J). Otherwise, my calendar is pretty well wide open.

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: [redacted]

Skype: david.welch_29

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

P Please consider the environment before printing this e-mail

From: Pisces

Sent: Thu Jul 30 12:34:04 2020

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- CCR Transmittal Memo form: Beside Communication, Email documents are also listed for selection
- Capture changes to contract basics to support CCR SOW review
- Support copying dates of template milestones if the milestone definition has not changed between source and destination SOWs
- Support editing a photo's latitude and longitude

- Stop creating “Deliverable marked complete” notification by default

Important bug fixes include:

- When adding a new document, cannot associate it to a new WE of a pending CCR
- Cannot add a Line Item Budget when using IE

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Pisces

Sent: Fri Jul 31 10:54:15 2020

To: Pisces

Subject: New Pisces Web Training Modules

Importance: Normal

Good Morning Pisces Users,

We have added some new content for users who need or would like some basic training in various aspects of Pisces Web.

The uploaded training modules include:

Module 1. Navigation Basics

Module 2. Building the Statement of Work

Module 3. Review SOW and Workflow

Module 4. Status Reports

Module 5. Notifications and Reminders

Module 6. Search Tools

Module 7. Contract Change Requisitions (CCR)

Module 8. Projects

Module 9. Portfolios (*coming, end of August*)

Module 10. Cost Share (*coming, end of August*)

Module 11. Photos (*coming, end of August*)

How to get there:

From any website page in cbfish.org, click on the **Help▼**link, top right, and choose **Help Center**. On the left menu, under Contents, click on **Pisces Web Training**, at the bottom, to expand, then click on ***Pisces Web Training 101***.

The Training list appears in the middle with links for Modules 1-8. Modules 9-11 will be added as a part of the late August Release.

If you have any questions or suggestions for additional materials, please let us know by emailing pisces@bpa.gov.

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Aug 04 17:29:24 2020

To: 'David Welch'

Subject: RE: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

Importance: Normal

Hi David,

Sorry for the slow response(b)(6) [redacted]. The group was very pleased with the presentation on your in press paper, and we still are preparing to brief upper management.

(b)(5) [redacted]

You can see some of the response in press and social media to the Biological Opinions and EIS officially released on July 31. (b)(5) (b)(5) [redacted] https://www.nrdc.org/experts/giulia-cs-good-stefani/our-rivers-increasingly-too-dam-hot-salmon

Christine Petersen

From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, July 21, 2020 10:05 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] RE: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

Thanks, Christine.

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, July 21, 2020 9:49 AM
To: David Welch <David.Welch@Kintama.com>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

This is great news. We are very glad it is being published. It looks like they selected some reviewers from different geographic locations who put some thought into this.

Your presentation a couple weeks ago was very positively received. We held a follow up discussion and Kristen Jule, Ben Zelinsky, Jody Lando will be briefing some of our higher level management at Bonneville about the content and some of the implications of your paper. That it is as good as accepted is very good as far as being able to promote and distribute the study potentially outside of the agency or to media.

Congratulations,

Christine P.

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, July 20, 2020 9:56 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] FW: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

Hi Christine--

Good news on our manuscript. We still have some additional minor work done based on the two new reviewers' comments below, but the paper is essentially guaranteed to be accepted for publication once we do so. (As always, I suppose that there could be surprises, but at this point I really don't think so).

Below are all of the comments on the manuscript. I have only deleted the log-in information that I need to submit the revision.

We will get started on the revision. I have read through the comments and don't see any big issues to address. Reviewer #3 is clearly very knowledgeable about the PST and Alaskan fisheries and a few minor tweaks will be required. Otherwise, I don't see any dealbreakers.

(b)(5)
[redacted]

David

P.S. Nice to see the comments from two of the reviewers about how much work we did to put the paper together… I doubt anyone really can grasp just how much effort went into both the collation and the analysis phases!

-----Original Message-----
From: Paul Hart <onbehalfof@manuscriptcentral.com>
Sent: Monday, July 20, 2020 2:35 AM
To: David Welch <David.Welch@Kintama.com>
Subject: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

20-Jul-2020

Dear Dr. Welch

Manuscript ID FaF-20-Jun-OA-162 entitled "Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)" which you submitted to Fish and Fisheries, has been reviewed. The comments of the reviewers are included at the bottom of this letter.

The reviewers have recommended some minor revisions to your manuscript. Therefore, I invite you to respond to the reviewers' comments and revise your manuscript.

You will be unable to make your revisions on the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer.

Once the revised manuscript is prepared, you can upload it and submit it through your Author Center. Please include a letter in the space provided to let me know how you have responded to each of the comments made by the reviewers; please be as specific as possible.

There are two ways to submit your revised manuscript. You may use the link below to submit your revision online with no need to enter log in details:

*** PLEASE NOTE: This is a two-step process. After clicking on the link, you will be directed to a webpage to confirm. ***

[DW>] ***DELETED***

Alternatively log into https://mc.manuscriptcentral.com/faf and enter your Author Center. You can use the revision link or you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision. Please DO NOT upload your revised manuscripts as a new submission.

IMPORTANT:

• Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

• Please remember to edit the 'Manuscript Data – Metadata' under 'Manuscript Information' to accurately reflect the number of words, pages etc. in your revision.

Because we are trying to facilitate timely publication of manuscripts submitted to Fish and Fisheries, your revised manuscript should be uploaded as soon as possible. If you feel that you will be unable to submit your revision within two months please contact me to discuss the possibility of extending the revision time.

Once again, thank you for submitting your manuscript to Fish and Fisheries and I look forward to receiving your revision.

Sincerely

Paul Hart

Editor, Fish and Fisheries (2016 IF 9.0, 2017 IF 7.0, 2018 IF 6.7) pbh@le.ac.uk

Editor Comments to Author:

The first reviewer also saw your original submission. The other two are new and have a fresh take on your paper but both agree that minor revisions are appropriate.

The second reviewer makes a very important point relating to the geographical scope of the paper. As it states in our Aims and Objectives "A paper in Fish and Fisheries must draw upon all key elements of the existing literature on a topic, normally have a broad geographic and/or taxonomic scope, and provide points of generic value, which make it compelling to a wide range of readers whatever their geographical location". To fulfil this objective it would be valuable if you could makes some comment about the SAR status in other parts of the chinook's distribution. Has any work in Japan been done on this? I don't expect a comprehensive survey of what's happening on the western side of the Pacific but it would be useful to readers who are not salmon specialists to be able to put your results into a wider context.

Please also pay attention to the Instructions to Authors which gives details as to how the manuscript is laid out. At present it does not follow the instructions. If the paper is accepted you will have to make the necessary changes anyway so you might as well do it now.

Reviewers' Comments to Author:

Reviewer: 1

Comments to the Author

I've carefully reviewed the re-submitted manuscript and response letter. The paper has really improved structurally in my opinion and I appreciate the authors willingness to incorporate numerous recommendations brought up during the first round of review. I also appreciated their thorough and detailed responses to my original comments. Between the substantive revisions that I see and thorough response letter, I have no additional concerns and satisfied with the paper as is.

Reviewer: 2

Comments to the Author

Within the world of “salmonology”, this paper will have considerable impact. Its key finding – that there have been fairly consistent region-wide reductions in ocean survival of Chinook salmon – has important policy implications as people consider where to invest in recovery. The authors specifically take aim at attempts to improve freshwater spawning and production, arguing that this may be fruitless if the major cause of declines is reduced ocean survival, including in areas where habitat remains relatively pristine. It is very valuable to have all of the data from such disparate sources assembled in one place. I give credit to the authors for the enormous amount of work that was required to assemble the data and analyze them, while dealing with numerous limitations of the methods that generate survival.

A key issue for this journal is whether this paper will be sufficiently understandable and interesting to a wide audience. It spends a lot of time in the weeds with the details of analyses, specifics of populations, etc. It has to do this, because these details really matter (and it would be good to ensure that the paper is reviewed by people with more experience than I have at analyses of datasets like this, to ensure that issues of comparability of data among sources and across time is adequate to support the authors’ conclusions). But the editor should read the paper with an eye as to whether it aims broadly enough with its Intro, Discussion, and Conclusions to serve Fish and Fisheries’ objectives.

Line 126. “If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon.” This seems logical, but I don’t think most people involved in stream restoration are aiming for a “newly productive environment”. They are aiming to increase the number of smolts that migrate to the sea, in the hopes that this will lead to stronger adult returns. If ocean survival is cut in half, then if twice as many smolts leave, that MIGHT mitigate the reduced ocean survival, though this depends crucially on the fitness of the smolts when they leave (e.g. reduced survival from hatcheries) and on negative density dependence, which could be severe if the ocean's carrying capacity is lower. All of this is just to say that the wording should be chosen carefully, in terms of objectives and caveats.

Line 142. "Although not explicitly stated, this seems to be the basis for setting the 2-6% rebuilding standard for the Columbia River." It's interesting that it's not obvious where this target came from, and the explanation doesn't mention 2%. It would be good if the authors could pin down the derivation of the targets, perhaps by contacting the authors of the report.

Line 146. "The SAR is the three-fold product of freshwater smolt survival during downstream migration multiplied by the marine survival experienced over two to three years in the ocean, and multiplied by adult freshwater survival during the upstream migration to the final census point." It would be good to state explicitly how fishing mortality fits in here. When I think of "returns" I usually take this to mean not including fishing mortality, i.e. returns are the num number of fish that return to the coast, and then may or may not be caught. This seems to be the correct interpretation based on Line 244, but readers shouldn't have to wait that long to find out.

Line 179. "Attempts to improve SARs by addressing region-specific issues such as freshwater habitat degradation or salmon aquaculture in coastal zones are therefore unlikely to be successful." Don't you mean "hatcheries", not "aquaculture"? Aquaculture is fish farming; no intentional releases and nothing to do with attempts to improve fish survival. And again, smolt-to-adult returns may not be improved by addressing habitat degradation, but the total number of smolts that leave may be improved.

Line 220. Typo. "is to note that that after log-transformation the mean…"

Line 221. Something missing here "We therefore use the simpler terminology both for clarity and because. Furthermore, the median is invariant under log-transformation, which is not true for the mean. Pacific Salmon Commission (CWT)".

Line 274. "should include hatchery rack returns," What is a hatchery rack return?

Fig. 2 is difficult to read. Consider splitting it in half and present 2 panels one below the other. There is no logical reason to run them all out in a single horizontal row. The caption says "Annual SAR estimates for Hatchery (H), Wild (W), and mixed hatchery-wild data sources (B) are shown…". I don't see those symbols / distinctions among data sources in this figure.

Fig. 3. At first I missed the legend to distinguish whether populations are wild, hatchery or mixture. Why do some population names include additional symbols for these distinctions, but others not?

Reviewer: 3

Comments to the Author

Title: Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)

Authors: DW Welch, AD Porter, EL Rechisky Manuscript ID: FaF-20-Jun-OA-162

Summary: In this manuscript the authors present an analysis and review of patterns and trends in the survival of Chinook salmon stocks from southeastern Alaska to California. To accomplish this, they collected the historical smolt and return data for 123 stocks that are tagged as juveniles or smolt using either coded-wire (CWT) or passive integrated transponder tags (PIT). Survival was estimated as the smolt-to-adult return (SAR) rate, where return included both harvest and escapement information. While there is are comprehensive programs to sample harvest for CWT across this stretch of coast, no such program exists for PIT leading to SAR estimates that are concordant but biased compared with CWT-based estimates. The authors find that survivals have generally declined across stocks and almost all are below the rebuilding targets (2-6%) set for Columbia River stocks. Based on the observation that declines are consistent across a geographical scale where freshwater habitats range from highly compromised to almost pristine, the authors propose that the main causes are to be found in the marine environment.

Assessment: This manuscript will be interesting to a variety of audiences and will contribute to the ongoing conversation around the current demographic patterns and trends in this species in specific and all Pacific salmon species in general. The concept that one or more critical periods exist in the marine portion of the Chinook salmon life history has been discussed for decades, but the collation of data and presentation of a widespread pattern across this species adds to the discussion. Likewise, the discussion and demonstration that there are significant differences in data depending on the technology and design of application. Sometimes a great technology can't make up for lack of information. I appreciate the time and attention paid to the style and grammar used, which helped with reading and comprehension.

Recommendation: Publish with minor edits

Comments:

1. Line 130 – This is the first use of SAR and a definition is not supplied until Line 145

2. Line 170 – From the text (e.g. Line 734) the changes referred to at this point happened two decades ago, in 1999. The treaty has been renegotiated twice in that period. This needs clarification.

3. Line 182 – Why is the call to funding agencies and not management agencies or trans-jurisdictional management organizations?

4. Line 221 – The end of this sentence is missing.

5. Line 225 – “coastwide” is not and appropriate descriptor. The Treaty only covers fisheries from Cape Suckling, Alaska to Cape Falcon, Oregon.

6. Line 312 – This statemen is true, but could be better worded since the point being made concerns the measurement of the “return”, a term that is hidden in the acronym, SAR. The finer point here may not be clear to a reader that is not familiar with salmon management. See Line 635.

7. Line 341 – “essentially immune” may be too strong as there can be fishery removals at remote marine locations in the Gulf of Alaska and southern Bering Sea and many yearling stocks are subject to a period of harvest in nearshore fisheries.

8. Lines 350 to 354 – Limiting the years to 2010-2014 is explained, but the rationale is not clear. Not including through 2008 because it was unusually cold while not acknowledging the unusual warmth that these boodyears experienced in the marine environment during 2014 and 2015 seems inconsistent.

9. Line 360 – It would help to incorporate the description of this analysis in Lines 444-446 into the description here. The inclusion of SAR_SNAK,j in the equation was confusing until I was reminded that every region was normalized to the Snake River.

10. Line 551 ff – Consider including Howard et al. 2016 and/or Murphy et al. 2017 to the lists for growth and

ocean conditions to extend the range of observations

11. Line 558 – Consider including Seitz et al., 2019 for marine predation

12. Line 607 – This statement is backwards according to the equation at Line 235

13. The style and format of the intext citations varies widely and was actually quite distracting. For example in the paragraph beginning at Line 551.

14. Citation at line 1135 is missing information and difficult to locate. Suggest adding the following information: "Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative retrieved from http://www.aykssi.org/aykssi-chinook-salmon-research-action-plan-2013/"

15. Figure 2 was too small to be informative.

Suggested Citations:

Howard, K. G., Murphy, J. M., Wilson, L. I., Moss, J. H., & Farley Jr, E. V. (2016). Size-selective mortality of Chinook salmon in relation to body energy after the first summer in nearshore marine habitats. N Pac Anad Fish Comm Bull, 6, 1-11.

Murphy, J. M., Howard, K. G., Gann, J. C., Cieciel, K. C., Templin, W. D., & Guthrie III, C. M. (2017). Juvenile Chinook salmon abundance in the northern Bering Sea: Implications for future returns and fisheries in the Yukon River. Deep Sea Research Part II: Topical Studies in Oceanography, 135, 156-167.

Seitz, A. C., Courtney, M. B., Evans, M. D., & Manishin, K. (2019). Pop-up satellite archival tags reveal evidence of intense predation on large immature Chinook salmon (Oncorhynchus tshawytscha) in the North Pacific Ocean.

Canadian Journal of Fisheries and Aquatic Sciences, 76(9), 1608-1615.

Reviewer: 1

Reviewer Identity:

Reviewer: 2

Reviewer Identity:

Reviewer: 3

Reviewer Identity:

From: David Welch

Sent: Fri Aug 21 11:05:43 2020

To: Ben Zelinsky

Subject: [EXTERNAL] A potential Opportunity to expand West Coast telemetry arrays....

Importance: Normal

Hi Ben-

I wonder if we could have a catch up call? Communications with Christine and colleagues seems to have fallen way off, presumably because of exhaustion from getting the EIS published and trying to fit in summer holidays.

A possible opportunity has come up that might address some issues that Scott Armentrout's predecessor, Bryan Mercier, had said to me in a conversation 3(?) years ago.

(b)(5) [redacted]

I know that the timing is poor from BPA's perspective with Elliot Mainzer just announcing he is stepping down, but I think it would be worth outlining the opportunity from BPA (& the region's) perspective.

Just about anytime works for me other than today. [redacted]

Hope you are well,

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: +[redacted]

Home Tel: [redacted] (For the duration of the pandemic!)

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fisheries work on-line: http://kintama.com/media/videos/

Please consider the environment before printing this e-mail

From: Pisces

Sent: Thu Aug 27 12:56:38 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- RM&E WSE SOW Report: Add additional columns
- Make BiOp Implementation Plan report available again
- Widget: Contract List by Project
- Support editing a photo's latitude and longitude

Important bug fixes include:

- Contracts grid: Continuations column may display duplicate contracts

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Thu Aug 27 14:59:08 2020

To: 'David Welch'

Subject: RE: Fraser sockeye returns

Importance: Normal

Hi David,

I was able to speak with Jody Lando. I suppose our answer might sound similar to what we were saying before. Basically, we highly value your work, but are not in a position to pursue additional work at this time. I am not sure what to say regarding a future schedule of potentially initiating (or reinitiating) new technical services work. Our regional process relating to monitoring outcomes under the new 'flexible spill' rules, and tracking progress towards recovery under the Endangered species act will be ongoing and I think you are pretty [redacted] (b)(5) But I do not know when BPA will be able to start new things. Your current publication will be very valuable to distribute and share amongst regional parties.

Christine

-----Original Message-----
From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, August 26, 2020 12:07 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Fraser sockeye returns

I strongly suspect that the marine mammal issue is a big one all along the coast-- seals & sea lion populations are now 5X what they were in earlier decades. I also have a hunch that although some seals eat smolts on their way out to sea, the much bigger impact may be on the returning adults. I think the case for that is when we look at the return timing of the adult runs-- it is all over the map, starting with the Spring runs of Chinook (& a very few chum runs) to the late fall.

From an evolutionary perspective, giving up that last summer of growth shouldn't happen unless there are strong counteracting forces to staying out at sea until it is time to migrate upriver--body size would increase by about 50%, so that is giving up a 50% increase in egg numbers for females and the ability of males to fight & compete much more capably for females. So I suspect that there is much stronger and more directed predation at sea shaping these behavioural decisions than we currently perceive.

On a different note, I wonder if you could update me on whether BPA is interested in pursuing the other work that we had discussed (and some started) several years ago. I am sure it is challenging to get people together due to the EIS just wrapping up, summer holidays, and COVID challenges, but it would be helpful to get an idea as to whether BPA still has an interest and a budget to support that work.

David

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, August 25, 2020 2:03 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Fraser sockeye returns

Hi David,

That is interesting. The upper Columbia sockeye are having an average year as far as abundance (although I don't know if they could get a SAR yet - it would probably be either Jeff Fryer or the Okanagan Nation to do it). That is notable because the Fraser isn't doing so well, and the spring Chinook were doing poorly. It was also interesting that the upper Columbia summer run was doing fairly well - which is a subyearling run. Fall run are doing well in the first week. You could imagine that subyearlings are doing well either due to ocean conditions this past year (or being able to avoid the really high spill) but those sockeye go out earlier than the other yearlings two years ago. It could be that this run is just doing really well after they straightened out the habitat - so maybe there are a ton of juveniles in Wenatchee and Osoyoos.

Have you heard that NOAA has announced they will permit culling of about 800 sea lions per year? I don't know if it is very widely known yet - there hasn't been as much protest as several years ago when they did just a few. The tribes were really speaking up for this. The data from the Science Center really supports it as a limiting factor for the early spring run.

We should mostly be all back (but not in the office) in September. I'm going to talk to Jody Lando tomorrow.

Christine

-----Original Message-----
From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, August 18, 2020 9:49 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Fraser sockeye returns

Interesting report on just how dire the issues are for Fraser River sockeye.

David

https://thenarwhal.ca/low-fraser-river-sockeye-salmon-bc/

David Welch
M: (b)(6) [redacted]
Kintama Research Services
Sent from my iPhone

From: David Welch

Sent: Tue Sep 01 20:28:00 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Clearing Up, Issue 1968

Importance: Normal

Thanks!

(b)(5) [redacted]

There is now a rich and recent literature in the biomedical literature on just these issues—there has been a belated recognition that there is far too much interpretation of outcomes as opposed to analysis based on well-posed and high statistical power studies. I think that the Columbia River basin salmon issues suffer from this exact same selective bias.

I wonder if we could schedule a call to talk about your thoughts on what might develop next?—I am of two
(b)(5) [redacted]

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, September 01, 2020 12:11 PM
To: David Welch <David.Welch@Kintama.com>
Subject: Clearing Up, Issue 1968

Take a look at the River Partners proposal here, in the pdf version of Clearing Up. I wonder how they could achieve consensus on how to carry out an experiment. The current 'experiment' is a 10 year+ approach of doing higher spill and then debating what SAR and in-river survival we see.

I have been contemplating this graph this morning. I don't think this matches what we see with SARs for any ESU from the 60s or 70s until present. The PITPH calculation had us at 5-6 dams/8 back in the 1990s, but we are at 1-2 recently? Have SARs tripled?

https://www.fpc.org/documents/memos/30-20.pdf

Subject: [EXTERNAL] Clearing Up, Issue 1968

You can access this week's issue of Clearing Up on the Web or as a PDF...or both!

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https://www.newsdata.com/clearing_up/

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The Clearing Up website also features archives of past issues and links to other NewsData news and information services.

For the PDF version, click this link for this week's issue of Clearing Up:

https://grok.newsdata.com/cgi-bin/viewpdf.cgi?iss=cup1968&cid=IFJrjXxjxeiQ

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From: David Welch

Sent: Tue Sep 01 20:30:34 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Clearing Up, Issue 1968

Importance: Normal

Sorry—I hit send too quickly!

I wanted to add that I read the FPC document you sent the link to, but I am having some trouble interpreting what is intended by the graph below. Fill me in when you call please, and then I will provide a few comments.

d

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: Tuesday, September 01, 2020 12:11 PM
To: David Welch <David.Welch@Kintama.com>
Subject: Clearing Up, Issue 1968

Take a look at the River Partners proposal here, in the pdf version of Clearing Up. I wonder how they could achieve consensus on how to carry out an experiment. The current 'experiment' is a 10 year+ approach of doing higher spill and then debating what SAR and in-river survival we see.

I have been contemplating this graph this morning. I don't think this matches what we see with SARs for any ESU from the 60s or 70s until present. The PITPH calculation had us at 5-6 dams/8 back in the 1990s, but we are at 1-2 recently? Have SARs tripled?

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http://www.EnergyJobsPortal.com

From: David Welch

Sent: Wed Sep 02 11:03:20 2020

To: Christine Petersen

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] Fraser sockeye fishery could be shut down for years - Resources & Agriculture | Business in Vancouver

Importance: Normal

Fyi.. No dams and no salmon (including no Chinook or steelhead).

This is very sad, and we have seen this coming for decades.

David

https://biv.com/article/2020/09/fraser-sockeye-fishery-could-be-shut-down-years

David Welch, Kintama Research
Tel: (b)(6) [redacted]

From: BPA Mailings

Sent: Thu Sep 03 11:57:03 2020

Subject: Draft Environmental Assessment available for the proposed Columbia River Basin Tributary Habitat Restoration Environmental Assessment

Importance: Normal

Bonneville Power Administration is requesting comments on the draft Environmental Assessment for the **Columbia River Basin Tributary Habitat Restoration Environmental Assessment.**

To view the document, see when public meetings are scheduled, and find instructions on how and when to comment, please visit the project website at: *http://www.bpa.gov/goto/TribProgrammatic.*

Thank you for your interest.

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Tue Sep 08 11:57:03 2020

To: David Welch

Subject: [EXTERNAL] RE: [EXTERNAL] A potential Opportunity to expand West Coast telemetry arrays....

Importance: Normal

Yes - this is the most national news we have had in awhile - seems to be if greater interest nationally and internationally than locally frankly.

How about Mon at 10?

Glad you are using your old man "strength" to good effect :) It is a go to move of mine too.

Ben

Sent from Workspace ONE Boxer

On Sep 8, 2020 11:18 AM, David Welch <David.Welch@Kintama.com> wrote:

Good to hear all is well with you guys too… I know the out-of-control rioting in “Democrat controlled” Portland is unlikely to affect you & the others I know at BPA, but it is still sobering when it populations up in the news.

Anytime next week is wide open, apart from 4-5 pm on Tuesday, so suggest something that will work for you and I am sure I can accommodate.

David

P.S. [redacted]

From: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Sent: Tuesday, September 08, 2020 10:43 AM
To: David Welch <David.Welch@Kintama.com>
Subject: [EXTERNAL] A potential Opportunity to expand West Coast telemetry arrays....

Hello David

My apologies for the slow response and [redacted]

Glad to hear you are well. We are doing just fine too although the wind has knocked out our power for the day. One upside being I'm limited to working on my phone and catching up on email.

Let's find a time to catch up - I'd like to hear your thoughts. This week is a little crazy wrapping up the EIS Record of Decision but next week could work.

Any times better than others?

Ben

Sent from Workspace ONE Boxer

On Aug 21, 2020 11:05 AM, David Welch <David.Welch@Kintama.com> wrote:

Hi Ben-

I wonder if we could have a catch up call? Communications with Christine and colleagues seems to have fallen way off, presumably because of exhaustion from getting the EIS published and trying to fit in summer holidays.

A possible opportunity has come up that might address some issues that Scott Armentrout's predecessor, Bryan Mercier, had said to me in a conversation 3(?) years ago.

[redacted]

I know that the timing is poor from BPA's perspective with Elliot Mainzer just announcing he is stepping down, but I think it would be worth outlining the opportunity from BPA (& the region's) perspective.

Just about anytime works for me other than today. [redacted]

Hope you are well,

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

755 Terminal Ave N, Nanaimo BC V9S 4K1 Canada

Office Mobile: +[redacted]

Home Tel: [redacted] (For the duration of the pandemic!)

david.welch@kintama.com

www.kintama.com

Browse animations of our

fisheries work on-line: http://kintama.com/media/videos/

Please consider the environment before printing this e-mail

From: David Welch

Sent: Tue Sep 08 12:35:50 2020

To: Renner,Marcella P (BPA) - E-4

Subject: [EXTERNAL] Catch up on "the paper" (& life)

Importance: Normal

From: David Welch

Sent: Tue Sep 08 12:35:50 2020

To: Ben Zelinsky

Subject: Catch up on "the paper" (& life)

Importance: Normal

From: Zelinsky,Benjamin D (BPA) - E-4
Sent: Tue Sep 08 13:02:27 2020
To: David.Welch@Kintama.com
Subject: Accepted: [EXTERNAL] Catch up on "the paper" (& life)
Importance: Normal

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Wed Sep 09 05:39:26 2020

To: 'David Welch'

Subject: Accepted: [EXTERNAL] Catch up on "the paper" (& life)

Importance: Normal

From: David Welch

Sent: Wed Sep 09 10:28:32 2020

To: Lando,Jody B (BPA) - EWP-4

Subject: [EXTERNAL] RE: publication date

Importance: Normal

(b)(6) [redacted]

I hope you & your colleagues are doing well? Are you still strictly working virtually or are you back in the office?

From: Lando,Jody B (BPA) - EWP-4 <jblando@bpa.gov>
Sent: Wednesday, September 09, 2020 10:19 AM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: publication date

Thanks David. Good to know. I hope this finds you and yours safe and healthy.

Jody

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, September 9, 2020 10:17 AM
To: Lando,Jody B (BPA) - EWP-4 <jblando@bpa.gov>
Subject: [EXTERNAL] RE: publication date

Hi Jody—

The journal indicated that it would "probably" be the end of this month, but I have not yet heard back further from them.

David

From: Lando,Jody B (BPA) - EWP-4 <jblando@bpa.gov>
Sent: Wednesday, September 09, 2020 10:14 AM
To: David Welch <David.Welch@Kintama.com>
Subject: publication date

Hi David,

Do you know the anticipated publication date for your Comparative Survival Study of SARS?

Thanks very much,

Jody

Jody B. Lando, Ph.D.
Research, Monitoring and Evaluation Lead | EWP-4

Bonneville Power Administration
jblando@bpa.gov | P 503-230-5809 | C [redacted]

Facebook-Icon_31x31_v3Flickr-Icon_31x31Instagram-Icon_31x31LinkedIn-Icon_31x31Twitter_31x31YouTube_31x31

–

From: David Welch

Sent: Mon Sep 14 09:59:41 2020

To: Ben Zelinsky

Subject: [EXTERNAL] Zoom meeting invitation - David Welch's Personal Meeting Room

Importance: Normal

Attachments: Zoom-Meeting.ics; ATT00001.txt

David Welch is inviting you to a scheduled Zoom meeting.

Topic: David Welch's Personal Meeting Room

Join Zoom Meeting
https://us04web.zoom.us/j/6923559605?pwd=Wk1OMGhJYUpuUGo5eWFOMFFMNkFIZz09

Meeting ID: 692 355 9605
Passcode: 3ZCV8f

David Welch, Kintama Research
Tel: [redacted]

Sent:
Subject: David Welch's Personal Meeting Room
StartTime: Mon Sep 14 16:59:27 2020
EndTime: Mon Sep 14 17:59:27 2020
Location: https://us04web.zoom.us/j/6923559605?pwd=Wk1OMGhJYUpuUGo5eWFOMFFMNkFIZz09

David Welch is inviting you to a scheduled Zoom meeting.

Topic: David Welch's Personal Meeting Room

Join Zoom Meeting
https://us04web.zoom.us/j/6923559605?pwd=Wk1OMGhJYUpuUGo5eWFOMFFMNkFIZz09

Meeting ID: 692 355 9605
Passcode: 3ZCV8f

From: David Welch

Sent: Mon Sep 14 10:00:43 2020

To: Ben Zelinsky

Subject: [EXTERNAL] Please join Zoom meeting in progress

Importance: Normal

Join Zoom Meeting
https://us04web.zoom.us/j/6923559605?pwd=Wk1OMGhJYUpuUGo5eWFOMFFMNkFIZz09

Meeting ID: 692 355 9605
Passcode: 3ZCV8f

David Welch, Kintama Research
Tel: +[redacted]

From: David Welch

Sent: Tue Sep 15 10:26:45 2020

To: Ben Zelinsky

Subject: [EXTERNAL] Try for a call again?

Importance: Normal

Hi Ben-

I only realized yesterday when I was starting my call to you that I didn't actually have a pre-scheduled Team or Zoom meeting, so perhaps that's why you weren't on the call. (I hope it is that and not that fires are near your house!).

It is still worthwhile having a call soon and I think what I have to say should interest BPA senior management. There is a window of opportunity that BPA should be advised of.

My schedule is pretty open. What works for you?

David

From: Pisces

Sent: Thu Sep 24 14:12:13 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good Afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Add SOY Budgets to Fund Budgets Summary
- Add a portfolio category "Council Reviews" to maintain those portfolios specific to categorical reviews
- Transmittal Memo enhancement
- Request: Allow Dashboard Widgets to pop out in separate tab

Important bug fixes include:

- In Metrics tab, numeric entries with a comma are not supported
- Document Search crashes when result includes documents without project
- Contract Continuation may display more than one continuing contracts

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: David Welch

Sent: Thu Sep 24 16:26:33 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] FW: Manuscript Accepted - Updates Approved FaF-20-Jun-OA-162.R1 [email ref: ENR-AW-1-e]

Importance: Normal

Attachments: FaF-20-Jun-OA-162.R1_Proof_fl (23 Dept 2020).pdf

Hi Christine--

After a few trivial requests concerning the processing of the final paper, the paper has now been formally accepted and scheduled for publication. (See the email below; last week they asked us to change the title of the paper from "A Review..." to "A Synthesis..." for example. A few others of similar import had to be done as well, such as including the Latin name for the family of fish we were dealing with (Salmonidae...sigh!).).

Anyway, all that is done & dusted. I would expect from a message I received a month or two ago that the actual publication will occur in 2-3 weeks from now, but at this point with Britain moving into major COVID lockdown anything is possible, I suppose. "Batten down the hatches" is perhaps the best advice I can give!

It would be useful to touch base on a few final issues. Is there a time that would work for a Zoom or Teams call?

David

P.S. Final (now formally accepted) version of the paper is attached for your information. Nothing of substance has changed, as I indicated, apart from the title.

-----Original Message-----
From: Sue Hart <onbehalfof@manuscriptcentral.com>
Sent: September 24, 2020 4:10 PM
To: David Welch <David.Welch@Kintama.com>
Subject: Manuscript Accepted - Updates Approved FaF-20-Jun-OA-162.R1 [email ref: ENR-AW-1-e]

24-Sep-2020

Dear Dr. Welch:

Manuscript id: FaF-20-Jun-OA-162.R1

The final files that you submitted for your manuscript have been checked and have been found to be suitable for publication and so will be forwarded to the publisher shortly.

Publication in the journal is free and colour figures may be published online free of charge. There is, however, a cost for publishing colour figures in the print version.

If you supply colour figures you will be invited to complete a colour charge agreement in RightsLink for Author Services once the paper is published on Early View. You will be given the option of paying immediately with a credit or debit card, or you can request an invoice. If you choose not to purchase colour printing, the figures will be converted to black and white for the print issue of the journal.

Due to a change in the way in which proofs are presented to authors it may currently be the case that not all corrections that you make are transfered correctly to the final print-ready version.

Early View will be the first opportunity for you to see the final print-ready version unlike the former proof system which allowed one to see, read and edit a print-ready version of the paper.

We therefore suggest that you check your Early View paper carefully for any errors at the earliest opportunity and contact Production if there are any problems.

Sincerely,
Fish and Fisheries Editorial Office

A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha,* Salmonidae)

Short title: Coast-wide survival of Chinook

David Warren Welch[*,1], Aswea Dawn Porter[2], Erin Leanne Rechisky[3]

Kintama Research Services, 4737 Vista View Cr., Nanaimo, B.C. Canada V9V 1N8

* Corresponding Author E-Mail: david.welch@kintama.com

1: ORCID ID 0000-0001-8851-5436

2: ORCID ID 000-0002-1258-8265

3: ORCID ID 0000-0002-2811-8399

Abbreviations

BC- British Columbia, Canada

CSS- Comparative Survival Study

CWT-Coded Wire Tag

PSC- Pacific Salmon Commission

SAR-Smolt to Adult Return Rate (Survival)

PIT- Passive Integrated Transponder

Abstract

We collated smolt-to-adult return rate (SAR) data for Chinook salmon from all available regions of the Pacific coast of North America to examine the large-scale patterns of salmon survival. For consistency, our analyses primarily used coded wire tag-based (CWT) SAR estimates. Survival collapsed over the past half century by roughly a factor of three to ca. 1% for many regions. Within the Columbia River, the SARs of Snake River populations, often singled out as exemplars of poor survival, are unexceptional and in fact higher than estimates reported from many other regions of the west coast lacking dams. Given the seemingly congruent decline in SARs to similar levels, the notion that contemporary survival is driven primarily by broader oceanic factors rather than local factors should be considered. Ambitious Columbia River rebuilding targets may be unachievable because other regions with nearly pristine freshwater conditions, such as SE Alaska and northern BC, also largely fail to reach these levels. Passive integrated transponder (PIT) tag-based SAR estimates available for Columbia River basin populations are generally consistent with CWT findings; however, PIT tag-based SARs are not adjusted for harvest which compromises their intended use because harvest rates are large and variable. More attention is needed on how SARs should be quantified and how rebuilding targets are defined. We call for a systematic review by funding agencies to assess consistency and comparability of the SAR data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast. *(250/250 words)*

Keywords:

Columbia River, dams, delayed mortality, marine survival, smolt-to-adult return, Snake River

Table of Contents

References

INTRODUCTION

The abundance of salmon (family Salmonidae) in the North Pacific has reached record levels (Irvine et al., 2009; Ruggerone & Irvine, 2018; Schoen et al., 2017); however, most of the increase is in the two lowest valued species (pink, *Oncorhynchus gorbuscha,* and chum, *O. keta*) in far northern regions, at least in part due to ocean ranching (Ruggerone & Irvine, 2018). In contrast, essentially all west coast North American Chinook (*O. tshawytscha*) populations including Alaska are now performing poorly with dramatically reduced productivity (Dorner, Catalano, & Peterman, 2017; Ohlberger, Scheuerell, & Schindler, 2016).

The situation in North America is similar for most southern populations of coho (*O. kisutch*) (Logerwell, Mantua, Lawson, Francis, & Agostini, 2003; Zimmerman et al., 2015), sockeye (*O. nerka*) (Cohen, 2012; COSEWIC, 2017; Peterman & Dorner, 2012; Rand et al., 2012), and steelhead (*O. mykiss*) (Kendall, Marston, & Klungle, 2017). These poorly performing species are of higher economic value and the focus of indigenous, sport, and commercial fisheries.

The historical pattern of declines in salmon abundance (steeper in the south, less so in the north) were originally assumed to reflect a freshwater anthropogenic cause because of the greater degree of freshwater habitat modification in the more populous southern regions (Allendorf et al., 1997; Nehlsen, Williams, & Lichatowich, 1991). The growing appreciation of ocean climate change (Hare, Mantua, & Francis, 1999; Mantua, Hare, Zhang, Wallace, & Francis, 1997; Mantua & Hare, 2002) has brought an awareness of the role of the ocean in influencing salmon survival. As Ryding and Skalski (1999, p.2374) noted two decades ago, "*It is becoming increasingly clear that understanding the relationship between the marine environment and salmon survival is central to better management of our salmonid resources*".

Unfortunately, our understanding of survival during the marine phase remains extremely limited, so there has been little change in management strategy beyond the essential first step of reducing harvest rates in the face of falling marine survival. The recent recognition of the decline in Chinook returns across essentially all of Alaska (ADF&G Chinook Salmon Research Team, 2013; Cunningham, Westley, & Adkison, 2018; Ohlberger et al., 2016; Schindler et al., 2013) and the Canadian portion of the Yukon River (Bradford, von Finster, & Milligan, 2009), where anthropogenic freshwater habitat impacts are negligible, is another example of how simple explanations are potentially flawed. If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon.

Formal smolt-to-adult return (SAR) or survival recovery targets have not been specified for any region of the west coast of North America outside the Columbia River basin. Within the extensively dammed Columbia River basin, the Northwest Power and Conservation Council's Fish and Wildlife Program (NPCC) set rebuilding targets for SARs at 2%-6% (McCann et al., 2018, p. 4), roughly the survival observed in the 1960s prior to the completion of the eight-dam Federal Columbia River Power System (FCRPS) (Raymond, 1968, 1979). The NPCC SAR objectives did not specify the points in the life cycle where Chinook smolt and adult numbers should be determined; however, one extensive analysis for Snake River spring/summer Chinook was based on SARs calculated as the proportion of smolts reaching the uppermost dam in the migration path that survived to return there as adults and jacks (Marmorek, Peters, & Parnell, 1998): "*Median SARs must exceed 4% to achieve complete certainty of meeting the 48-year recovery standard, while ... A median of greater than 6% is needed to meet the 24-year survival standard with certainty*" (p. 41). Although not explicitly stated, this seems to be the basis for setting the 2-6% rebuilding standard for the Columbia River.

In this paper, we collate Chinook SAR time series for the west coast of North America to document broad patterns in survival. The SAR is the three-fold product of freshwater smolt survival during downstream migration multiplied by the marine survival experienced over two to three years in the ocean and multiplied by adult freshwater survival during the upstream migration to the final census point. Survival should include animals removed by the fisheries; however, as we show later, harvest is not included in PIT tag-based survival estimates, which has significant implications.

There are two major methods of estimating survival on the west coast of North America, one using Coded Wire Tags (CWT) and another using Passive Integrated Transponder tags (PIT). We assessed whether the SAR estimates using these methods could be pooled for analyses but concluded that they are not inter-convertible. The CWT program is more geographically extensive; thus, our primary analysis uses the CWT-based estimates for coast-wide survival comparison. However, within the Columbia River basin, PIT tags have been widely relied upon for over two decades as the primary source of survival data, so we separately analyzed the survival patterns reported using the PIT tag methodology. The collated data are presented by region, smolt age at outmigration, stock, and/or year of outmigration. We then tested the current similarity of SAR estimates across regions using data from the five most recent years of available data. Given the widely recognized poor survival of Snake River Chinook salmon, resulting in their listing under the US Endangered Species Act (NMFS, 2017a, 2017b), many of our analyses compare regional survival to that of the Snake River region. We show that, overall, Chinook salmon survival (SAR) has decreased by roughly the same amount everywhere along the west coast of North America and has now reached similar or lower survival levels than Snake River stocks.

In the process of assessing how well survival estimates from CWT and PIT-based tagging methodologies can be compared, we found that there were large population-specific changes in harvest rates over time which are not incorporated into PIT tag-based survival estimates. This previously unrecognized limitation of PIT tagging methodologies is critical to current conservation efforts in the Columbia River basin because of changes to the terms of the US-Canada Pacific Salmon Treaty, which we outline.

Finally, we examined the CWT and PIT tag SAR datasets to evaluate the broader evidence for "delayed mortality", an important theory that argues that the greater dam passage experienced by Snake River stocks predisposes these populations to lower subsequent survival after migration out of the hydropower system than populations not migrating through the Snake River dams.

At the broadest level, the major implication of our results is that most of the salmon conservation problem is determined in the ocean by common processes. Attempts to improve SARs by addressing region-specific issues such as freshwater habitat degradation or salmon aquaculture in coastal zones are therefore unlikely to be successful. Given the importance of these conclusions, we call for a joint systematic review by major funding agencies to further assess the broader consistency and comparability of SAR data with our findings.

METHODS

Data sources

Most survival rates of Pacific salmon are based on mark-recapture efforts, where juveniles are "marked"— implanted with either coded wire tags (CWT) or passive integrated transponder (PIT) tags—and recaptured in the fishery or detected upon return to the river. CWT technology dates back to the 1960s. A review is provided by (Johnson, 1990); the application of the methodology to coastal marine migrations of Coho and Chinook is described by Weitkamp (2009) and Weitkamp & Neely (2002) and to measuring harvest and survival by ADF&G Chinook Salmon Research Team (2013), Bernard & Clark (1996), and Chinook Technical Committee (2014). The CWT tag is implanted in the nose cartilage of smolts. If recaptured in the fishery, the fish must be dissected to recover the tag and the tag code must be read with a microscope. In contrast, PIT tags first came into widespread use in the Columbia River Basin in 1997. They are long-lived but short-distance radio-frequency tags that can successfully transmit their unique ID code when within <0.5 m of a detector (Prentice, Flagg, & McCutcheon, 1990a; Prentice, Flagg, McCutcheon, & Brastow, 1990b; Prentice, Flagg, McCutcheon, Brastow, & Cross, 1990c; Skalski, Smith, Iwamoto, Williams, & Hoffmann, 1998). The short detection range essentially limits the use of PIT tags to either small, shallow streams or the Columbia River dams, which channel sufficient tagged individuals close to the detectors to generate useful survival estimates.

We collated SAR time series for Chinook from several sources (Supplementary Table S1). For CWT-based estimates, the primary data are the survival estimates for the indicator stocks used by the Pacific Salmon Commission (PSC). These datasets are formally submitted to the PSC by a wide variety of management agencies under the terms of the bilateral US-Canada Pacific Salmon Treaty. We supplemented these with CWT-based SAR time series published in the primary or secondary literature or calculated directly from the Pacific States Marine Fisheries Commission's CWT database. Together, these data sets represent California, Oregon, Washington, British Columbia, and southeast Alaska. Early SAR estimates for the Upper Columbia and Snake Rivers are based on freeze-branding (Raymond, 1988), but were included because they are the only estimates available for the time period when SARs collapsed in those regions. Finally, because of their historical importance to monitoring in the Columbia River we compiled and separately analyzed the PIT tag-based SAR estimates reported by the Comparative Survival Study (McCann et al., 2018).

Because SAR data are typically log-normally distributed, we primarily report the median, as this is equivalent to the geometric mean some authors use. (A simple proof of this statement is to note that after log-transformation the mean of log-normal data will have 50% of the data above and below it). We therefore use the simpler terminology both for clarity and because the median is invariant under log-transformation, which is not true for the mean.

Pacific Salmon Commission (CWT-based estimates)

The PSC is a bilateral treaty organization between the US and Canada coordinating management of Pacific salmon from Cape Falcon, Oregon, north to Cape Suckling, Alaska. The data are contributed to the Chinook Technical Committee of the PSC by the various government agencies responsible for conducting the individual monitoring programs. This database was the source of CWT-based Chinook survival estimates for all regions outside the Columbia River basin and for a few stocks located in the Columbia River basin.

The PSC database provides several measures of SAR. We used their estimates calculated as the sum of adults returning at all ages or caught in the fisheries, uninflated for losses to natural mortality for Chinook remaining at sea for longer than two years:

$$SAR_{i,j} = \frac{\sum_{k=2 \text{ or } 3}^{\max age} \left(\sum_{l=1}^{n} (F_{i,j,k,l} + IM_{i,j,k,l}) + Esc_{i,j,k} \right)}{\mathrm{Rel}_{i,j}}$$

where $F_{i,j,k,l}$ = the tags recovered in fishery l, for age k, from brood year j, of stock i that are expanded for the fraction of the catch sampled; $IM_{i,j,k,l}$= the incidental mortalities; and $Esc_{i,j}$ = the number of tags recovered in the escapement including hatchery and spawning ground recoveries that are expanded for the fraction sampled. Columbia River stocks also have an inter-dam loss (IDL) calculation, so fish (or tags) returning to the river are adjusted upward to account for in-river mortality (Chinook Technical Committee, 2018).

CWT-based SAR estimates for hatchery-origin fish generally cover the period from hatchery release until adult return to the hatchery and/or spawning grounds and are compensated for harvest (i.e., mortalities due to harvest are included as survivors). Exceptions include five Alaskan hatcheries used in our analysis which are located at sea level and which release smolts directly into the ocean after several weeks of seawater acclimation in holding pens, eliminating losses in freshwater (see later). For wild stocks, juvenile fish are captured and tagged during downstream migration, and therefore some of the CWT-based survival estimates for wild stocks are biased high because they can exclude survival losses occurring in the initial phase of the migration upstream of the census point (McPherson, Jones, Fleischman, & Boyce, 2010). Other miscellaneous notes about this dataset are recorded as footnotes at the bottom of Supplementary Table S1.

Agency estimates (CWT-based estimates)

The PSC does not include indicator stocks for California or for yearling Chinook from the Columbia River, presumably because these stocks are not relevant to international management. We therefore included published estimates for fall, late-fall, and winter Chinook runs from the Sacramento River in California (Michel, 2018). For Columbia River basin spring Chinook, we collated some annual reports produced by individual hatcheries in the basin and/or contacted the hatcheries directly to build up a partial inventory of CWT-based SAR estimates for Chinook.

These supplemental estimates were calculated similarly to those done by the PSC but are unexpanded for incidental mortality (or inter-dam loss in the Columbia River). Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish. See Supplementary Table S1 for details.

Pacific States Marine Fisheries Commission estimates

All CWT release and recovery data are submitted to the Regional Mark Processing Center hosted by the Pacific State Marine Fisheries Commission, which maintains the online Regional Mark Information System (RMIS) to facilitate exchange of CWT data. We investigated this source; however, we could not verify that adult return numbers from all possible significant components were correctly incorporated and expanded for sampling effort. Ideally, adult returns should include hatchery rack returns (adults taken for brood stock), adult escapement to spawning grounds, and immature or maturing individuals caught in all fisheries (sport, commercial, tribal) and locations (at sea, in-river). For this reason, we focused on the PSC and Agency estimates described above. We used RMIS only for Entiat Spring Chinook (UCOL) after consulting with Entiat Hatchery biologists on the integrity of the data set (G. Fraser, *pers. comm.* USFWS, Leavenworth, WA. gregory_fraser@fws.gov).

Raymond (1988) estimates

Data on survival in the 1960s to early 1980s period for the Snake and Upper Columbia Rivers was based on mark-recapture estimates of the abundance of a mixture of freeze-branded hatchery and wild smolts passing the first dam encountered each year (Raymond 1988). An essentially complete enumeration of adult returns was possible at upstream dams several years later because the adults must ascend fish ladders and estimates were compensated for harvest. These SAR estimates are inflated relative to the CWT-based estimates described above because they do not include migration losses from the time downstream migration is initiated until the smolts are censused at the dams and also exclude adult upstream losses between the dam and the spawning grounds. Nevertheless, this dataset is important because it incorporates the period of relatively high survival in the 1960s and early 1970s and the period when survival collapsed, which was attributed primarily to dam construction. We used these estimates in conjunction with the CWT estimates for a more complete time series.

Comparative Survival Study (PIT tag-based estimates)

PIT tags have largely supplanted CWTs in the Columbia River basin because of the ability to measure smolt survival between dams and estimate SARs. We used the estimates of overall SAR from Chapter 4 of the Fish Passage Center's Comparative Survival Study (McCann et al., 2018) which are essentially the number of adults returning to the uppermost FCRPS dam with detection capability (Lower Granite, McNary, John Day and/or Bonneville dams depending on the population) divided by the estimated number of PIT-tagged smolts surviving to their uppermost dam during downstream migration. For example, for most Chinook salmon originating from the Snake River basin, the SAR is estimated from Lower Granite Dam back to Lower Granite Dam.

When estimates were available for multiple segments, we selected the SAR covering the greatest extent of the migratory life-history (i.e., smolt releases and adult returns to the uppermost dam available in the Columbia River basin), and we used SAR estimates that included jacks when available. In the mid-Columbia region, SAR estimates with jacks were sometimes available only for a shorter migration segment; in these cases we selected the SAR data sets representing the longer migration segment but excluding jacks because this was most similar to the CWT survival estimates. PIT tag-based SARs do not incorporate losses due to harvest (McCann et al., 2018, p. 95) because the commercial and sport catch is not monitored for PIT tags.

Because PIT tag-based SAR estimates contain several limitations that are problematic to the interpretation of survival (particularly lack of harvest information), we use these estimates only as a secondary validation of the major conclusions.

Division by life history

Chinook salmon display two major juvenile life history types (subyearling and yearling) that correspond with adult run-timing (fall or spring, respectively). These life history types are examined separately in our analysis because there are important ecological differences between them (see reviews by Riddell et al. (2018) and Sharma & Quinn (2012)) which likely influence survival. We review the general characteristics below but note that this simple picture is more complicated due to hatchery rearing practices and natural variability.

Subyearling/fall populations are widely distributed in low gradient coastal streams or the lower mainstem of major rivers but are absent from Alaska. They migrate to the ocean within a few months of hatching and almost certainly remain as long-term residents of the continental shelf off the west coast of North America where they are exposed to commercial and sport harvest in coastal marine waters over multiple years (Sharma & Quinn, 2012). Survival of shelf-resident subyearling Chinook populations can therefore be significantly reduced by coastal fisheries that can harvest these animals over several years of marine life.

Yearling/spring populations are found in headwater tributaries of large river systems penetrating well into the interior of the continent, such as the Columbia and Fraser rivers. They migrate to sea after completing one or more full years of life in freshwater and are thus significantly larger at ocean entry. Yearlings (generally) spend one less year in the ocean than subyearlings. Only the yearling life history type is found in Alaska (Healey, 1983).

Yearlings are thought to migrate along the continental shelf as juveniles and then move offshore and become purely open ocean residents for much of the marine phase, and thus are essentially immune to harvest by directed salmon fisheries until their return to the shelf and freshwater, where variable levels of harvest may occur. However, significant bycatch of Chinook populations originating from as far away as Washington and Oregon occurs in Alaskan trawl fisheries (Larson et al., 2013), which may possibly include yearling Chinook.

Comparisons between regions

To develop a formal statistical test of the similarity in SARs between regions in the most recent years of the record, we first grouped the CWT-based SAR data separately by smolt age (yearling/subyearling), region, and rearing type (hatchery/wild). For each of these groupings, we pooled all data in the 2010-2014 ocean entry period across all populations in a region, and then resampled the pooled data with replacement N=10,000 times, each time drawing a sample of the same size as the original pooled data. We chose this time period because there was a consistent number of populations contributing to each regional grouping used in the comparison period (2014 being the last year with essentially complete data available for all populations) and it avoided including 2008, a year of unusually cold conditions (Arguez et al., 2020). Limiting the samples to this period ensured the data were current and removed the potential variability due to differing lengths of the time series. For each group, we calculated the *N* median SARs, and then calculated the ratio of those *N* medians with those from each of the other regions in turn. The empirical distribution of the *N* ratios allows for a formal statistical test of the proposition that median SARs in two regions are equal (i.e. that the ratios are not different from one). The normalized SAR ratio for region *i* relative to the Snake River in sample j=1,.., *N* was then $SAR_{i,j}/SAR_{SNAK,j}$. Because of the generally recognized poor survival of Snake River Chinook salmon, we present the results of the comparison to the Snake River in the main text but also provide the comparison using all possible regions in the denominator in Supplementary Figure S1.

Comparison between CWT and PIT tag-based SARs

There are some fundamental differences between PIT and CWT tag-based SAR estimates. PIT tag-based SARs exclude smolt and adult survival upstream of the topmost dam where they are censused and do not account for harvest in ocean or mainstem river fisheries. CWT-based estimates incorporate these factors. Therefore, an aggregate correction factor $\widehat{c_{i,j}}$ for the PIT-based SAR estimates to make them consistent with the CWT-based SAR estimates is:

$$\widehat{c_{i,j}} = \frac{S_{i,j}^{smolt} * S_{i,j}^{adult}}{(1 - h_{i,j})}$$

where $S_{i,j}^{smolt}$ = the estimated survival of stock *i* between the hatchery or pre-smolt rearing grounds and the uppermost dam for smolts from brood year *j*; $S_{i,j}^{adult}$ = the estimated survival of stock *i* between the uppermost dam and return to the hatchery/spawning grounds; and $h_{i,j}$ = the estimated harvest of stock *i* in year *j*. For notational simplicity, we neglect harvest in years prior to adult return. Here the numerator corrects for upwards bias in PIT-based SAR estimates caused by excluding survival above the topmost dam while the denominator corrects for the downward bias caused by excluding harvest.

We were interested in estimating $c_{i,j}$ to assess if it was reasonable to use it to combine these data into a single term that could provide a reliable metric for converting between PIT and CWT-based SAR estimates. To do this, we first attempted to collate the three components ($S_{i,j}^{smolt}$, $S_{i,j}^{adult}$, and $h_{i,j}$) for the populations with PIT tag SAR estimates, but we encountered difficulty obtaining sufficient data, particularly for the adult stage. However, combined ocean plus mainstem harvest rates were readily available for the PSC's indicator stocks. For yearling populations, marine harvest rates are thought to be very low (Waples, Teel, Myers, & Marshall, 2004) and are not included in the CTC database. We therefore collated mainstem harvest data from other sources for yearlings (Supplementary Table S2).

Our second approach to estimating $c_{i,j}$ was to identify populations with both CWT- and PIT-based SAR estimates generated in the same years and then use simple linear regression to identify the relationship. If there was no difference between estimation methodologies, then the regression of CWT SAR estimates on PIT tag-based SAR estimates should have a regression slope of $\hat{c} = 1$.

RESULTS

We collated 123 eastern North Pacific Ocean Chinook salmon SAR time series totaling 2,279 years of monitoring (Fig. 1). SAR estimates included in our analysis were from populations extending from central California to south east Alaska and include 94 hatchery populations, 26 wild, and 3 hatchery-wild (mixed) populations. These populations were then aggregated by geographic area to compare regional SARs. All time series outside the Columbia River watershed are based on CWTs. Within the Columbia, both PIT and CWT-based SARs were available.

SARs from coded wire tags

Most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift (Beamish, 1993; Beamish & Bouillon, 1993; Ebbesmeyer et al., 1990; Francis & Hare, 1994; Mantua et al., 1997) show an approximate three-fold decrease in SARs for hatchery populations (Fig. 2). This applies to hatchery subyearling Chinook from west coast Vancouver Island, the Strait of Georgia, Puget Sound, and the mid-Columbia River; and to hatchery yearling Chinook from SE Alaska, the lower and upper Columbia River, and the Snake River (upper Columbia and Snake rivers are relative to the historical freeze brand data from Raymond (1988)). Except for coastal Oregon subyearlings, average CWT-based SARs for hatchery fish for all regions are now approximately 1% or less.

Within the Columbia River basin, hatchery Chinook from all regions except for yearlings from the lower Columbia show some increase in CWT-based SARs since the 1980s and early 1990s, the period when SARs reached their lowest values in the basin. None of these time series have recovered to the survival levels measured by Raymond (1988) in the 1960s.

Median population specific SARs show that wild populations generally have higher survival than hatchery populations; however, there are limitations: CWT data are limited for wild populations and there are no data available for a direct hatchery vs wild comparison for the same population (Fig. 3). The wild yearling Chinook populations in SE Alaska tend to have lower survival than the hatchery-reared population; however, the Alaskan hatchery SAR estimate provided to the PSC is based on combined data for five hatcheries that all release smolts directly into the ocean after acclimation to seawater for several weeks, eliminating losses from freshwater migration (Bill Gass, Production Manager, Southern Southeast Regional Aquaculture Association, & John Eiler, NOAA; pers. comms.).

Median SARs for hatchery or wild populations within a given region tend to cluster together, but a few populations (University of Washington experimental hatchery releases in Puget Sound and the Chilliwack hatchery in the Strait of Georgia) have unusually high SARs relative to other stocks in their respective region. These are also the only populations whose medians substantively attain the 2-6% SAR recovery level adopted in the Columbia River basin.

Apart from SE Alaska and north-central BC yearlings and Oregon Coast subyearlings, which have higher regional survivals, populations from other regions have only rarely reached this level of production.

Comparison between regions

To compare the current status of regional CWT-based SARs, we included the five most recent years of consistently available SAR data (2010-2014) in a resampling procedure to statistically quantify relative SARs. We used Snake River population SARs as the baseline region to compare all other regions with because of the perceived status of the Snake River as having particularly poor survival; the same analysis using other regions as the basis for comparison are presented in Supplementary Figure S1. A striking result emerges for hatchery-reared subyearling Chinook: median SARs in all regions except the Oregon Coast are lower than median Snake River SARs (Fig. 4). Only in three of nine regions with numerically lower SARs does the upper 5th percentile of the empirical distribution include the possibility of equal SARs with the Snake River region (North-Central BC, Mid, and Upper Columbia). For all other regions, subyearling SARs are statistically lower than the Snake River survivals. There are no CWT-based SAR estimates for wild subyearling Chinook.

Applying the same procedure to hatchery-reared yearling Chinook, current regional SARs were statistically indistinguishable from Snake River SARs for the Salish Sea (Strait of Georgia, Puget Sound) and all other regions of the Columbia River basin (Lower, Mid, and Upper; Fig. 4). California, northern BC, and SE Alaska yearling SARs were significantly higher than Snake River yearling populations. The SARs of SE Alaska wild yearling Chinook (four river systems) were significantly lower than the SARs of the one wild stock of Snake River yearling Chinook for which we have data (Tucannon River; Fig 3).

SARs from PIT tags

PIT tag-based SAR estimates are available for Chinook salmon originating from the Columbia River Basin and published annually by the Fish Passage Center (McCann et al., 2018). Comparing PIT tag-based SARs across regions of the Columbia River basin (Fig. 5) yields similar results to the CWT analysis: wild fish generally have higher survival and different regions have similar or lower median SARs to the Snake River. The exceptions are two mid-

Columbia populations of wild yearling Chinook salmon (John Day River and Yakima River) which have consistently high SARs that fall within the 2-6% rebuilding target set for Columbia River Basin yearling Chinook. However, both wild and hatchery subyearling SARs from the mid-Columbia fall well below the Snake River medians, and all other populations (including three hatchery-reared mid-Columbia yearling populations) have SARs which rarely or never exceed 2%; from this perspective only the two wild yearling populations have substantively higher SARs.

Comparison of CWT and PIT-based SARs

We attempted to develop a correction factor for PIT tag-based SAR estimates so that we could incorporate PIT-based SAR datasets into our regional comparisons; however, PIT-based estimates differ in two major ways from CWT estimates: (1) they exclude sport, commercial, and indigenous harvest and (2) they exclude smolt and adult losses in the region lying between the uppermost dam and the hatchery or spawning site. Unfortunately, it was difficult to find sufficient comparable data. Where both data types were available for individual populations, regression relationships were strong (very high R^2) but biased (greater than or less than the expected 1:1 relationship; Fig. 6). Subyearling CWT-based SAR estimates were consistently higher than PIT-based estimates (1.3 to 3.0 times), presumably because the high subyearling harvest rates not captured in PIT-based estimates (currently between ~45-80%; Fig. 7) outweigh the influence of excluding upstream losses. In contrast, CWT-based SARs for yearling populations were consistently lower than PIT-based estimates (0.39 to 0.73 times), indicating that mortality above the uppermost dam outweighs the influence of the generally lower (but not insignificant) harvest rates on yearling populations. Although fitted linear relationships had high R^2, the substantial differences in regression slopes among populations suggests that population-specific factors strongly influence the relationship. A simple correction factor between PIT and CWT-based SAR estimates appears infeasible.

DISCUSSION

SAR comparison

Evidence that Chinook salmon survival (SARs) has decreased to roughly 1% in many regions along the west coast of North America is both surprising and important. Direct measurements of SARs are lacking for stocks located west of SE Alaska, but the decrease in the number of adult Chinook returning to the rest of Alaska (ADF&G Chinook Salmon Research Team, 2013; Ohlberger et al., 2016; Schindler et al., 2013) demonstrates that survival has fallen over a very large geographic range.

Although survival data for Asian Chinook salmon populations appear to be lacking, Asian populations have had similarly large decreases in abundance relative to North America, suggesting that the drop in Chinook survival is not restricted only to North America. The reported Asian commercial catch of Chinook averaged just under 10% of the total North Pacific Chinook catch for the 1970-2019 period (NPAFC, 2020). Russian catches for the most recent decade, 2010-2019, were only ¼ of the 1970-79 average. For Japan, catches in the 2010-2019 period were only 1/60th of the 1970s (NPAFC, 2020). Some of the decrease in Japanese catches is attributable to regulation changes, particularly the 1977 Law of the Sea Treaty which extended coastal state control out to 200 nautical miles (320 km), and resulted in the transfer of harvesting opportunities from Japan to other coastal states. However, the combined Asian catch still declined to only 17% (~1/6th) the level of the 1970s. Thus, although we only have survival data for North American populations, the decline in Chinook abundance due to decreased survival appears to be Pacific basin-wide.

The North American decreases in survival have occurred despite governments' best attempts to increase salmon populations through harvest regulation, hatchery enhancement, and habitat restoration. A major assumption underlying these efforts is that regional factors such as freshwater habitat degradation or salmon aquaculture make important contributions to the decreasing survival of salmon observed coastwide; however, the similar timing of the decline in the Salish Sea, west coast of Vancouver Island, and Columbia River basin suggests the primary influence of a broad ocean driver (Beamish, 1993; Beamish & Bouillon, 1993; Mantua et al., 1997). The evidence for a roughly similar drop in Asian Chinook catches reviewed above also indicates that the geographic footprint of any ocean (or freshwater) driver must either be large or that many populations must migrate to common geographic regions where their survival can be similarly reduced.

In the Snake River basin, where ESA-listed Chinook salmon migrate through eight major dams, subyearling survival of hatchery Chinook is higher than aggregate subyearling SARs from most regions of the west coast of North America, despite the shortness of streams in these other regions and the general absence of dams (Fig. 4; Oregon coast is the clear exception). For hatchery-origin yearling populations, the SARs for ESA-listed Snake River populations are lower than those reported for three regions (California, north-central BC, and SE Alaska) but are statistically indistinguishable from all other regions (Puget Sound, Strait of Georgia, and lower, mid, and upper Columbia River).

When comparing wild populations, the few Chinook SAR time series outside of the Columbia River basin are also not consistently better than wild Snake River SARs, as conventional thinking would assume. The median SAR of four wild Alaskan stocks is slightly lower than the median SAR of three Snake River wild stocks when all years of data are considered (Fig. 3) and markedly lower when the comparison is restricted to the 2010-2014 time period (note that the Tucannon River is the only wild population for the Snake River region with recent data; Fig. 4). The conclusion is similar when comparing all years of CWT and PIT tag data for most populations (Figs. 2, 3 and 5): median SARs are poor everywhere, and generally ~1% except in the earliest years of the time series. Thus, the numerical similarity in SARs is not an artifact of some recent event but something that has persisted for many years. (Supplementary Tables S3 and S4 provide a summary of the actual numeric values.)

A few populations with anomalously high SARs relative to other populations in the same region exist, and provide intriguing evidence that some populations have an intrinsic ability to support higher SARs meeting the Columbia River basin's current 2-6% recovery targets (subyearlings from the Chilliwack hatchery in the lower Fraser River (SOG), and a ten year record of experimental hatchery releases from the University of Washington (PS)). It is unclear why these two populations are more productive. Similarly, a few populations with anomalously low SARs relative to regional medians also are evident (Fig. 3). If the underlying reasons for higher or lower survival can be identified it might be possible to improve hatchery productivity more broadly.

Intriguingly, the higher SARs of the two coastal Oregon subyearling populations and Chinook from California (Figs. 3, 4) all involve populations that apparently do not migrate far north. The SARs of California Chinook are particularly noteworthy because freshwater survival is exceedingly low (Michel, 2018); for overall SARS to be higher than Snake River stocks suggests much higher survival during the marine phase. Riddell et al. (2018, p. 580) note the unique marine distributions of southern Oregon Chinook stocks, which restricts them for their entire ocean phase to life in the southern region of the California Current, similar to the assumed ocean distribution of California stocks. It thus seems plausible that specific salmon populations home to distinct feeding grounds, some of which may confer better survival (Quinn, Chamberlain, & Banks, 2011; Tucker et al., 2011; Welch, Boehlert, & Ward, 2002).

The reasons for poor marine survival of Chinook are likely multiple, with mechanisms proposed in the last decade alone including: growth (Claiborne, Fisher, Hayes, & Emmett, 2011; Duffy & Beauchamp, 2011; Graham, Sutton, Adkison, McPhee, & Richards, 2019; Howard, Murphy, Wilson, Moss, & Farley Jr, 2016; Lewis, Grant, Brenner, & Hamazaki, 2015; Losee, Miller, Peterson, Teel, & Jacobson, 2014; MacFarlane, 2010; Miller, Teel, Peterson, & Baptista, 2014; Ohlberger, Ward, Schindler, & Lewis, 2018; Orsi, 2013; Schindler et al., 2013; Tomaro, Teel, Peterson, & Miller, 2012); hatchery practices (Chamberlin, Essington, Ferguson, & Quinn, 2011; Nelson, Shelton, Anderson, Ford, & Ward, 2019; Sabal et al., 2016; Tomaro, 2010); predation (Chasco et al., 2017; Friedman et al., 2019; Miller, Teel, Baptista, & Morgan, 2013; Nelson, Walters, Trites, & McAllister, 2019; Seitz, Courtney, Evans, & Manishin, 2019); competition (Cunningham et al., 2018; Miller et al., 2013); bycatch mortality in fisheries (Cunningham et al., 2018); and ocean conditions (Dorner et al., 2017; Murphy et al., 2017; Ruff et al., 2017; Sharma, Vélez-Espino, Wertheimer, Mantua, & Francis, 2013).

Delayed mortality, the theory that greater dam passage results in poorer survival of Snake River Spring Chinook relative to mid-Columbia Chinook populations after smolts migrate past the dams (Budy, Thiede, Bouwes, Petrosky, & Schaller, 2002; Independent Scientific Advisory Board (ISAB), 2007; Schaller & Petrosky, 2007; Schaller, Petrosky, & Langness, 1999), is specific to the Columbia River basin. The theory still plays an important role in Columbia River salmon management (McCann et al., 2019, pp. 116-119);

however, direct tests of the theory have not found evidence to support it (ISAB, 2019; Rechisky, Welch, Porter, Hess, & Narum, 2014; Rechisky, Welch, Porter, Jacobs-Scott, & Winchell, 2013; Rechisky, Welch, Porter, Jacobs, & Ladouceur, 2009). The PIT and CWT-based SAR estimates assembled here also fail to support the theory because the SARs of Snake River populations are not reduced on average when compared to other regions. Apart from two mid-Columbia wild yearling populations (Yakima River and John Day River) with higher than average survival estimates, all other SAR estimates are similar to Snake River values regardless of differences in the number of dams lying in the migration path. Three PIT-tagged hatchery-reared mid-Columbia yearling populations and two Upper Columbia populations have similar SARs to Snake River populations (Fig. 5), and CWT-based SAR estimates for Lower-, Mid- and Upper-Columbia yearling populations have survival consistent with Snake River populations (Fig. 4). Also of note, both PIT- and CWT-based SAR estimates for Mid-Columbia populations of wild and hatchery subyearling Chinook are generally lower than Snake River values. Thus, none of these comparisons support the claim that greater dam passage—and Snake River dam passage in particular—results in subsequently reduced survival. Our point is not to question that dams cause mortality, but rather to note that their current contribution to reduced survival is likely much smaller than originally believed. We urge biologists to consider all available data when evaluating the delated mortality theory, not just select comparisons that fit the proposed theory.

Credibility of SAR estimates

CWT-based estimates

We restricted most SAR comparisons to CWT-based data, as these are available for the entire west coast to as far north as SE Alaska. Most estimates are for hatchery-reared indicator stocks collated by the Pacific Salmon Commission; few estimates are available for wild populations. For upper Columbia and Snake yearling populations we used several estimates generated by individual fishery agencies. The PSC cites several challenges with CWT-based estimates including representativeness of the indicator populations, limitations on sampling the fishery and spawning grounds, and distortions introduced by mark-selective fisheries (Hankin et al., 2005). Agencies presumably generate these data using internally consistent methodologies over time to avoid biasing parts of the time series, thus, the large concurrent downward trend in survival of individual populations is likely to be credible.

PIT tag-based estimates

PIT tag detectors in dam bypasses and fish ladders census both the downstream and upstream movements of PIT-tagged salmon within the Columbia River basin. Originally developed to study smolt survival, PIT tag-based studies subsequently expanded to measure adult returns, presumably because of the unique ability to completely enumerate returning adults as they ascend fish ladders. SAR data sets are now generated for many yearling and subyearling Chinook populations (McCann et al., 2018) and as a result PIT tags have largely supplanted CWT tags for estimating SARs in the Columbia River basin. Dividing estimated smolt counts at the dams in the ocean entry year into the returning adult counts in subsequent years provides the SAR.

PIT tag-based SAR estimates show that recent SARs are higher than in the 1980s and 1990s but are generally low compared to historical levels, where available (Fig. 2) and track well with CWT-based estimates for individual populations (Fig. 6); however, our results indicate that PIT tag-based estimates for Columbia River basin Chinook are overestimated relative to CWT-based estimates for yearling Chinook and underestimated for subyearling Chinook (Fig. 6). Despite being consistent for individual populations, the two methods are therefore not inter-convertible. There are two reasons for this. First, for dam-to-dam estimates (e.g., Lower Granite Dam exiting smolts to Lower Granite Dam returning adults) the survival losses incurred upstream of the dam can vary substantially between populations (Faulkner, Widener, Smith, Marsh, & Zabel, 2017). Unless census points are located at the start and end of the migration period, the amount of excluded upstream survival acts as a population-specific random variable influenced by the excluded distance. This is true for essentially all published PIT-based SAR data (McCann et al., 2018) and for some CWT-based SAR estimates for wild populations, where smolt abundance is censused after migration has started (e.g., McPherson et al., 2010).

The second reason is that Chinook harvested in fisheries prior to return are not accounted for in PIT tag-based estimates. Authors have previously noted that PIT tag-based SAR estimates do not include harvest (Marmorek & Peters, 2001; McCann et al., 2018) and recommendations have recently been made to incorporate harvest (ISRP, 2019, p. 22), but neither the magnitude of the harvest nor the variability over time has been recognized. The result is that PIT tag-based

SARs represent the surviving adults left over from the operation of multiple fisheries operating over several years. So although PIT tag-based estimates of juvenile survival in the hydrosystem appear reliable, the influence of commercial, sport, and tribal fisheries on adult returns is large, and therefore PIT-based SARs likely do not provide a credible measure of smolt-to-adult survival but rather estimates of escapement from the fisheries to the river.

Harvest and PIT-based SARs

The potential of PIT tags to identify all returning adults to the Columbia River is compromised by the inability to identify PIT-tagged fish in the harvest. Ocean harvest rates on Columbia River basin yearling (Spring) Chinook stocks are ≤2% (Schaller et al., 1999; Waples et al., 2004), presumably because maturing Spring Chinook cross the continental shelf only near their natal river mouth on return and are not exposed to the many coastal fisheries operating along the shelf; however, yearling Chinook harvests in freshwater are still substantial (Fig 7). Harvest rates for Upriver Spring Chinook increased from 10% to 20% of the number arriving at the river mouth over the 1998-2010 period (PFMC, 2019). Not accounting for this river harvest results in underestimating the true SAR by ca. 10% in 1999 (near the beginning of the PIT tag record) and 25% in the more recent years of the record. For other yearling stocks the correction is larger.

For subyearling Chinook, which are much more heavily harvested, PIT-based SAR estimates likely understate survival by 300-400% in recent years. For example, Lyons Ferry (Snake River) subyearling Chinook harvest rates rose from a low of ~20% in 2004 to >70% in 2012. These values imply correction factors increasing from 1.25X to >3X over eight years.

The varying patterns of increase in harvest rates towards the most recent years of the record are particularly important because PIT tag-based SAR estimates do not reflect the higher harvests of recent years and therefore understate the improvements in adult survival that actually occurred. Given the variability in harvest rates over time and between populations, a reliable correction factor to account for harvest will be difficult to achieve for PIT tag-based SAR estimates, while leaving these estimates uncorrected for harvest results in a substantial downwards bias in survival estimates (Fig 6).

Another challenge with using PIT tag-based SAR estimates to set quantitative recovery targets for Columbia River basin Chinook (e.g., 2-6% SAR) is that the fisheries management strategy is currently divorced from these goals. Under the terms of the renegotiated Pacific Salmon Treaty, beginning in 1999 coastwide management of ocean fisheries for Chinook is explicitly abundance-based (Caldwell, 1999; Miller, 2003): fisheries are intensified when abundance is high and restricted when low. Consequently, PIT-based SAR estimates will inaccurately reflect survival if managers identify increases in abundance and increase harvest rates—which is precisely what the treaty dictates they should do. In fact, if managers had perfect control of ocean fisheries survival changes would never be reflected in PIT tag-based SAR estimates because any change in abundance would simply be compensated for by altering harvests. In practice, over or under-harvesting is likely, so PIT-based SAR fluctuations will also reflect the inability to perfectly manage fisheries. Even for Snake River Spring Chinook, where harvest rates are lowest and the inter-annual fluctuations in harvest are on the order of 10-20% (Fig. 6), survival fluctuations of this size would generally be considered significant. That PIT tag-based SAR fluctuations may simply reflect limitations inherent to the treaty is of concern and appears to be unrecognized. Equally important, expensive changes to the operation of the Federal Columbia River Power System intended to improve survival may benefit the fisheries without credit accruing to those bearing the costs. In future, closer coordination is advisable between the managers implementing abundance-based harvest in the various fisheries and the biologists assessing the impact of Columbia River basin hydropower operations on survival.

CONCLUSIONS

The policy implications of Chinook salmon SARs falling to about 1/3rd of early levels and converging to similar levels nearly everywhere along the west coast of North America are profound. Current efforts to conserve salmon populations assume that restoring habitats modified by anthropogenic factors (e.g., dams, dykes, forestry, road culverts, salmon farms in the coastal ocean) will improve salmon returns and at least partially compensate for worsening ocean conditions (Roni, 2019). However, if survival also falls by roughly the same amount in regions with nearly pristine freshwater habitats (SE Alaska, north-central British Columbia), it is difficult to argue for a major role of regional factors in causing the decline.

Given the geographically widespread collapse in survival to numerically similar levels and the steadily increasing effort devoted to survival monitoring for salmonids (Fig. 8), the fisheries community need to re-assess several core conservation assumptions. Of primary importance is the actual effectiveness of freshwater habitat restoration initiatives when northern populations with nearly pristine freshwater conditions have similar SARs. The resulting policy questions range from the prospect of successfully feeding killer whales with increased hatchery Chinook production, the hypothesized suppressive effect of salmon aquaculture (salmon farming) on wild salmon stocks, to the real role of dams in the demise of endangered Snake River salmon stocks.

As declining survival has reduced adult return rates, there has been mounting effort to increase monitoring. However, we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. In addition, some survival time series exclude variable proportions of upstream survival for both smolts and adults. Unless smolt counts are taken at the hatchery (or at the initiation of migration for wild smolts) and adult counts occur on the spawning grounds, variability is introduced into survival estimates because different amounts of the migratory life history are incorporated for different populations. Exactly where abundance is estimated during migration and what components of adult returns are included should be more carefully documented. A coast-wide review of the quality and consistency of smolt-to-adult survival methodologies is needed to ensure that the many initiatives now monitoring survival are achieving sufficient accuracy to be useful.

Because of poor survival, the costs of hatchery supplementation are now extremely high. In Puget Sound, where the reported survival of subyearling (Fall) Chinook has fallen to significantly lower survival levels than the Snake River, the cost of hatchery operations to yield one sport-caught adult Chinook has increased from ~\$55 (USD) per fish in the 1970s to \$768 (yearlings) and \$392 (subyearlings) in the 1990s (Table 5 of Anonymous (2010); costs unadjusted for inflation). High costs of production are also noted in British Columbia, particularly for Upper Fraser River Chinook, where costs were estimated at \$380 (CDN) per returning adult in the 1980s (Winton & Hilborn, 1994). Given the similarity of the decline in survival, the economics of hatchery Chinook production are likely similar in other regions. Understanding the real drivers of poor survival might substantially improve the economics of hatchery production. The few regional hatchery programs with anomalously high SARs should be investigated to determine when in the post-release life history period survival is high as a first step to understanding why it is low elsewhere.

It is also important to more carefully consider the role of harvest. Harvest levels for some yearling populations are a considerable fraction of adult returns to the river, while for subyearling populations they are substantially larger than adult escapement. A key part of the renegotiation of the terms of the bilateral US-Canada Pacific Salmon Treaty in 1999 was securing coastwide agreement that managers would modify harvest in response to abundance. Unfortunately, what went unrecognized was the effect on the many Columbia River studies based on PIT tags. It is unclear whether the quality of reported harvest rate estimates is good enough for past PIT-based SAR estimates to be reliably converted into useful survival estimates. This is an important point because the basic ecological models used to inform the Environmental Impact Statements (EIS) for many ESA-listed Columbia River salmon stocks are calibrated using PIT tag-based SAR estimates (McCann et al., 2018; Zabel et al., 2008). The use of modern parentage-based genetic stock ID methods (Beacham et al., 2020; Freshwater et al., 2016; Hess, Matala, & Narum, 2011; Matala, Hess, & Narum, 2011; Satterthwaite et al., 2014) may allow apportioning harvest from the various fisheries to source populations with sufficient precision to be useful for survival analysis in the Columbia in the future. However, whether these methods can provide sufficient resolution for past harvest rate estimates to be incorporated into SAR estimate is unclear.

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Data Availability

All data used in the analysis are available without limitation from the Dryad open-access repository (doi:10.5061/dryad.w6m905qmm).

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Figures

Fig. 1. Map of the locations of Chinook salmon survival time series used in the analyses. Numbers inside symbols are keyed to the populations in Table S1. SEAK=SE Alaska/Northern British Columbia Transboundary Rivers; NCBC=North-Central British Columbia; WCVI=West Coast Vancouver Island; WAC=Washington Coastal; ORC=Oregon Coastal; SOG=Strait of Georgia; PS=Puget Sound; CA=California. (Figure appears in colour in the online version only).

Fig. 2. Time series of smolt-to-adult return (SAR) estimates for Chinook salmon plotted by source. (The on-line version of the figure supports substantial magnification to examine the details of each panel). Annual SAR estimates for hatchery (H), wild (W), and mixed hatchery-wild data sources (B) are shown, but regional loess curves of survival and associated 95% confidence interval use hatchery data only, colour coded by data source. In order to focus on the trends, a few SAR estimates have been clipped by restricting the y-axis maximum to near the loess curve maxima. Blank panels indicate regions where the life history type does not occur. The SAR 2-6% recovery target adopted for Snake River Spring Chinook is shown as a grey band. The timing of the major regime shifts starting in 1977, 1989, and 1998 are indicated by vertical dotted lines. The horizontal dotted line indicates 1% SAR. Note logarithmic y-axis. Sources correspond to Table S1 as follows: PSC CWT= PSC 2019; CSS PIT=McCann et al. 2018; Agency CWT=all other sources exclusive of Raymond 1998 and Michel 2019. CWT=coded wire tag; CSS=Comparative Survival Study, PIT= Passive-Integrated-Transponder; SEAK=SE Alaska/Northern British Columbia Transboundary Rivers; NCBC=North-Central British Columbia; WCVI=West Coast Vancouver Island; SOG=Strait of Georgia; PS=Puget Sound; WAC=Washington Coastal; LCOL=Lower Columbia River; MCOL=Mid-Columbia River; UCOL=Upper Columbia River, SNAK=Snake River; ORC=Oregon Coastal; CA=California. (Figure appears in colour in the online version only).

Fig. 3. Chinook survival (SAR) based on coded wire tags, disaggregated by population and region; all years combined. Central lines show medians, boxes show the inter-quartile range (central 50% of data points), whiskers bracket 1.5 times the interquartile range, and open circles identify outliers. Regional medians are computed using all populations and shown as vertical blue (hatchery) or gold (wild) lines, with Snake River medians overplotted as vertical red lines on all panels for comparison (H=solid red and W=dashed red). The 2-6% target recovery range for Snake River SARs is shown as a shaded band. The number of SAR estimates for each population is shown to the right. See Table S1 for definitions of population acronyms and Fig. 2 for region acronyms. H=hatchery; W=wild; HW=mixture. *Indicates data sets ending prior to 1998 (all data from Raymond (1998) and three Puget Sound data series from PSC (2019)). (Figure appears in colour in the online version only).

Fig. 4. Regional CWT-based SAR estimates for Chinook salmon normalized relative to Snake River SARs for the 2010-2014 period. Estimates above the horizontal black dotted line indicate higher survival than Snake River populations. Horizontal red lines show the empirical 5% and 95% percentiles on the sampling distribution of the normalized ratio. See Fig. S1 for SAR estimates normalized to all other regions. H=hatchery; W=wild. (Figure appears in colour in the online version only).

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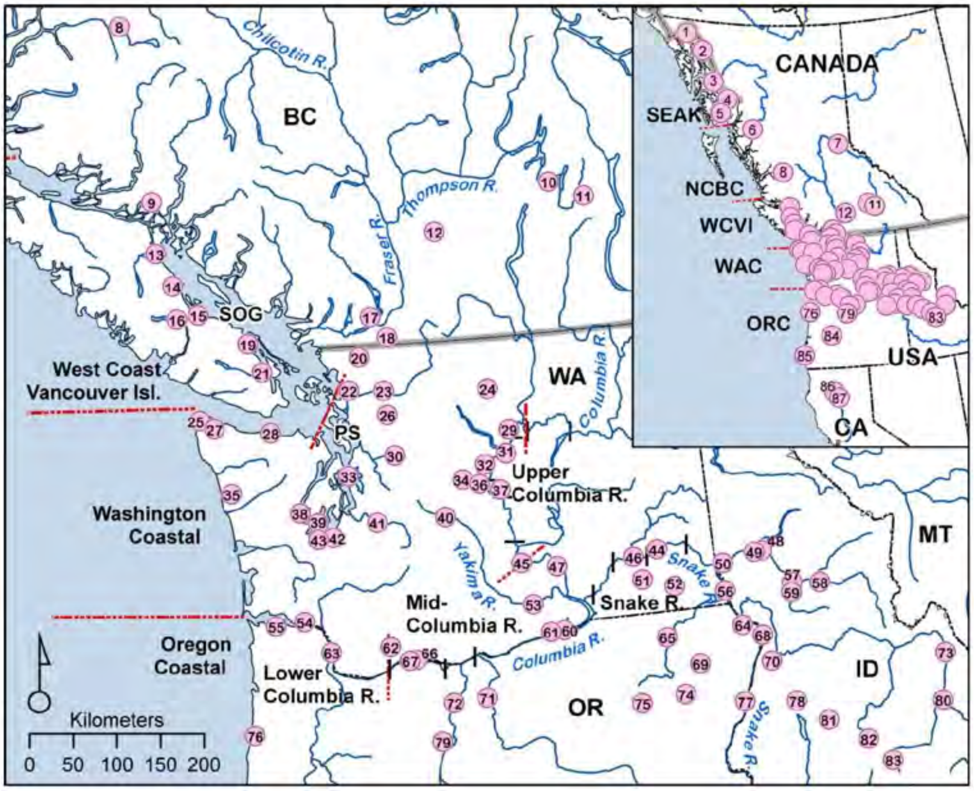
Fig. 7. Annual Columbia River Chinook harvest rate estimates, fitted loess trend lines, and associated 95% confidence intervals. The right-hand axis shows reported aggregate harvest before Chinook reach McNary Dam. The left-hand axis shows the corresponding value that PIT tag-based SAR estimates should be multiplied by to correct for exclusion of harvest; note log scale. Tributary harvests (i.e., above McNary Dam) are excluded. Substantial variation over time and between populations is evident after 1998 (vertical dashed line), when PIT tag-based survival estimation began. Data sources that present harvest estimates by brood year were converted to return year using the dominant year of return. See Table S2 for population names and references. (Figure appears in colour in the online version only).

Fig. 8. Increase in the number of annual SAR estimates used in this paper. The drop in monitoring evident in the most recent years probably reflects lags in data processing rather than a

decrease in effort. See Table S1 for specific populations included. (Figure appears in colour in the online version only).



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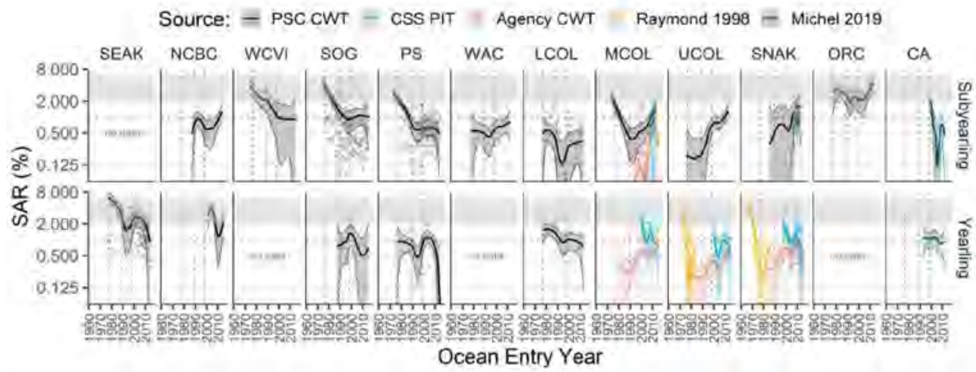

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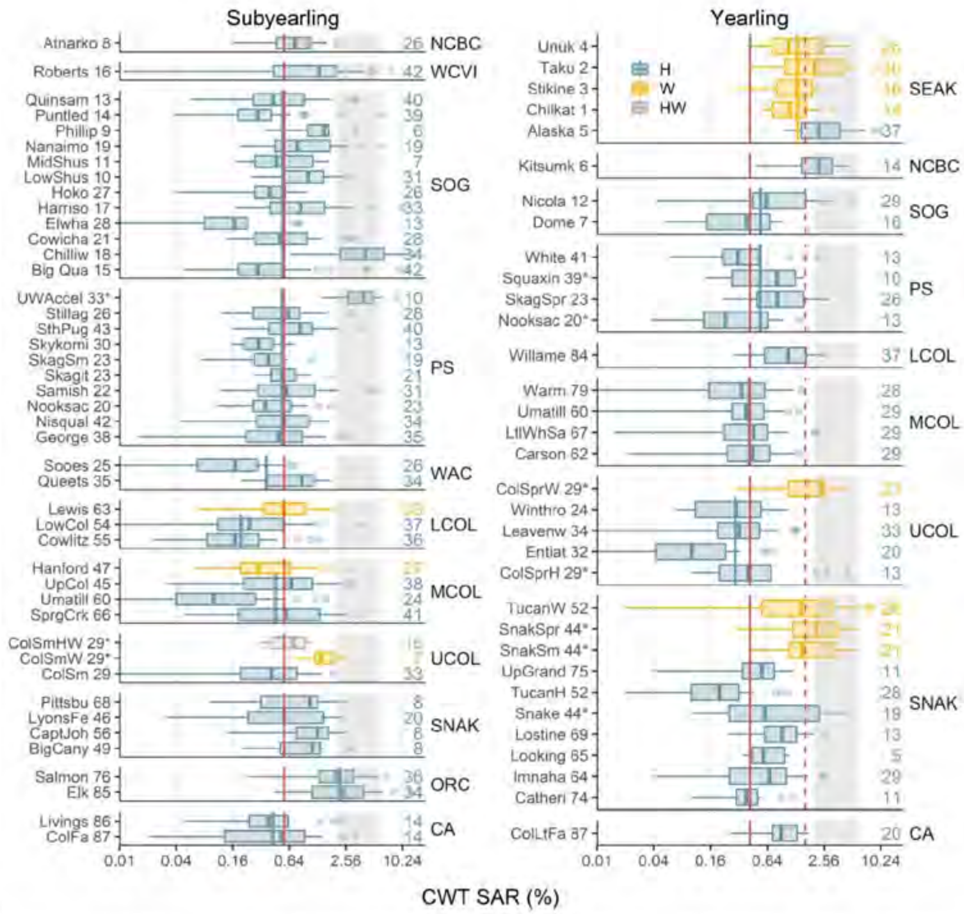

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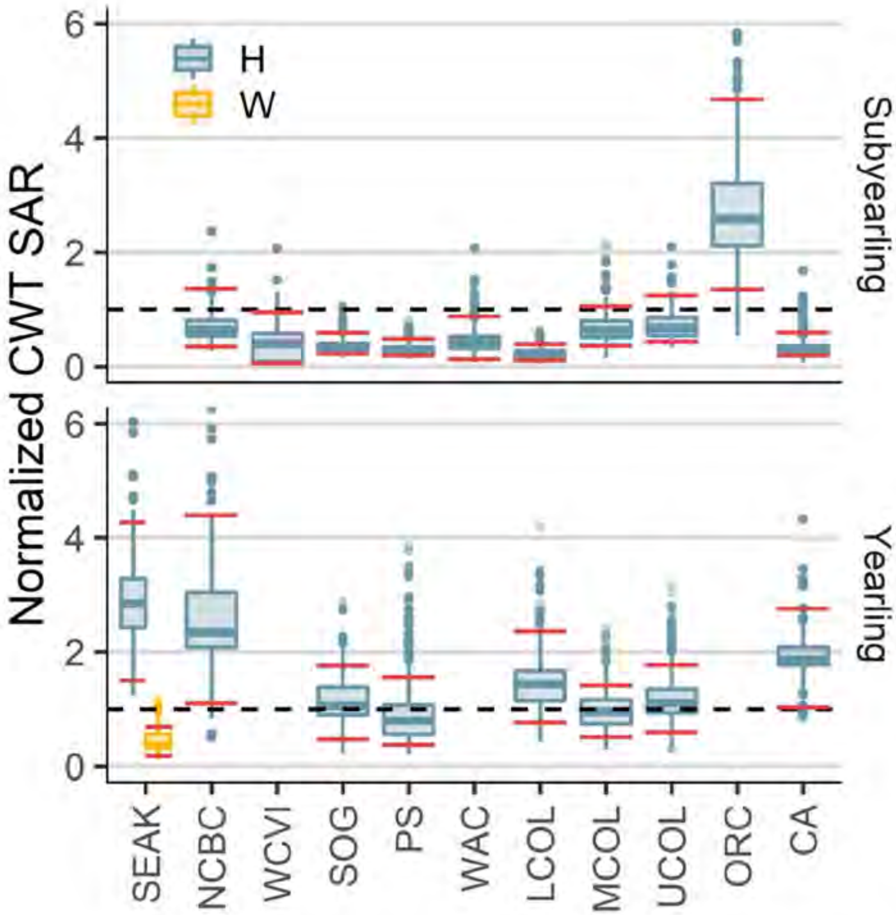

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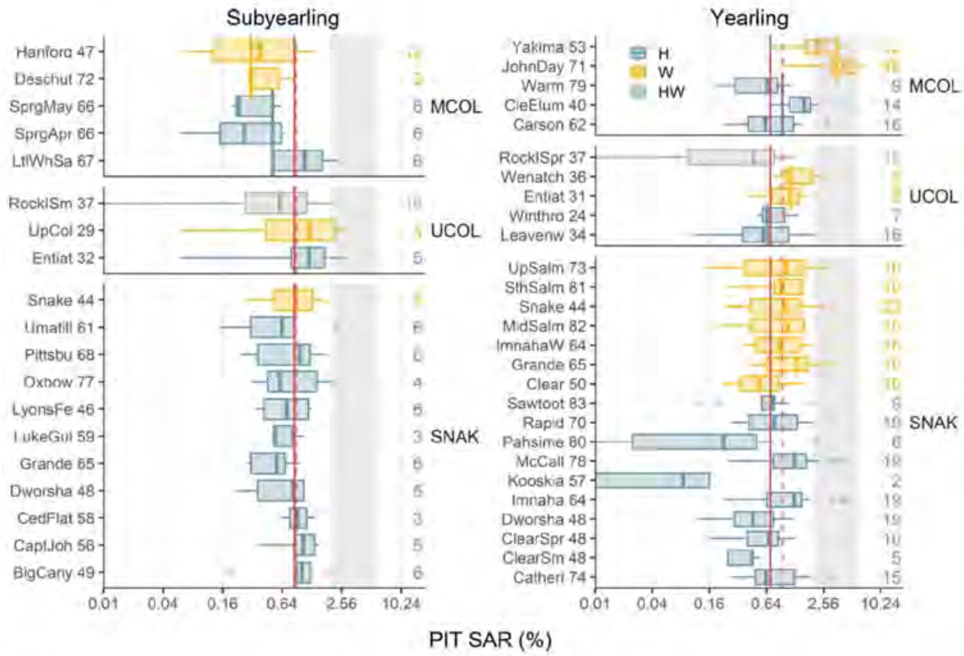

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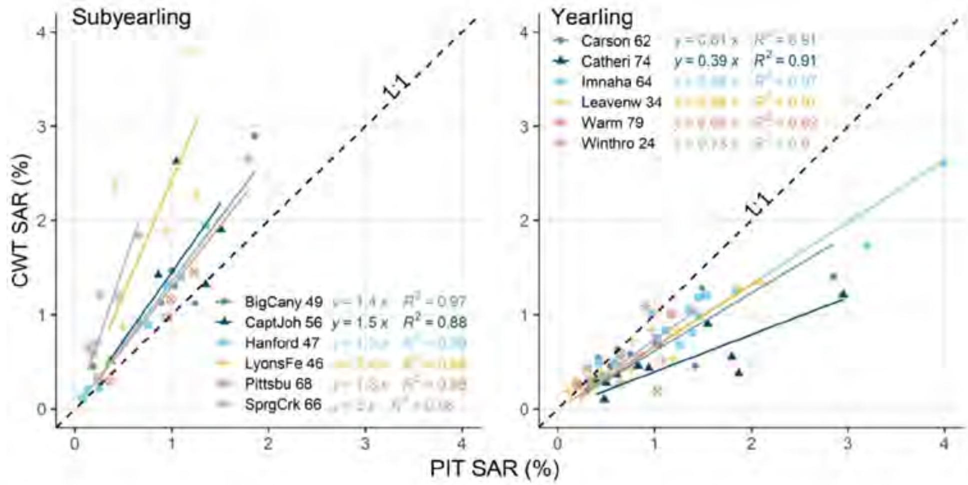

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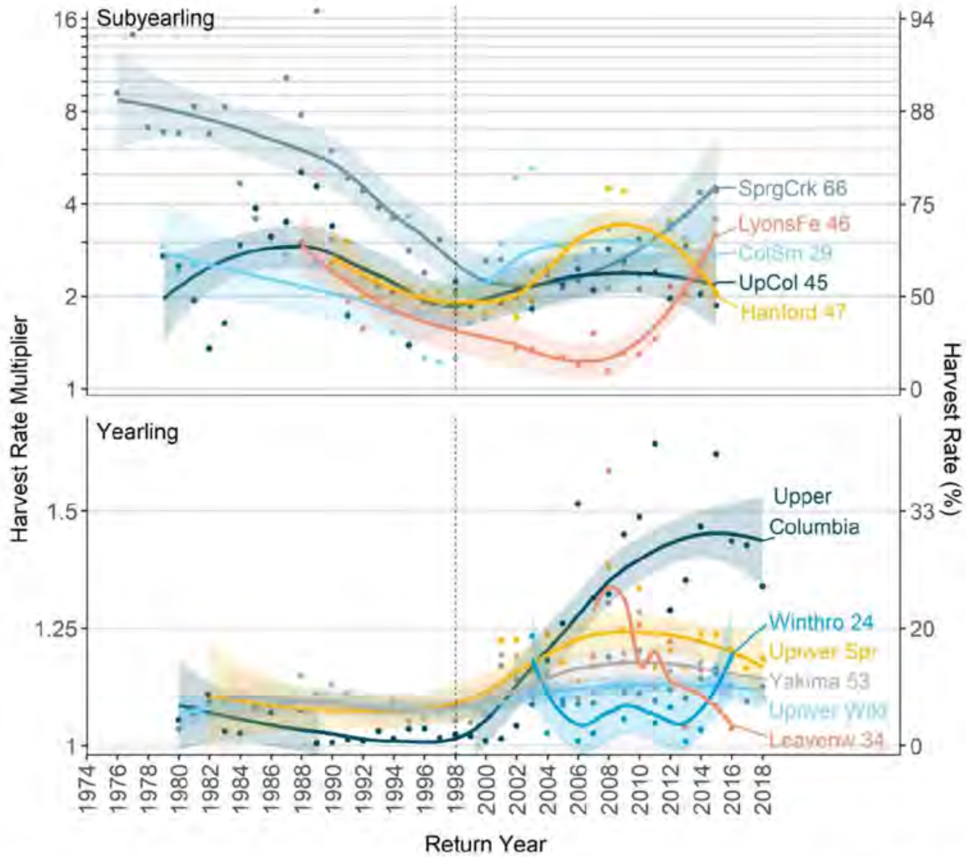

Fig. 7. Annual Columbia River Chinook harvest rate estimates, fitted loess trend lines, and associated 95% confidence intervals. The right-hand axis shows reported aggregate harvest before Chinook reach McNary Dam. The left-hand axis shows the corresponding value that PIT tag-based SAR estimates should be multiplied by to correct for exclusion of harvest; note log scale. Tributary harvests (i.e., above McNary Dam) are excluded. Substantial variation over time and between populations is evident after 1998 (vertical dashed line), when PIT tag-based survival estimation began. Data sources that present harvest estimates by brood year were converted to return year using the dominant year of return. See Table S2 for population names and references.

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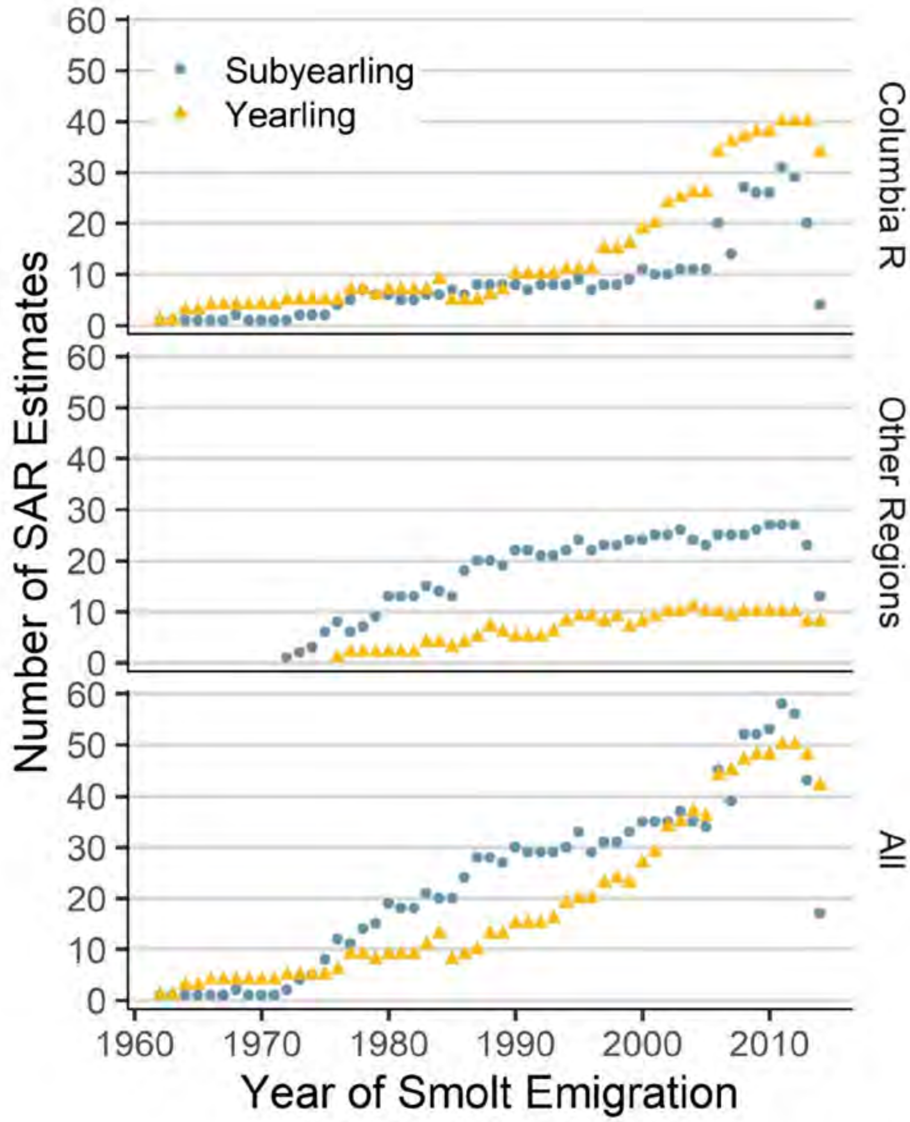

Fig. 8. Increase in the number of annual SAR estimates used in this paper. The drop in monitoring evident in the most recent years probably reflects lags in data processing rather than a decrease in effort. See Table S1 for specific populations included.

79x99mm (800 x 800 DPI)

From: Petersen,Christine H (BPA) - EWP-4

Sent: Fri Sep 25 16:50:47 2020

To: 'David Welch'

Subject: RE: Manuscript Accepted - Updates Approved FaF-20-Jun-OA-162.R1 [email ref: ENR-AW-1-e]

Importance: Normal

Hi David,

Congratulations! [redacted]

I spoke with Jody, and we would like to follow up with a phone call, but I need her to suggest the time and set it up. She has been briefing our upper management on your paper.

I am in Seattle area this week [redacted]). This rain is luckily putting out these fires. A couple years ago, it was BC suffering the worst wildfires. It is amazing how it is so wind driven - one of the fires came from the Warm Springs reservation area where it had been puffing along without serious danger during the previous month. A lot of these areas where the five recent fires spread are by the Willamette river reservoirs, and we have yet to see how intense they were - one of the TV stations showed the Detroit reservoir area, and parts of it made it look like the fire was rather patchy and did spare a lot of trees, however a few small towns suffered major losses of houses.

We will hopefully contact you next week to cover the manuscript and other things - Jody Lando will set it up.

I hope you have a nice weekend - I might try to do the north Cascades highway with family.
Christine Petersen

-----Original Message-----
From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, September 24, 2020 4:27 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: Manuscript Accepted - Updates Approved FaF-20-Jun-OA-162.R1 [email ref: ENR-AW-1-e]

Hi Christine--

After a few trivial requests concerning the processing of the final paper, the paper has now been formally accepted and scheduled for publication. (See the email below; last week they asked us to change the title of the paper from "A Review..." to "A Synthesis..." for example. A few others of similar import had to be done as well, such as including the Latin name for the family of fish we were dealing with (Salmonidae...sigh!).).

Anyway, all that is done & dusted. I would expect from a message I received a month or two ago that the actual publication will occur in 2-3 weeks from now, but at this point with Britain moving into major COVID lockdown anything is possible, I suppose. "Batten down the hatches" is perhaps the best advice I can give!

It would be useful to touch base on a few final issues. Is there a time that would work for a Zoom or Teams call?

David

P.S. Final (now formally accepted) version of the paper is attached for your information. Nothing of substance has changed, as I indicated, apart from the title.

-----Original Message-----
From: Sue Hart <onbehalfof@manuscriptcentral.com>
Sent: September 24, 2020 4:10 PM
To: David Welch <David.Welch@Kintama.com>
Subject: Manuscript Accepted - Updates Approved FaF-20-Jun-OA-162.R1 [email ref: ENR-AW-1-e]

24-Sep-2020

Dear Dr. Welch:

Manuscript id: FaF-20-Jun-OA-162.R1

The final files that you submitted for your manuscript have been checked and have been found to be suitable for publication and so will be forwarded to the publisher shortly.

Publication in the journal is free and colour figures may be published online free of charge. There is, however, a cost for publishing colour figures in the print version.

If you supply colour figures you will be invited to complete a colour charge agreement in RightsLink for Author Services once the paper is published on Early View. You will be given the option of paying immediately with a credit or debit card, or you can request an invoice. If you choose not to purchase colour printing, the figures will be converted to black and white for the print issue of the journal.

Due to a change in the way in which proofs are presented to authors it may currently be the case that not all corrections that you make are transfered correctly to the final print-ready version.

Early View will be the first opportunity for you to see the final print-ready version unlike the former proof system which allowed one to see, read and edit a print-ready version of the paper.

We therefore suggest that you check your Early View paper carefully for any errors at the earliest opportunity and contact Production if there are any problems.

Sincerely,
Fish and Fisheries Editorial Office

From: Plemons,Jennifer E (CONTR) - EC-4

Sent: Thu Oct 01 13:03:15 2020

To: Plemons,Jennifer E (CONTR) - EC-4

Subject: Draft Environmental Assessment available for the proposed Columbia River Basin Tributary Habitat Restoration Environmental Assessment

Importance: High

Hello!

The Bonneville Power Administration and the Bureau of Reclamation will be extending the public comment period on the draft of the **Columbia River Basin Tributary Habitat Restoration Environmental Assessment** until October 16, 2020 to ensure sufficient time for interested parties to comment.

To view the document, please visit the project website at: *http://www.bpa.gov/goto/TribProgrammatic.*

Thank you for your interest.

Jennifer Plemons
(ContR) Flux Resources

Program Support Specialist II | Environmental Planning & Analysis (EC-4)

Bonneville Power Administration
bpa.gov | P 503-230-3837

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From: David Welch

Sent: Mon Oct 05 12:37:16 2020

To: Rich Zabel (rich.zabel@noaa.gov)

Cc: David Welch; Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Subject: [EXTERNAL] Important--Publication of Chinook Survival paper in Fish & Fisheries

Importance: High

Attachments: FaF-20-Jun-OA-162.R1_Proof_fl (23 Sept 2020).pdf; Kintama-Summary of Coastwide Chinook Survival Study (FINAL).pdf

Rich-

I am giving you a courtesy heads up of the impending publication of our new paper on the coast-wide survival of Chinook in Fish & Fisheries. I do not have an exact date as yet, but anticipate publication sometime this month.

I believe you are aware of our general scientific conclusion that Chinook SARs have fallen to about the same low level coastwide. However, the reviewers of an earlier version of this paper, submitted to PLoS ONE 20 months ago, criticized some elements of the original analysis. This caused us to dig deeper into how survival estimates are developed and how comparable they are between CWT & PIT-tag based methodologies. The revised paper, to appear in Fish & Fisheries in the next few weeks, also reports on the results of this additional analysis.

The results are going to be explosive for the Columbia River basin; particularly so because they are (unfortunately) appearing after the most recent BiOP review has completed. I am writing you now so that you & your colleagues at NOAA can have some time to assess the results and decide on your messaging, because the results indicate that ***both*** the FPC & NOAA's PIT tag-based survival analyses are compromised.

We report three major findings in our paper (attached):

1. Chinook survival has fallen by 65% virtually everywhere along the west coast of North America (and possibly in Asia as well), to the same low level. Crucially, the survival level of Snake R Chinook is not different from anywhere else, so it is hard to argue that the dams play much of a role in determining returns to the Snake R. (This conclusion hasn't changed from the earlier manuscript).

2. ***Crucially, we found that PIT tag-based survival estimates in the Columbia River basin are grossly in error.*** This applies to both the Fish Passage Center and NOAA's estimates, and occurs because harvest rates of Chinook are not negligible as originally assumed. We have developed a short summary for policy makers, attached, which explains why this is important. The key point is that when we were trying to reconstruct the FPC's survival estimates (they stonewalled us when we originally asked them for their data) we found that harvest rates of Columbia River stocks was large and time-varying, not "*always negligible*", as assumed. I don't see an easy way to fix this issue and it thus contaminates the SAR estimates that all of the BiOPs are based on.

3. **Making matters worse, there is a negative feedback system at play here.** Harvest managers are directed under the terms of the Pacific Salmon Treaty to manage the fishery in such a way that their mandate is to increase harvest when Chinook survival is high (& fish are abundant) and reduce harvest rates when Chinook survival is low (& Chinook are sparse). However, this behaviour will essentially obscure any meaningful signal of how modification of the dams' operations influences adult returns. So, to take just the most glaring example,

> the current management system of increasing spill & TDG to improve adult returns is based on Steve Haeseker's original analysis (& more recent similar analyses by the FPC) which predict much better adult returns by spilling more water--management based on a weak correlation projected far outside the range of real experience. To this already questionable approach we are showing that the SARs data that the analysis is based on may be completely wrong.

Unfortunately, this finding will affect NOAA's analyses as well. You had indicated in response to an ealier email of mine that problems with the FPC's PIT tag-based SAR analyses wouldn't affect NOAA's results because you folks just pulled your data from PITAGIS, and therefore weren't relying on the FPC's analyses. But the problem we identified is that harvested fish with PIT tags aren't censused, so they aren't in PITAGIS, so I think the same issue will apply to NOAA's analyses. (If I am wrong, please let me know).

I am around this week if you want to discuss this further, but I am giving you some advance notice of the cpntents of the paper because the just signed-off BiOP will be largely based on analysis of adult returns. Unless I am incorrect in my understanding of how you use the PITAGIS database, this problem will also affect your organization's results as well.

Regards, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +(b)(6) [redacted]

A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha*, Salmonidae)

Short title: Coast-wide survival of Chinook

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Abbreviations

BC- British Columbia, Canada

CSS- Comparative Survival Study

CWT-Coded Wire Tag

PSC- Pacific Salmon Commission

SAR-Smolt to Adult Return Rate (Survival)

PIT- Passive Integrated Transponder

Abstract

We collated smolt-to-adult return rate (SAR) data for Chinook salmon from all available regions of the Pacific coast of North America to examine the large-scale patterns of salmon survival. For consistency, our analyses primarily used coded wire tag-based (CWT) SAR estimates. Survival collapsed over the past half century by roughly a factor of three to ca. 1% for many regions. Within the Columbia River, the SARs of Snake River populations, often singled out as exemplars of poor survival, are unexceptional and in fact higher than estimates reported from many other regions of the west coast lacking dams. Given the seemingly congruent decline in SARs to similar levels, the notion that contemporary survival is driven primarily by broader oceanic factors rather than local factors should be considered. Ambitious Columbia River rebuilding targets may be unachievable because other regions with nearly pristine freshwater conditions, such as SE Alaska and northern BC, also largely fail to reach these levels. Passive integrated transponder (PIT) tag-based SAR estimates available for Columbia River basin populations are generally consistent with CWT findings; however, PIT tag-based SARs are not adjusted for harvest which compromises their intended use because harvest rates are large and variable. More attention is needed on how SARs should be quantified and how rebuilding targets are defined. We call for a systematic review by funding agencies to assess consistency and comparability of the SAR data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast. *(250/250 words)*

Keywords:

Columbia River, dams, delayed mortality, marine survival, smolt-to-adult return, Snake River

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References

INTRODUCTION

The abundance of salmon (family Salmonidae) in the North Pacific has reached record levels (Irvine et al., 2009; Ruggerone & Irvine, 2018; Schoen et al., 2017); however, most of the increase is in the two lowest valued species (pink, *Oncorhynchus gorbuscha,* and chum, *O. keta*) in far northern regions, at least in part due to ocean ranching (Ruggerone & Irvine, 2018). In contrast, essentially all west coast North American Chinook (*O. tshawytscha*) populations including Alaska are now performing poorly with dramatically reduced productivity (Dorner, Catalano, & Peterman, 2017; Ohlberger, Scheuerell, & Schindler, 2016).

The situation in North America is similar for most southern populations of coho (*O. kisutch*) (Logerwell, Mantua, Lawson, Francis, & Agostini, 2003; Zimmerman et al., 2015), sockeye (*O. nerka*) (Cohen, 2012; COSEWIC, 2017; Peterman & Dorner, 2012; Rand et al., 2012), and steelhead (*O. mykiss*) (Kendall, Marston, & Klungle, 2017). These poorly performing species are of higher economic value and the focus of indigenous, sport, and commercial fisheries.

The historical pattern of declines in salmon abundance (steeper in the south, less so in the north) were originally assumed to reflect a freshwater anthropogenic cause because of the greater degree of freshwater habitat modification in the more populous southern regions (Allendorf et al., 1997; Nehlsen, Williams, & Lichatowich, 1991). The growing appreciation of ocean climate change (Hare, Mantua, & Francis, 1999; Mantua, Hare, Zhang, Wallace, & Francis, 1997; Mantua & Hare, 2002) has brought an awareness of the role of the ocean in influencing salmon survival. As Ryding and Skalski (1999, p.2374) noted two decades ago, "*It is becoming increasingly clear that understanding the relationship between the marine environment and salmon survival is central to better management of our salmonid resources*".

Unfortunately, our understanding of survival during the marine phase remains extremely limited, so there has been little change in management strategy beyond the essential first step of reducing harvest rates in the face of falling marine survival. The recent recognition of the decline in Chinook returns across essentially all of Alaska (ADF&G Chinook Salmon Research Team, 2013; Cunningham, Westley, & Adkison, 2018; Ohlberger et al., 2016; Schindler et al., 2013) and the Canadian portion of the Yukon River (Bradford, von Finster, & Milligan, 2009), where anthropogenic freshwater habitat impacts are negligible, is another example of how simple explanations are potentially flawed. If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon.

Formal smolt-to-adult return (SAR) or survival recovery targets have not been specified for any region of the west coast of North America outside the Columbia River basin. Within the extensively dammed Columbia River basin, the Northwest Power and Conservation Council's Fish and Wildlife Program (NPCC) set rebuilding targets for SARs at 2%-6% (McCann et al., 2018, p. 4), roughly the survival observed in the 1960s prior to the completion of the eight-dam Federal Columbia River Power System (FCRPS) (Raymond, 1968, 1979). The NPCC SAR objectives did not specify the points in the life cycle where Chinook smolt and adult numbers should be determined; however, one extensive analysis for Snake River spring/summer Chinook was based on SARs calculated as the proportion of smolts reaching the uppermost dam in the migration path that survived to return there as adults and jacks (Marmorek, Peters, & Parnell, 1998): "*Median SARs must exceed 4% to achieve complete certainty of meeting the 48-year recovery standard, while ... A median of greater than 6% is needed to meet the 24-year survival standard with certainty*" (p. 41). Although not explicitly stated, this seems to be the basis for setting the 2-6% rebuilding standard for the Columbia River.

In this paper, we collate Chinook SAR time series for the west coast of North America to document broad patterns in survival. The SAR is the three-fold product of freshwater smolt survival during downstream migration multiplied by the marine survival experienced over two to three years in the ocean and multiplied by adult freshwater survival during the upstream migration to the final census point. Survival should include animals removed by the fisheries; however, as we show later, harvest is not included in PIT tag-based survival estimates, which has significant implications.

There are two major methods of estimating survival on the west coast of North America, one using Coded Wire Tags (CWT) and another using Passive Integrated Transponder tags (PIT). We assessed whether the SAR estimates using these methods could be pooled for analyses but concluded that they are not inter-convertible. The CWT program is more geographically extensive; thus, our primary analysis uses the CWT-based estimates for coast-wide survival comparison. However, within the Columbia River basin, PIT tags have been widely relied upon for over two decades as the primary source of survival data, so we separately analyzed the survival patterns reported using the PIT tag methodology. The collated data are presented by region, smolt age at outmigration, stock, and/or year of outmigration. We then tested the current similarity of SAR estimates across regions using data from the five most recent years of available data. Given the widely recognized poor survival of Snake River Chinook salmon, resulting in their listing under the US Endangered Species Act (NMFS, 2017a, 2017b), many of our analyses compare regional survival to that of the Snake River region. We show that, overall, Chinook salmon survival (SAR) has decreased by roughly the same amount everywhere along the west coast of North America and has now reached similar or lower survival levels than Snake River stocks.

In the process of assessing how well survival estimates from CWT and PIT-based tagging methodologies can be compared, we found that there were large population-specific changes in harvest rates over time which are not incorporated into PIT tag-based survival estimates. This previously unrecognized limitation of PIT tagging methodologies is critical to current conservation efforts in the Columbia River basin because of changes to the terms of the US-Canada Pacific Salmon Treaty, which we outline.

Finally, we examined the CWT and PIT tag SAR datasets to evaluate the broader evidence for "delayed mortality", an important theory that argues that the greater dam passage experienced by Snake River stocks predisposes these populations to lower subsequent survival after migration out of the hydropower system than populations not migrating through the Snake River dams.

At the broadest level, the major implication of our results is that most of the salmon conservation problem is determined in the ocean by common processes. Attempts to improve SARs by addressing region-specific issues such as freshwater habitat degradation or salmon aquaculture in coastal zones are therefore unlikely to be successful. Given the importance of these conclusions, we call for a joint systematic review by major funding agencies to further assess the broader consistency and comparability of SAR data with our findings.

METHODS

Data sources

Most survival rates of Pacific salmon are based on mark-recapture efforts, where juveniles are "marked"— implanted with either coded wire tags (CWT) or passive integrated transponder (PIT) tags—and recaptured in the fishery or detected upon return to the river. CWT technology dates back to the 1960s. A review is provided by (Johnson, 1990); the application of the methodology to coastal marine migrations of Coho and Chinook is described by Weitkamp (2009) and Weitkamp & Neely (2002) and to measuring harvest and survival by ADF&G Chinook Salmon Research Team (2013), Bernard & Clark (1996), and Chinook Technical Committee (2014). The CWT tag is implanted in the nose cartilage of smolts. If recaptured in the fishery, the fish must be dissected to recover the tag and the tag code must be read with a microscope. In contrast, PIT tags first came into widespread use in the Columbia River Basin in 1997. They are long-lived but short-distance radio-frequency tags that can successfully transmit their unique ID code when within <0.5 m of a detector (Prentice, Flagg, & McCutcheon, 1990a; Prentice, Flagg, McCutcheon, & Brastow, 1990b; Prentice, Flagg, McCutcheon, Brastow, & Cross, 1990c; Skalski, Smith, Iwamoto, Williams, & Hoffmann, 1998). The short detection range essentially limits the use of PIT tags to either small, shallow streams or the Columbia River dams, which channel sufficient tagged individuals close to the detectors to generate useful survival estimates.

We collated SAR time series for Chinook from several sources (Supplementary Table S1). For CWT-based estimates, the primary data are the survival estimates for the indicator stocks used by the Pacific Salmon Commission (PSC). These datasets are formally submitted to the PSC by a wide variety of management agencies under the terms of the bilateral US-Canada Pacific Salmon Treaty. We supplemented these with CWT-based SAR time series published in the primary or secondary literature or calculated directly from the Pacific States Marine Fisheries Commission's CWT database. Together, these data sets represent California, Oregon, Washington, British Columbia, and southeast Alaska. Early SAR estimates for the Upper Columbia and Snake Rivers are based on freeze-branding (Raymond, 1988), but were included because they are the only estimates available for the time period when SARs collapsed in those regions. Finally, because of their historical importance to monitoring in the Columbia River we compiled and separately analyzed the PIT tag-based SAR estimates reported by the Comparative Survival Study (McCann et al., 2018).

Because SAR data are typically log-normally distributed, we primarily report the median, as this is equivalent to the geometric mean some authors use. (A simple proof of this statement is to note that after log-transformation the mean of log-normal data will have 50% of the data above and below it). We therefore use the simpler terminology both for clarity and because the median is invariant under log-transformation, which is not true for the mean.

Pacific Salmon Commission (CWT-based estimates)

The PSC is a bilateral treaty organization between the US and Canada coordinating management of Pacific salmon from Cape Falcon, Oregon, north to Cape Suckling, Alaska. The data are contributed to the Chinook Technical Committee of the PSC by the various government agencies responsible for conducting the individual monitoring programs. This database was the source of CWT-based Chinook survival estimates for all regions outside the Columbia River basin and for a few stocks located in the Columbia River basin.

The PSC database provides several measures of SAR. We used their estimates calculated as the sum of adults returning at all ages or caught in the fisheries, uninflated for losses to natural mortality for Chinook remaining at sea for longer than two years:

$$SAR_{i,j} = \frac{\sum_{k=2 or 3}^{max\ age} \left(\sum_{l=1}^{n} (F_{i,j,k,l} + IM_{i,j,k,l}) + Esc_{i,j,k} \right)}{\mathrm{Rel}_{i,j}}$$

where $F_{i,j,k,l}$ = the tags recovered in fishery l, for age k, from brood year j, of stock i that are expanded for the fraction of the catch sampled; $IM_{i,j,k,l}$= the incidental mortalities; and $Esc_{i,j}$ = the number of tags recovered in the escapement including hatchery and spawning ground recoveries that are expanded for the fraction sampled. Columbia River stocks also have an inter-dam loss (IDL) calculation, so fish (or tags) returning to the river are adjusted upward to account for in-river mortality (Chinook Technical Committee, 2018).

CWT-based SAR estimates for hatchery-origin fish generally cover the period from hatchery release until adult return to the hatchery and/or spawning grounds and are compensated for harvest (i.e., mortalities due to harvest are included as survivors). Exceptions include five Alaskan hatcheries used in our analysis which are located at sea level and which release smolts directly into the ocean after several weeks of seawater acclimation in holding pens, eliminating losses in freshwater (see later). For wild stocks, juvenile fish are captured and tagged during downstream migration, and therefore some of the CWT-based survival estimates for wild stocks are biased high because they can exclude survival losses occurring in the initial phase of the migration upstream of the census point (McPherson, Jones, Fleischman, & Boyce, 2010). Other miscellaneous notes about this dataset are recorded as footnotes at the bottom of Supplementary Table S1.

Agency estimates (CWT-based estimates)

The PSC does not include indicator stocks for California or for yearling Chinook from the Columbia River, presumably because these stocks are not relevant to international management. We therefore included published estimates for fall, late-fall, and winter Chinook runs from the Sacramento River in California (Michel, 2018). For Columbia River basin spring Chinook, we collated some annual reports produced by individual hatcheries in the basin and/or contacted the hatcheries directly to build up a partial inventory of CWT-based SAR estimates for Chinook.

These supplemental estimates were calculated similarly to those done by the PSC but are unexpanded for incidental mortality (or inter-dam loss in the Columbia River). Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish. See Supplementary Table S1 for details.

Pacific States Marine Fisheries Commission estimates

All CWT release and recovery data are submitted to the Regional Mark Processing Center hosted by the Pacific State Marine Fisheries Commission, which maintains the online Regional Mark Information System (RMIS) to facilitate exchange of CWT data. We investigated this source; however, we could not verify that adult return numbers from all possible significant components were correctly incorporated and expanded for sampling effort. Ideally, adult returns should include hatchery rack returns (adults taken for brood stock), adult escapement to spawning grounds, and immature or maturing individuals caught in all fisheries (sport, commercial, tribal) and locations (at sea, in-river). For this reason, we focused on the PSC and Agency estimates described above. We used RMIS only for Entiat Spring Chinook (UCOL) after consulting with Entiat Hatchery biologists on the integrity of the data set (G. Fraser, *pers. comm.* USFWS, Leavenworth, WA. gregory_fraser@fws.gov).

Raymond (1988) estimates

Data on survival in the 1960s to early 1980s period for the Snake and Upper Columbia Rivers was based on mark-recapture estimates of the abundance of a mixture of freeze-branded hatchery and wild smolts passing the first dam encountered each year (Raymond 1988). An essentially complete enumeration of adult returns was possible at upstream dams several years later because the adults must ascend fish ladders and estimates were compensated for harvest. These SAR estimates are inflated relative to the CWT-based estimates described above because they do not include migration losses from the time downstream migration is initiated until the smolts are censused at the dams and also exclude adult upstream losses between the dam and the spawning grounds. Nevertheless, this dataset is important because it incorporates the period of relatively high survival in the 1960s and early 1970s and the period when survival collapsed, which was attributed primarily to dam construction. We used these estimates in conjunction with the CWT estimates for a more complete time series.

Comparative Survival Study (PIT tag-based estimates)

PIT tags have largely supplanted CWTs in the Columbia River basin because of the ability to measure smolt survival between dams and estimate SARs. We used the estimates of overall SAR from Chapter 4 of the Fish Passage Center's Comparative Survival Study (McCann et al., 2018) which are essentially the number of adults returning to the uppermost FCRPS dam with detection capability (Lower Granite, McNary, John Day and/or Bonneville dams depending on the population) divided by the estimated number of PIT-tagged smolts surviving to their uppermost dam during downstream migration. For example, for most Chinook salmon originating from the Snake River basin, the SAR is estimated from Lower Granite Dam back to Lower Granite Dam.

When estimates were available for multiple segments, we selected the SAR covering the greatest extent of the migratory life-history (i.e., smolt releases and adult returns to the uppermost dam available in the Columbia River basin), and we used SAR estimates that included jacks when available. In the mid-Columbia region, SAR estimates with jacks were sometimes available only for a shorter migration segment; in these cases we selected the SAR data sets representing the longer migration segment but excluding jacks because this was most similar to the CWT survival estimates. PIT tag-based SARs do not incorporate losses due to harvest (McCann et al., 2018, p. 95) because the commercial and sport catch is not monitored for PIT tags.

Because PIT tag-based SAR estimates contain several limitations that are problematic to the interpretation of survival (particularly lack of harvest information), we use these estimates only as a secondary validation of the major conclusions.

Division by life history

Chinook salmon display two major juvenile life history types (subyearling and yearling) that correspond with adult run-timing (fall or spring, respectively). These life history types are examined separately in our analysis because there are important ecological differences between them (see reviews by Riddell et al. (2018) and Sharma & Quinn (2012)) which likely influence survival. We review the general characteristics below but note that this simple picture is more complicated due to hatchery rearing practices and natural variability.

Subyearling/fall populations are widely distributed in low gradient coastal streams or the lower mainstem of major rivers but are absent from Alaska. They migrate to the ocean within a few months of hatching and almost certainly remain as long-term residents of the continental shelf off the west coast of North America where they are exposed to commercial and sport harvest in coastal marine waters over multiple years (Sharma & Quinn, 2012). Survival of shelf-resident subyearling Chinook populations can therefore be significantly reduced by coastal fisheries that can harvest these animals over several years of marine life.

Yearling/spring populations are found in headwater tributaries of large river systems penetrating well into the interior of the continent, such as the Columbia and Fraser rivers. They migrate to sea after completing one or more full years of life in freshwater and are thus significantly larger at ocean entry. Yearlings (generally) spend one less year in the ocean than subyearlings. Only the yearling life history type is found in Alaska (Healey, 1983).

Yearlings are thought to migrate along the continental shelf as juveniles and then move offshore and become purely open ocean residents for much of the marine phase, and thus are essentially immune to harvest by directed salmon fisheries until their return to the shelf and freshwater, where variable levels of harvest may occur. However, significant bycatch of Chinook populations originating from as far away as Washington and Oregon occurs in Alaskan trawl fisheries (Larson et al., 2013), which may possibly include yearling Chinook.

Comparisons between regions

To develop a formal statistical test of the similarity in SARs between regions in the most recent years of the record, we first grouped the CWT-based SAR data separately by smolt age (yearling/subyearling), region, and rearing type (hatchery/wild). For each of these groupings, we pooled all data in the 2010-2014 ocean entry period across all populations in a region, and then resampled the pooled data with replacement N=10,000 times, each time drawing a sample of the same size as the original pooled data. We chose this time period because there was a consistent number of populations contributing to each regional grouping used in the comparison period (2014 being the last year with essentially complete data available for all populations) and it avoided including 2008, a year of unusually cold conditions (Arguez et al., 2020). Limiting the samples to this period ensured the data were current and removed the potential variability due to differing lengths of the time series. For each group, we calculated the *N* median SARs, and then calculated the ratio of those *N* medians with those from each of the other regions in turn. The empirical distribution of the *N* ratios allows for a formal statistical test of the proposition that median SARs in two regions are equal (i.e. that the ratios are not different from one). The normalized SAR ratio for region *i* relative to the Snake River in sample j=1,.., *N* was then $SAR_{i,j}/SAR_{SNAK,j}$. Because of the generally recognized poor survival of Snake River Chinook salmon, we present the results of the comparison to the Snake River in the main text but also provide the comparison using all possible regions in the denominator in Supplementary Figure S1.

Comparison between CWT and PIT tag-based SARs

There are some fundamental differences between PIT and CWT tag-based SAR estimates. PIT tag-based SARs exclude smolt and adult survival upstream of the topmost dam where they are censused and do not account for harvest in ocean or mainstem river fisheries. CWT-based estimates incorporate these factors. Therefore, an aggregate correction factor $\widehat{c_{i,j}}$ for the PIT-based SAR estimates to make them consistent with the CWT-based SAR estimates is:

$$\widehat{c_{i,j}} = \frac{S_{i,j}^{smolt} * S_{i,j}^{adult}}{(1 - h_{i,j})}$$

where $S_{i,j}^{smolt}$ = the estimated survival of stock *i* between the hatchery or pre-smolt rearing grounds and the uppermost dam for smolts from brood year *j*; $S_{i,j}^{adult}$ = the estimated survival of stock *i* between the uppermost dam and return to the hatchery/spawning grounds; and $h_{i,j}$ = the estimated harvest of stock *i* in year *j*. For notational simplicity, we neglect harvest in years prior to adult return. Here the numerator corrects for upwards bias in PIT-based SAR estimates caused by excluding survival above the topmost dam while the denominator corrects for the downward bias caused by excluding harvest.

We were interested in estimating $c_{i,j}$ to assess if it was reasonable to use it to combine these data into a single term that could provide a reliable metric for converting between PIT and CWT-based SAR estimates. To do this, we first attempted to collate the three components ($S_{i,j}^{smolt}$, $S_{i,j}^{adult}$, and $h_{i,j}$) for the populations with PIT tag SAR estimates, but we encountered difficulty obtaining sufficient data, particularly for the adult stage. However, combined ocean plus mainstem harvest rates were readily available for the PSC's indicator stocks. For yearling populations, marine harvest rates are thought to be very low (Waples, Teel, Myers, & Marshall, 2004) and are not included in the CTC database. We therefore collated mainstem harvest data from other sources for yearlings (Supplementary Table S2).

Our second approach to estimating $c_{i,j}$ was to identify populations with both CWT- and PIT-based SAR estimates generated in the same years and then use simple linear regression to identify the relationship. If there was no difference between estimation methodologies, then the regression of CWT SAR estimates on PIT tag-based SAR estimates should have a regression slope of $\hat{c} = 1$.

RESULTS

We collated 123 eastern North Pacific Ocean Chinook salmon SAR time series totaling 2,279 years of monitoring (Fig. 1). SAR estimates included in our analysis were from populations extending from central California to south east Alaska and include 94 hatchery populations, 26 wild, and 3 hatchery-wild (mixed) populations. These populations were then aggregated by geographic area to compare regional SARs. All time series outside the Columbia River watershed are based on CWTs. Within the Columbia, both PIT and CWT-based SARs were available.

SARs from coded wire tags

Most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift (Beamish, 1993; Beamish & Bouillon, 1993; Ebbesmeyer et al., 1990; Francis & Hare, 1994; Mantua et al., 1997) show an approximate three-fold decrease in SARs for hatchery populations (Fig. 2). This applies to hatchery subyearling Chinook from west coast Vancouver Island, the Strait of Georgia, Puget Sound, and the mid-Columbia River; and to hatchery yearling Chinook from SE Alaska, the lower and upper Columbia River, and the Snake River (upper Columbia and Snake rivers are relative to the historical freeze brand data from Raymond (1988)). Except for coastal Oregon subyearlings, average CWT-based SARs for hatchery fish for all regions are now approximately 1% or less.

Within the Columbia River basin, hatchery Chinook from all regions except for yearlings from the lower Columbia show some increase in CWT-based SARs since the 1980s and early 1990s, the period when SARs reached their lowest values in the basin. None of these time series have recovered to the survival levels measured by Raymond (1988) in the 1960s.

Median population specific SARs show that wild populations generally have higher survival than hatchery populations; however, there are limitations: CWT data are limited for wild populations and there are no data available for a direct hatchery vs wild comparison for the same population (Fig. 3). The wild yearling Chinook populations in SE Alaska tend to have lower survival than the hatchery-reared population; however, the Alaskan hatchery SAR estimate provided to the PSC is based on combined data for five hatcheries that all release smolts directly into the ocean after acclimation to seawater for several weeks, eliminating losses from freshwater migration (Bill Gass, Production Manager, Southern Southeast Regional Aquaculture Association, & John Eiler, NOAA; pers. comms.).

Median SARs for hatchery or wild populations within a given region tend to cluster together, but a few populations (University of Washington experimental hatchery releases in Puget Sound and the Chilliwack hatchery in the Strait of Georgia) have unusually high SARs relative to other stocks in their respective region. These are also the only populations whose medians substantively attain the 2-6% SAR recovery level adopted in the Columbia River basin.

Apart from SE Alaska and north-central BC yearlings and Oregon Coast subyearlings, which have higher regional survivals, populations from other regions have only rarely reached this level of production.

Comparison between regions

To compare the current status of regional CWT-based SARs, we included the five most recent years of consistently available SAR data (2010-2014) in a resampling procedure to statistically quantify relative SARs. We used Snake River population SARs as the baseline region to compare all other regions with because of the perceived status of the Snake River as having particularly poor survival; the same analysis using other regions as the basis for comparison are presented in Supplementary Figure S1. A striking result emerges for hatchery-reared subyearling Chinook: median SARs in all regions except the Oregon Coast are lower than median Snake River SARs (Fig. 4). Only in three of nine regions with numerically lower SARs does the upper 5th percentile of the empirical distribution include the possibility of equal SARs with the Snake River region (North-Central BC, Mid, and Upper Columbia). For all other regions, subyearling SARs are statistically lower than the Snake River survivals. There are no CWT-based SAR estimates for wild subyearling Chinook.

Applying the same procedure to hatchery-reared yearling Chinook, current regional SARs were statistically indistinguishable from Snake River SARs for the Salish Sea (Strait of Georgia, Puget Sound) and all other regions of the Columbia River basin (Lower, Mid, and Upper; Fig. 4). California, northern BC, and SE Alaska yearling SARs were significantly higher than Snake River yearling populations. The SARs of SE Alaska wild yearling Chinook (four river systems) were significantly lower than the SARs of the one wild stock of Snake River yearling Chinook for which we have data (Tucannon River; Fig 3).

SARs from PIT tags

PIT tag-based SAR estimates are available for Chinook salmon originating from the Columbia River Basin and published annually by the Fish Passage Center (McCann et al., 2018). Comparing PIT tag-based SARs across regions of the Columbia River basin (Fig. 5) yields similar results to the CWT analysis: wild fish generally have higher survival and different regions have similar or lower median SARs to the Snake River. The exceptions are two mid-

Columbia populations of wild yearling Chinook salmon (John Day River and Yakima River) which have consistently high SARs that fall within the 2-6% rebuilding target set for Columbia River Basin yearling Chinook. However, both wild and hatchery subyearling SARs from the mid-Columbia fall well below the Snake River medians, and all other populations (including three hatchery-reared mid-Columbia yearling populations) have SARs which rarely or never exceed 2%; from this perspective only the two wild yearling populations have substantively higher SARs.

Comparison of CWT and PIT-based SARs

We attempted to develop a correction factor for PIT tag-based SAR estimates so that we could incorporate PIT-based SAR datasets into our regional comparisons; however, PIT-based estimates differ in two major ways from CWT estimates: (1) they exclude sport, commercial, and indigenous harvest and (2) they exclude smolt and adult losses in the region lying between the uppermost dam and the hatchery or spawning site. Unfortunately, it was difficult to find sufficient comparable data. Where both data types were available for individual populations, regression relationships were strong (very high R^2) but biased (greater than or less than the expected 1:1 relationship; Fig. 6). Subyearling CWT-based SAR estimates were consistently higher than PIT-based estimates (1.3 to 3.0 times), presumably because the high subyearling harvest rates not captured in PIT-based estimates (currently between ~45-80%; Fig. 7) outweigh the influence of excluding upstream losses. In contrast, CWT-based SARs for yearling populations were consistently lower than PIT-based estimates (0.39 to 0.73 times), indicating that mortality above the uppermost dam outweighs the influence of the generally lower (but not insignificant) harvest rates on yearling populations. Although fitted linear relationships had high R^2, the substantial differences in regression slopes among populations suggests that population-specific factors strongly influence the relationship. A simple correction factor between PIT and CWT-based SAR estimates appears infeasible.

DISCUSSION

SAR comparison

Evidence that Chinook salmon survival (SARs) has decreased to roughly 1% in many regions along the west coast of North America is both surprising and important. Direct measurements of SARs are lacking for stocks located west of SE Alaska, but the decrease in the number of adult Chinook returning to the rest of Alaska (ADF&G Chinook Salmon Research Team, 2013; Ohlberger et al., 2016; Schindler et al., 2013) demonstrates that survival has fallen over a very large geographic range.

Although survival data for Asian Chinook salmon populations appear to be lacking, Asian populations have had similarly large decreases in abundance relative to North America, suggesting that the drop in Chinook survival is not restricted only to North America. The reported Asian commercial catch of Chinook averaged just under 10% of the total North Pacific Chinook catch for the 1970-2019 period (NPAFC, 2020). Russian catches for the most recent decade, 2010-2019, were only ¼ of the 1970-79 average. For Japan, catches in the 2010-2019 period were only 1/60th of the 1970s (NPAFC, 2020). Some of the decrease in Japanese catches is attributable to regulation changes, particularly the 1977 Law of the Sea Treaty which extended coastal state control out to 200 nautical miles (320 km), and resulted in the transfer of harvesting opportunities from Japan to other coastal states. However, the combined Asian catch still declined to only 17% (~1/6th) the level of the 1970s. Thus, although we only have survival data for North American populations, the decline in Chinook abundance due to decreased survival appears to be Pacific basin-wide.

The North American decreases in survival have occurred despite governments' best attempts to increase salmon populations through harvest regulation, hatchery enhancement, and habitat restoration. A major assumption underlying these efforts is that regional factors such as freshwater habitat degradation or salmon aquaculture make important contributions to the decreasing survival of salmon observed coastwide; however, the similar timing of the decline in the Salish Sea, west coast of Vancouver Island, and Columbia River basin suggests the primary influence of a broad ocean driver (Beamish, 1993; Beamish & Bouillon, 1993; Mantua et al., 1997). The evidence for a roughly similar drop in Asian Chinook catches reviewed above also indicates that the geographic footprint of any ocean (or freshwater) driver must either be large or that many populations must migrate to common geographic regions where their survival can be similarly reduced.

In the Snake River basin, where ESA-listed Chinook salmon migrate through eight major dams, subyearling survival of hatchery Chinook is higher than aggregate subyearling SARs from most regions of the west coast of North America, despite the shortness of streams in these other regions and the general absence of dams (Fig. 4; Oregon coast is the clear exception). For hatchery-origin yearling populations, the SARs for ESA-listed Snake River populations are lower than those reported for three regions (California, north-central BC, and SE Alaska) but are statistically indistinguishable from all other regions (Puget Sound, Strait of Georgia, and lower, mid, and upper Columbia River).

When comparing wild populations, the few Chinook SAR time series outside of the Columbia River basin are also not consistently better than wild Snake River SARs, as conventional thinking would assume. The median SAR of four wild Alaskan stocks is slightly lower than the median SAR of three Snake River wild stocks when all years of data are considered (Fig. 3) and markedly lower when the comparison is restricted to the 2010-2014 time period (note that the Tucannon River is the only wild population for the Snake River region with recent data; Fig. 4). The conclusion is similar when comparing all years of CWT and PIT tag data for most populations (Figs. 2, 3 and 5): median SARs are poor everywhere, and generally ~1% except in the earliest years of the time series. Thus, the numerical similarity in SARs is not an artifact of some recent event but something that has persisted for many years. (Supplementary Tables S3 and S4 provide a summary of the actual numeric values.)

A few populations with anomalously high SARs relative to other populations in the same region exist, and provide intriguing evidence that some populations have an intrinsic ability to support higher SARs meeting the Columbia River basin's current 2-6% recovery targets (subyearlings from the Chilliwack hatchery in the lower Fraser River (SOG), and a ten year record of experimental hatchery releases from the University of Washington (PS)). It is unclear why these two populations are more productive. Similarly, a few populations with anomalously low SARs relative to regional medians also are evident (Fig. 3). If the underlying reasons for higher or lower survival can be identified it might be possible to improve hatchery productivity more broadly.

Intriguingly, the higher SARs of the two coastal Oregon subyearling populations and Chinook from California (Figs. 3, 4) all involve populations that apparently do not migrate far north. The SARs of California Chinook are particularly noteworthy because freshwater survival is exceedingly low (Michel, 2018); for overall SARS to be higher than Snake River stocks suggests much higher survival during the marine phase. Riddell et al. (2018, p. 580) note the unique marine distributions of southern Oregon Chinook stocks, which restricts them for their entire ocean phase to life in the southern region of the California Current, similar to the assumed ocean distribution of California stocks. It thus seems plausible that specific salmon populations home to distinct feeding grounds, some of which may confer better survival (Quinn, Chamberlain, & Banks, 2011; Tucker et al., 2011; Welch, Boehlert, & Ward, 2002).

The reasons for poor marine survival of Chinook are likely multiple, with mechanisms proposed in the last decade alone including: growth (Claiborne, Fisher, Hayes, & Emmett, 2011; Duffy & Beauchamp, 2011; Graham, Sutton, Adkison, McPhee, & Richards, 2019; Howard, Murphy, Wilson, Moss, & Farley Jr, 2016; Lewis, Grant, Brenner, & Hamazaki, 2015; Losee, Miller, Peterson, Teel, & Jacobson, 2014; MacFarlane, 2010; Miller, Teel, Peterson, & Baptista, 2014; Ohlberger, Ward, Schindler, & Lewis, 2018; Orsi, 2013; Schindler et al., 2013; Tomaro, Teel, Peterson, & Miller, 2012); hatchery practices (Chamberlin, Essington, Ferguson, & Quinn, 2011; Nelson, Shelton, Anderson, Ford, & Ward, 2019; Sabal et al., 2016; Tomaro, 2010); predation (Chasco et al., 2017; Friedman et al., 2019; Miller, Teel, Baptista, & Morgan, 2013; Nelson, Walters, Trites, & McAllister, 2019; Seitz, Courtney, Evans, & Manishin, 2019); competition (Cunningham et al., 2018; Miller et al., 2013); bycatch mortality in fisheries (Cunningham et al., 2018); and ocean conditions (Dorner et al., 2017; Murphy et al., 2017; Ruff et al., 2017; Sharma, Vélez-Espino, Wertheimer, Mantua, & Francis, 2013).

Delayed mortality, the theory that greater dam passage results in poorer survival of Snake River Spring Chinook relative to mid-Columbia Chinook populations after smolts migrate past the dams (Budy, Thiede, Bouwes, Petrosky, & Schaller, 2002; Independent Scientific Advisory Board (ISAB), 2007; Schaller & Petrosky, 2007; Schaller, Petrosky, & Langness, 1999), is specific to the Columbia River basin. The theory still plays an important role in Columbia River salmon management (McCann et al., 2019, pp. 116-119);

however, direct tests of the theory have not found evidence to support it (ISAB, 2019; Rechisky, Welch, Porter, Hess, & Narum, 2014; Rechisky, Welch, Porter, Jacobs-Scott, & Winchell, 2013; Rechisky, Welch, Porter, Jacobs, & Ladouceur, 2009). The PIT and CWT-based SAR estimates assembled here also fail to support the theory because the SARs of Snake River populations are not reduced on average when compared to other regions. Apart from two mid-Columbia wild yearling populations (Yakima River and John Day River) with higher than average survival estimates, all other SAR estimates are similar to Snake River values regardless of differences in the number of dams lying in the migration path. Three PIT-tagged hatchery-reared mid-Columbia yearling populations and two Upper Columbia populations have similar SARs to Snake River populations (Fig. 5), and CWT-based SAR estimates for Lower-, Mid- and Upper-Columbia yearling populations have survival consistent with Snake River populations (Fig. 4). Also of note, both PIT- and CWT-based SAR estimates for Mid-Columbia populations of wild and hatchery subyearling Chinook are generally lower than Snake River values. Thus, none of these comparisons support the claim that greater dam passage—and Snake River dam passage in particular—results in subsequently reduced survival. Our point is not to question that dams cause mortality, but rather to note that their current contribution to reduced survival is likely much smaller than originally believed. We urge biologists to consider all available data when evaluating the delated mortality theory, not just select comparisons that fit the proposed theory.

Credibility of SAR estimates

CWT-based estimates

We restricted most SAR comparisons to CWT-based data, as these are available for the entire west coast to as far north as SE Alaska. Most estimates are for hatchery-reared indicator stocks collated by the Pacific Salmon Commission; few estimates are available for wild populations. For upper Columbia and Snake yearling populations we used several estimates generated by individual fishery agencies. The PSC cites several challenges with CWT-based estimates including representativeness of the indicator populations, limitations on sampling the fishery and spawning grounds, and distortions introduced by mark-selective fisheries (Hankin et al., 2005). Agencies presumably generate these data using internally consistent methodologies over time to avoid biasing parts of the time series, thus, the large concurrent downward trend in survival of individual populations is likely to be credible.

PIT tag-based estimates

PIT tag detectors in dam bypasses and fish ladders census both the downstream and upstream movements of PIT-tagged salmon within the Columbia River basin. Originally developed to study smolt survival, PIT tag-based studies subsequently expanded to measure adult returns, presumably because of the unique ability to completely enumerate returning adults as they ascend fish ladders. SAR data sets are now generated for many yearling and subyearling Chinook populations (McCann et al., 2018) and as a result PIT tags have largely supplanted CWT tags for estimating SARs in the Columbia River basin. Dividing estimated smolt counts at the dams in the ocean entry year into the returning adult counts in subsequent years provides the SAR.

PIT tag-based SAR estimates show that recent SARs are higher than in the 1980s and 1990s but are generally low compared to historical levels, where available (Fig. 2) and track well with CWT-based estimates for individual populations (Fig. 6); however, our results indicate that PIT tag-based estimates for Columbia River basin Chinook are overestimated relative to CWT-based estimates for yearling Chinook and underestimated for subyearling Chinook (Fig. 6). Despite being consistent for individual populations, the two methods are therefore not inter-convertible. There are two reasons for this. First, for dam-to-dam estimates (e.g., Lower Granite Dam exiting smolts to Lower Granite Dam returning adults) the survival losses incurred upstream of the dam can vary substantially between populations (Faulkner, Widener, Smith, Marsh, & Zabel, 2017). Unless census points are located at the start and end of the migration period, the amount of excluded upstream survival acts as a population-specific random variable influenced by the excluded distance. This is true for essentially all published PIT-based SAR data (McCann et al., 2018) and for some CWT-based SAR estimates for wild populations, where smolt abundance is censused after migration has started (e.g., McPherson et al., 2010).

The second reason is that Chinook harvested in fisheries prior to return are not accounted for in PIT tag-based estimates. Authors have previously noted that PIT tag-based SAR estimates do not include harvest (Marmorek & Peters, 2001; McCann et al., 2018) and recommendations have recently been made to incorporate harvest (ISRP, 2019, p. 22), but neither the magnitude of the harvest nor the variability over time has been recognized. The result is that PIT tag-based

SARs represent the surviving adults left over from the operation of multiple fisheries operating over several years. So although PIT tag-based estimates of juvenile survival in the hydrosystem appear reliable, the influence of commercial, sport, and tribal fisheries on adult returns is large, and therefore PIT-based SARs likely do not provide a credible measure of smolt-to-adult survival but rather estimates of escapement from the fisheries to the river.

Harvest and PIT-based SARs

The potential of PIT tags to identify all returning adults to the Columbia River is compromised by the inability to identify PIT-tagged fish in the harvest. Ocean harvest rates on Columbia River basin yearling (Spring) Chinook stocks are ≤2% (Schaller et al., 1999; Waples et al., 2004), presumably because maturing Spring Chinook cross the continental shelf only near their natal river mouth on return and are not exposed to the many coastal fisheries operating along the shelf; however, yearling Chinook harvests in freshwater are still substantial (Fig 7). Harvest rates for Upriver Spring Chinook increased from 10% to 20% of the number arriving at the river mouth over the 1998-2010 period (PFMC, 2019). Not accounting for this river harvest results in underestimating the true SAR by ca. 10% in 1999 (near the beginning of the PIT tag record) and 25% in the more recent years of the record. For other yearling stocks the correction is larger.

For subyearling Chinook, which are much more heavily harvested, PIT-based SAR estimates likely understate survival by 300-400% in recent years. For example, Lyons Ferry (Snake River) subyearling Chinook harvest rates rose from a low of ~20% in 2004 to >70% in 2012. These values imply correction factors increasing from 1.25X to >3X over eight years.

The varying patterns of increase in harvest rates towards the most recent years of the record are particularly important because PIT tag-based SAR estimates do not reflect the higher harvests of recent years and therefore understate the improvements in adult survival that actually occurred. Given the variability in harvest rates over time and between populations, a reliable correction factor to account for harvest will be difficult to achieve for PIT tag-based SAR estimates, while leaving these estimates uncorrected for harvest results in a substantial downwards bias in survival estimates (Fig 6).

Another challenge with using PIT tag-based SAR estimates to set quantitative recovery targets for Columbia River basin Chinook (e.g., 2-6% SAR) is that the fisheries management strategy is currently divorced from these goals. Under the terms of the renegotiated Pacific Salmon Treaty, beginning in 1999 coastwide management of ocean fisheries for Chinook is explicitly abundance-based (Caldwell, 1999; Miller, 2003): fisheries are intensified when abundance is high and restricted when low. Consequently, PIT-based SAR estimates will inaccurately reflect survival if managers identify increases in abundance and increase harvest rates—which is precisely what the treaty dictates they should do. In fact, if managers had perfect control of ocean fisheries survival changes would never be reflected in PIT tag-based SAR estimates because any change in abundance would simply be compensated for by altering harvests. In practice, over or under-harvesting is likely, so PIT-based SAR fluctuations will also reflect the inability to perfectly manage fisheries. Even for Snake River Spring Chinook, where harvest rates are lowest and the inter-annual fluctuations in harvest are on the order of 10-20% (Fig. 6), survival fluctuations of this size would generally be considered significant. That PIT tag-based SAR fluctuations may simply reflect limitations inherent to the treaty is of concern and appears to be unrecognized. Equally important, expensive changes to the operation of the Federal Columbia River Power System intended to improve survival may benefit the fisheries without credit accruing to those bearing the costs. In future, closer coordination is advisable between the managers implementing abundance-based harvest in the various fisheries and the biologists assessing the impact of Columbia River basin hydropower operations on survival.

CONCLUSIONS

The policy implications of Chinook salmon SARs falling to about 1/3rd of early levels and converging to similar levels nearly everywhere along the west coast of North America are profound. Current efforts to conserve salmon populations assume that restoring habitats modified by anthropogenic factors (e.g., dams, dykes, forestry, road culverts, salmon farms in the coastal ocean) will improve salmon returns and at least partially compensate for worsening ocean conditions (Roni, 2019). However, if survival also falls by roughly the same amount in regions with nearly pristine freshwater habitats (SE Alaska, north-central British Columbia), it is difficult to argue for a major role of regional factors in causing the decline.

Given the geographically widespread collapse in survival to numerically similar levels and the steadily increasing effort devoted to survival monitoring for salmonids (Fig. 8), the fisheries community need to re-assess several core conservation assumptions. Of primary importance is the actual effectiveness of freshwater habitat restoration initiatives when northern populations with nearly pristine freshwater conditions have similar SARs. The resulting policy questions range from the prospect of successfully feeding killer whales with increased hatchery Chinook production, the hypothesized suppressive effect of salmon aquaculture (salmon farming) on wild salmon stocks, to the real role of dams in the demise of endangered Snake River salmon stocks.

As declining survival has reduced adult return rates, there has been mounting effort to increase monitoring. However, we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. In addition, some survival time series exclude variable proportions of upstream survival for both smolts and adults. Unless smolt counts are taken at the hatchery (or at the initiation of migration for wild smolts) and adult counts occur on the spawning grounds, variability is introduced into survival estimates because different amounts of the migratory life history are incorporated for different populations. Exactly where abundance is estimated during migration and what components of adult returns are included should be more carefully documented. A coast-wide review of the quality and consistency of smolt-to-adult survival methodologies is needed to ensure that the many initiatives now monitoring survival are achieving sufficient accuracy to be useful.

Because of poor survival, the costs of hatchery supplementation are now extremely high. In Puget Sound, where the reported survival of subyearling (Fall) Chinook has fallen to significantly lower survival levels than the Snake River, the cost of hatchery operations to yield one sport-caught adult Chinook has increased from ~$55 (USD) per fish in the 1970s to $768 (yearlings) and $392 (subyearlings) in the 1990s (Table 5 of Anonymous (2010); costs unadjusted for inflation). High costs of production are also noted in British Columbia, particularly for Upper Fraser River Chinook, where costs were estimated at $380 (CDN) per returning adult in the 1980s (Winton & Hilborn, 1994). Given the similarity of the decline in survival, the economics of hatchery Chinook production are likely similar in other regions. Understanding the real drivers of poor survival might substantially improve the economics of hatchery production. The few regional hatchery programs with anomalously high SARs should be investigated to determine when in the post-release life history period survival is high as a first step to understanding why it is low elsewhere.

It is also important to more carefully consider the role of harvest. Harvest levels for some yearling populations are a considerable fraction of adult returns to the river, while for subyearling populations they are substantially larger than adult escapement. A key part of the renegotiation of the terms of the bilateral US-Canada Pacific Salmon Treaty in 1999 was securing coastwide agreement that managers would modify harvest in response to abundance. Unfortunately, what went unrecognized was the effect on the many Columbia River studies based on PIT tags. It is unclear whether the quality of reported harvest rate estimates is good enough for past PIT-based SAR estimates to be reliably converted into useful survival estimates. This is an important point because the basic ecological models used to inform the Environmental Impact Statements (EIS) for many ESA-listed Columbia River salmon stocks are calibrated using PIT tag-based SAR estimates (McCann et al., 2018; Zabel et al., 2008). The use of modern parentage-based genetic stock ID methods (Beacham et al., 2020; Freshwater et al., 2016; Hess, Matala, & Narum, 2011; Matala, Hess, & Narum, 2011; Satterthwaite et al., 2014) may allow apportioning harvest from the various fisheries to source populations with sufficient precision to be useful for survival analysis in the Columbia in the future. However, whether these methods can provide sufficient resolution for past harvest rate estimates to be incorporated into SAR estimate is unclear.

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Data Availability

All data used in the analysis are available without limitation from the Dryad open-access repository (doi:10.5061/dryad.w6m905qmm).

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Figures

Fig. 1. Map of the locations of Chinook salmon survival time series used in the analyses. Numbers inside symbols are keyed to the populations in Table S1. SEAK=SE Alaska/Northern British Columbia Transboundary Rivers; NCBC=North-Central British Columbia; WCVI=West Coast Vancouver Island; WAC=Washington Coastal; ORC=Oregon Coastal; SOG=Strait of Georgia; PS=Puget Sound; CA=California. (Figure appears in colour in the online version only).

Fig. 2. Time series of smolt-to-adult return (SAR) estimates for Chinook salmon plotted by source. (The on-line version of the figure supports substantial magnification to examine the details of each panel). Annual SAR estimates for hatchery (H), wild (W), and mixed hatchery-wild data sources (B) are shown, but regional loess curves of survival and associated 95% confidence interval use hatchery data only, colour coded by data source. In order to focus on the trends, a few SAR estimates have been clipped by restricting the y-axis maximum to near the loess curve maxima. Blank panels indicate regions where the life history type does not occur. The SAR 2-6% recovery target adopted for Snake River Spring Chinook is shown as a grey band. The timing of the major regime shifts starting in 1977, 1989, and 1998 are indicated by vertical dotted lines. The horizontal dotted line indicates 1% SAR. Note logarithmic y-axis. Sources correspond to Table S1 as follows: PSC CWT= PSC 2019; CSS PIT=McCann et al. 2018; Agency CWT=all other sources exclusive of Raymond 1998 and Michel 2019. CWT=coded wire tag; CSS=Comparative Survival Study, PIT= Passive-Integrated-Transponder; SEAK=SE Alaska/Northern British Columbia Transboundary Rivers; NCBC=North-Central British Columbia; WCVI=West Coast Vancouver Island; SOG=Strait of Georgia; PS=Puget Sound; WAC=Washington Coastal; LCOL=Lower Columbia River; MCOL=Mid-Columbia River; UCOL=Upper Columbia River, SNAK=Snake River; ORC=Oregon Coastal; CA=California. (Figure appears in colour in the online version only).

Fig. 3. Chinook survival (SAR) based on coded wire tags, disaggregated by population and region; all years combined. Central lines show medians, boxes show the inter-quartile range (central 50% of data points), whiskers bracket 1.5 times the interquartile range, and open circles identify outliers. Regional medians are computed using all populations and shown as vertical blue (hatchery) or gold (wild) lines, with Snake River medians overplotted as vertical red lines on all panels for comparison (H=solid red and W=dashed red). The 2-6% target recovery range for Snake River SARs is shown as a shaded band. The number of SAR estimates for each population is shown to the right. See Table S1 for definitions of population acronyms and Fig. 2 for region acronyms. H=hatchery; W=wild; HW=mixture. *Indicates data sets ending prior to 1998 (all data from Raymond (1998) and three Puget Sound data series from PSC (2019)). (Figure appears in colour in the online version only).

Fig. 4. Regional CWT-based SAR estimates for Chinook salmon normalized relative to Snake River SARs for the 2010-2014 period. Estimates above the horizontal black dotted line indicate higher survival than Snake River populations. Horizontal red lines show the empirical 5% and 95% percentiles on the sampling distribution of the normalized ratio. See Fig. S1 for SAR estimates normalized to all other regions. H=hatchery; W=wild. (Figure appears in colour in the online version only).

Fig. 5. Box plots of Chinook PIT tag-based SAR estimates in the Columbia River basin, disaggregated by population and region; all years combined. These SAR estimates exclude harvest and smolt and adult losses above the top-most dam. Regional medians are computed using all populations and shown as vertical blue (H) or gold (W) lines, with Snake River medians overplotted as vertical red lines on all panels for comparison (H=solid and W=dashed). The 2-6% target recovery range for Snake River SARs is shown as a shaded band. The number of SAR estimates is shown on the right. H=hatchery; W=wild; HW=mixture. All data from (McCann et al., 2018). (Figure appears in colour in the online version only).

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Fig. 7. Annual Columbia River Chinook harvest rate estimates, fitted loess trend lines, and associated 95% confidence intervals. The right-hand axis shows reported aggregate harvest before Chinook reach McNary Dam. The left-hand axis shows the corresponding value that PIT tag-based SAR estimates should be multiplied by to correct for exclusion of harvest; note log scale. Tributary harvests (i.e., above McNary Dam) are excluded. Substantial variation over time and between populations is evident after 1998 (vertical dashed line), when PIT tag-based survival estimation began. Data sources that present harvest estimates by brood year were converted to return year using the dominant year of return. See Table S2 for population names and references. (Figure appears in colour in the online version only).

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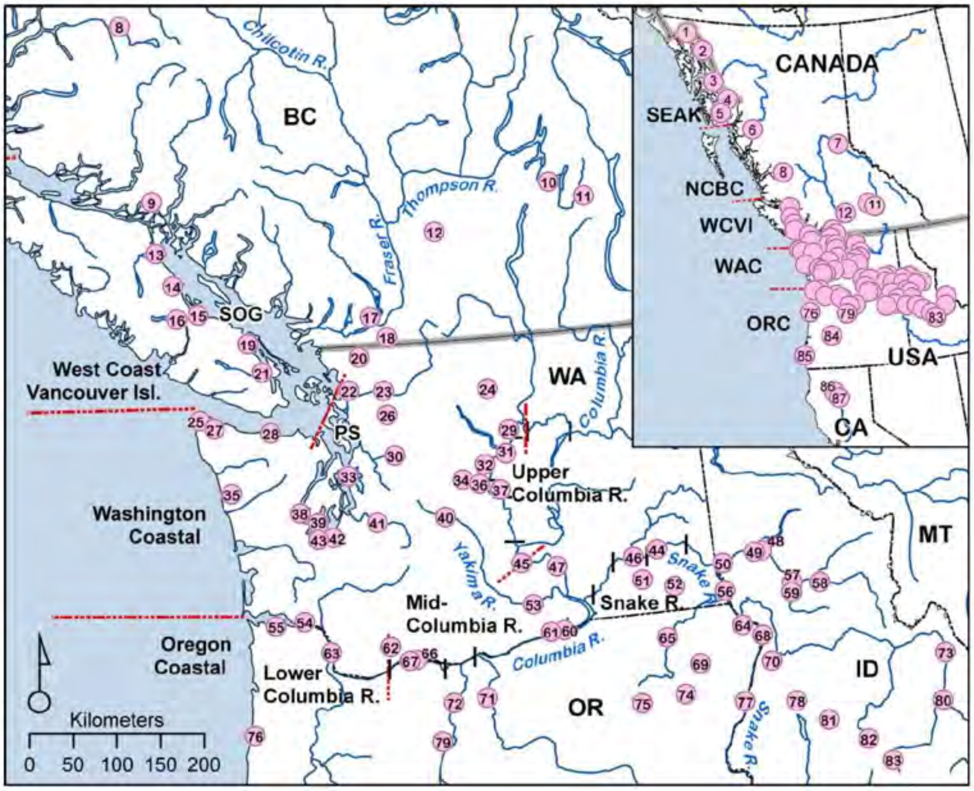

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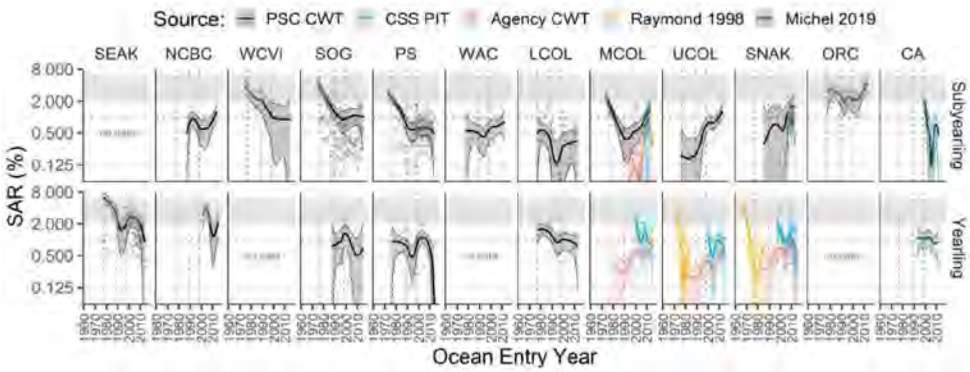

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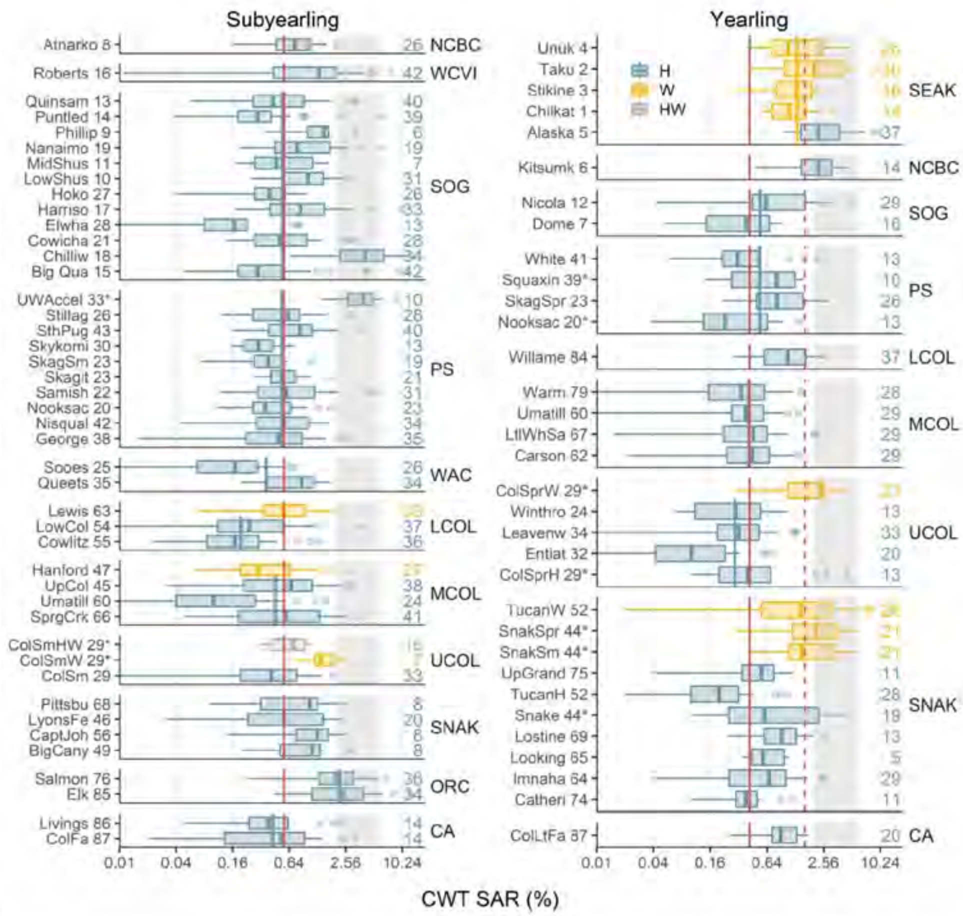

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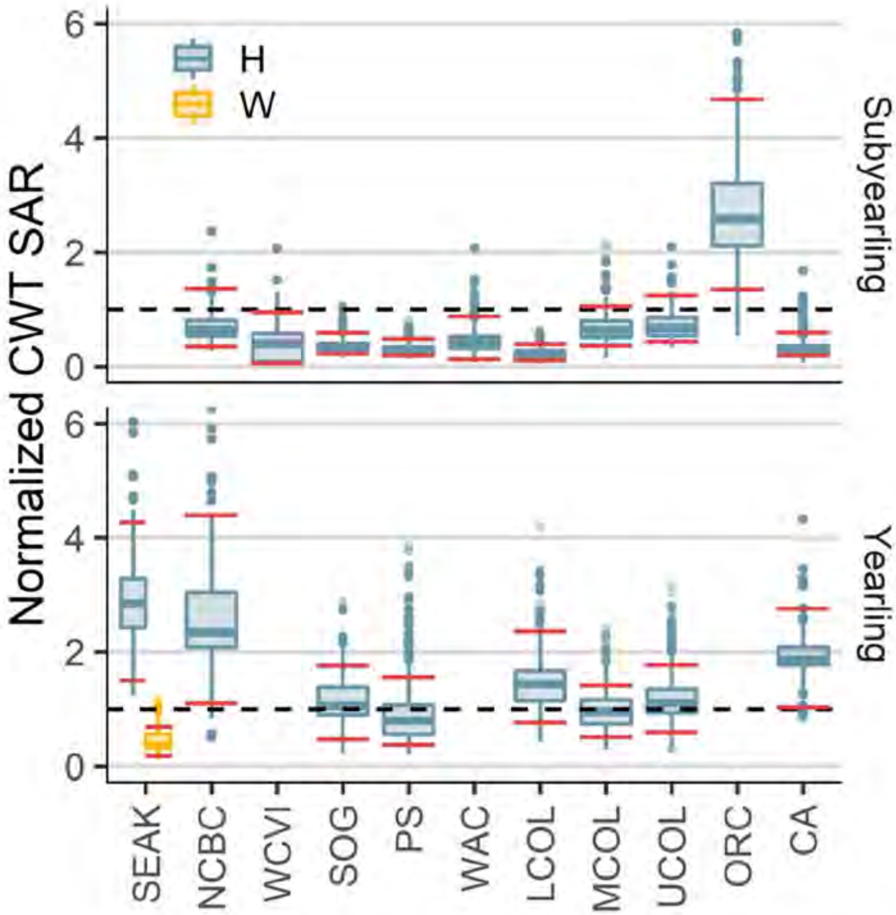

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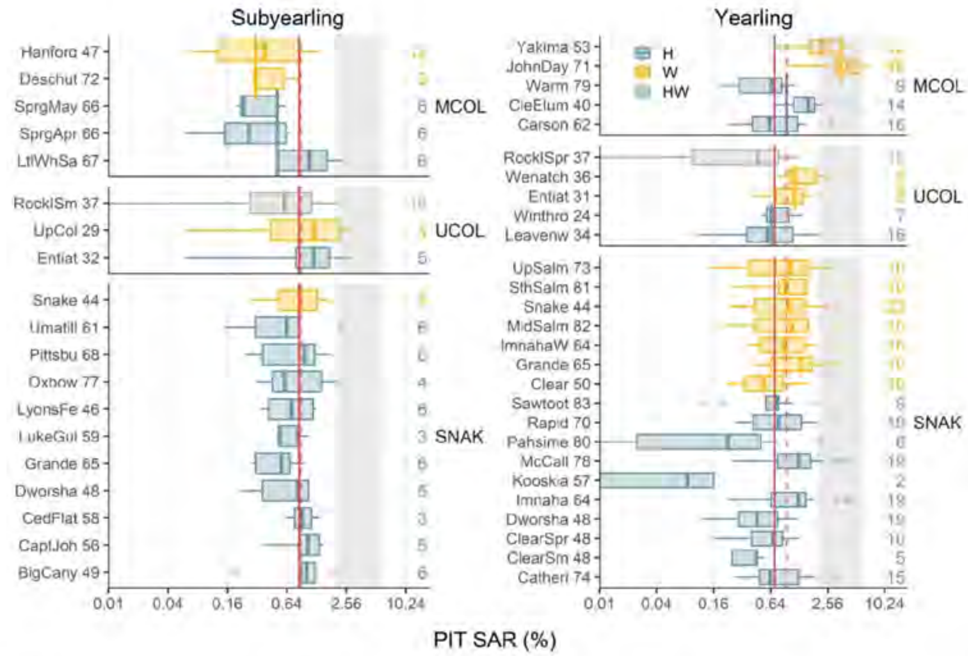

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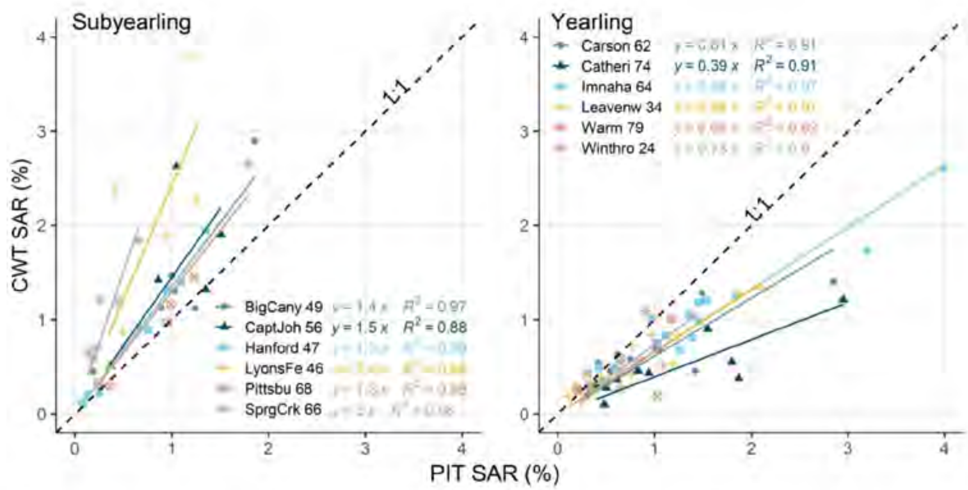

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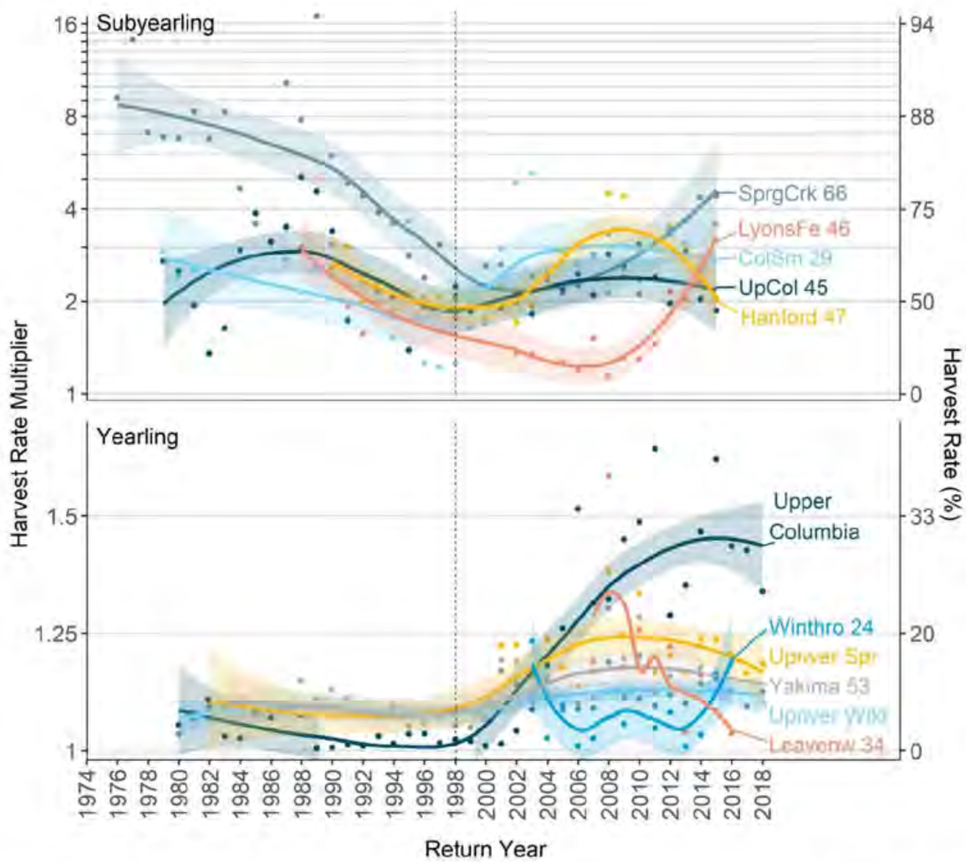

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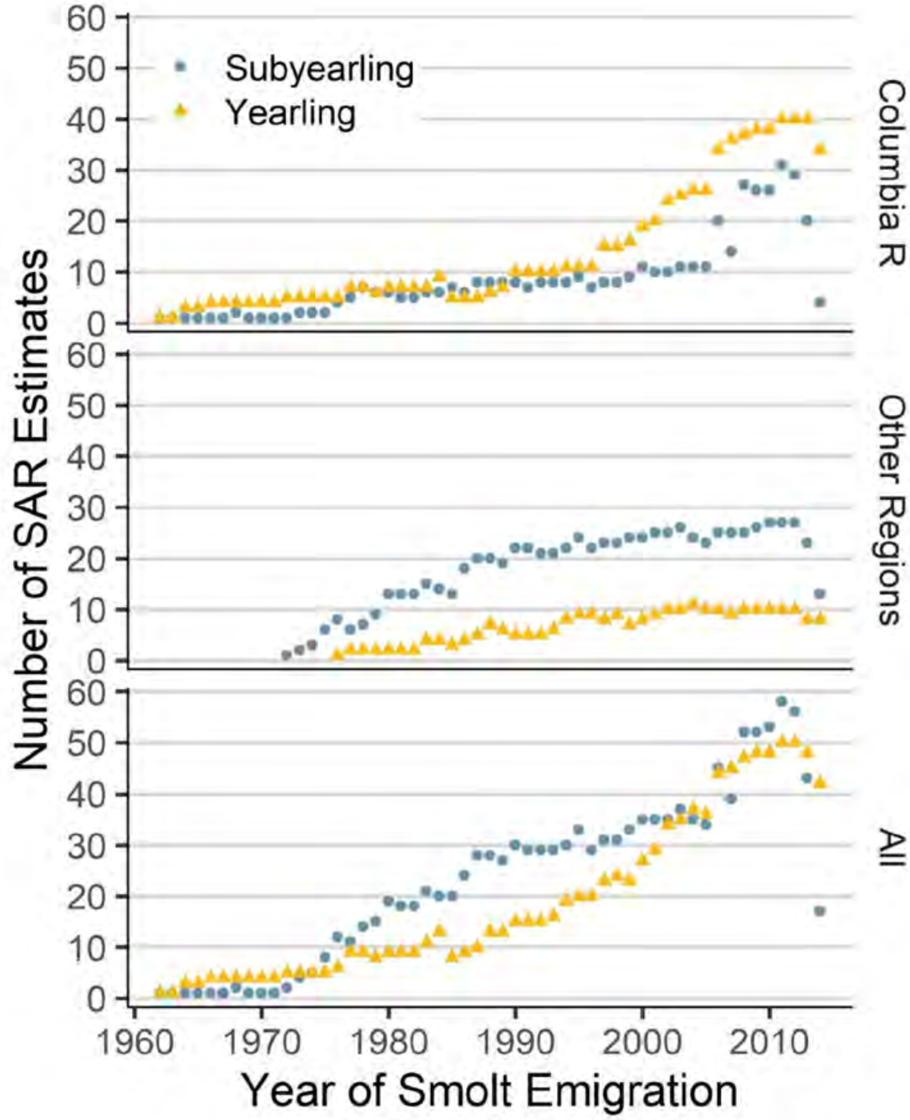

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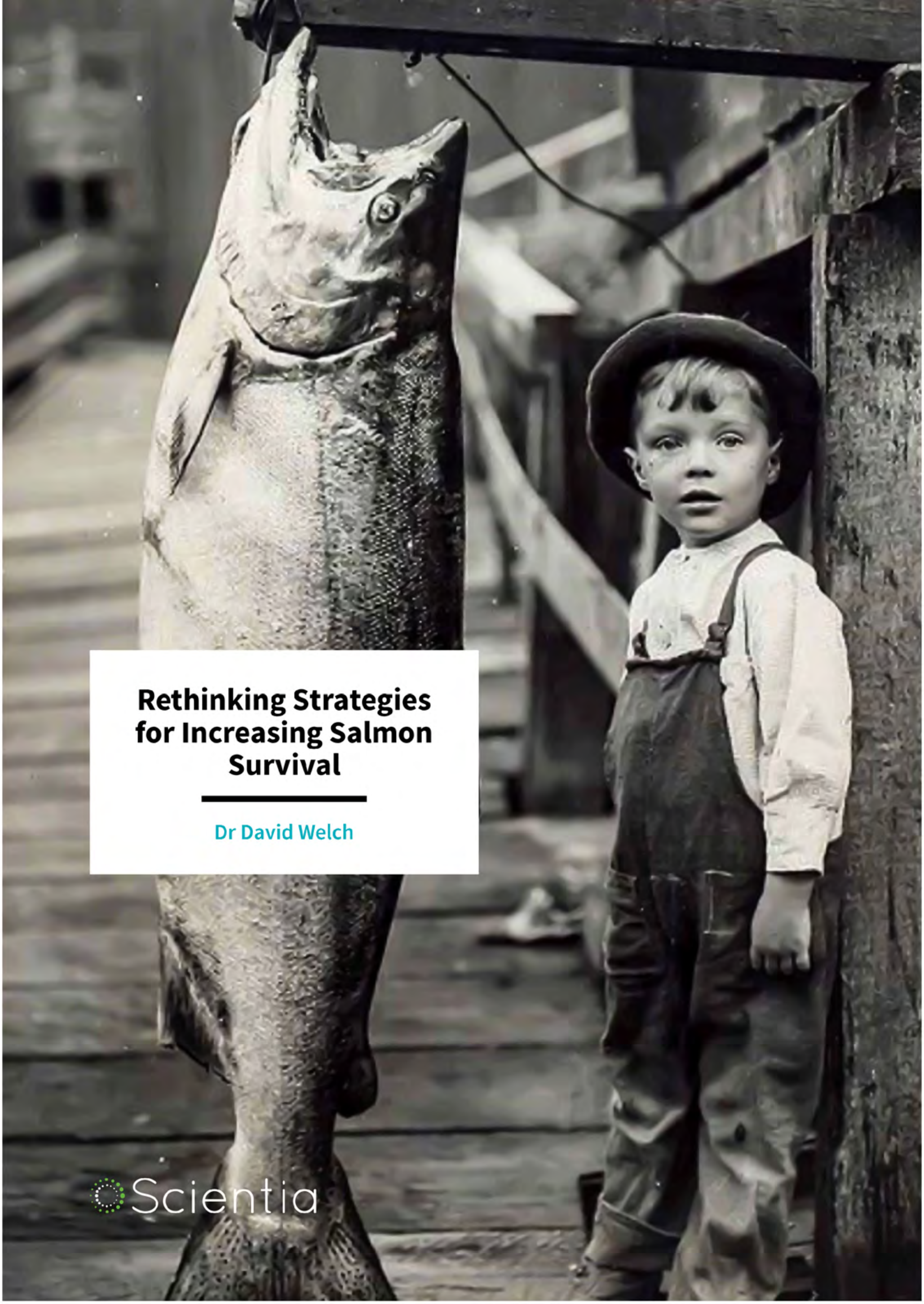

Rethinking Strategies for Increasing Salmon Survival

Dr David Welch

Scientia

RETHINKING STRATEGIES FOR INCREASING SALMON SURVIVAL

It's a long-held belief that a series of dams in the Snake River in Northwest USA constructed nearly 50 years ago has led to serious declines in Chinook salmon populations. However, new research by **Dr David Welch** and his team from Kintama Research Services Ltd shows that survival of Chinook salmon measured by a wide range of government agencies has fallen by 65% along the whole North American West Coast over this period. These results have significant implications for informing conservation strategies to protect and restore this important species.

Salmon Populations in Trouble

The abundance of salmon in the North Pacific has reached record levels. However, most of this increase is in just two species – pink and chum salmon – in far northern regions, attributed in part to ocean ranching – a type of fish farming where juvenile fish reared in hatcheries are released into the ocean to grow before harvest.

In contrast, all West Coast North American Chinook salmon populations are experiencing serious declines. The situation is similar for most southern populations of coho, sockeye, and steelhead salmon. These dwindling species are of higher economic value and are the focus of many indigenous, sport, and commercial fisheries.

Chinook salmon are native to the North Pacific Ocean and the river systems of western North America, ranging from California to Alaska. They are born in freshwater and can undertake complex movements among a variety of freshwater habitats to find food before migrating to the sea as 'smolts'. They then spend multiple years at sea before returning to their natal freshwater habitat to spawn and die.

In North America, declines in salmon populations since the 1970s were originally assumed to be caused by humans modifying freshwater habitats in the populous southern regions, which initially saw the greatest decrease. On the Snake River, the largest tributary of the Columbia River, many dams have been constructed between its headwaters in the Rocky Mountains to where the Snake joins the Columbia River mainstem. It is widely believed that these dams are a major factor behind population declines in Chinook salmon in the Columbia River Basin. The poor survival of Snake River Chinook salmon has resulted in them being listed under the US Endangered Species Act.

In order to examine the large-scale patterns of Chinook salmon survival from the Snake River and other regions, Dr Welch and his colleagues at Kintama Research Services Ltd have been analysing government data to compare the 'smolt-to-adult return rate' for Chinook salmon from central California to southeast Alaska. The team used the results to examine existing theories around population decreases, and to question whether current management practices are appropriate.

'We were shocked to discover that the survival of salmon across British Columbia or in Puget Sound is now as low or lower than the reported survival of Snake River populations, which everyone thought had terrible survival because of the dams.'

Challenging Existing Theories

One long-held theory is that the survival of Snake River Chinook is low because poor survival at sea is caused by 'delayed mortality'. In a nutshell, the theory argues that ocean survival is bad partly because of the many dams the young fish had to migrate through to get there. However, the new data analysis by Dr Welch and his team indicates that Chinook salmon declines are similar from California to Alaska – and most of these river basins have no dams.

'Our analysis of all the available data shows that survival everywhere is low – and has fallen by three-fold, or 65%, across the board over the last 50 years,' says Dr Welch. 'We were shocked to discover that the survival of salmon across British Columbia or in Puget Sound is now as low or lower than the reported survival of Snake River populations. Everyone thought that Snake River populations had terrible survival because of the dams.'

Dr Welch is keen to point out that this doesn't mean that the dams aren't causing problems for the salmon; rather, the team's results suggest that the dams' influence could be minor and they aren't a major factor affecting salmon productivity.

'The existence of this same decline in Chinook returns across essentially all of Alaska and the Canadian portion of the Yukon River, where human-induced freshwater habitat impacts are negligible, is an example of how simple explanations are potentially wrong,' says Dr Welch. 'If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon.'

Another key issue identified by the team was a problem with the Passive Integrated Transponder (PIT) tagging system used to record adult salmon survival in the Columbia River. Many millions of dollars are spent each year on this system and in analysing the data from it. However, when Dr Welch and his team looked closely at the system, they found that the harvest of PIT tagged salmon in the fisheries was unaccounted for and was large and variable. This omission introduces major biases into the many survival studies using PIT tags, which assume that harvest in fisheries is negligible.

In fact, the use of the PIT tagging system for studying salmon survival could be even more problematic. Under the terms of the US-Canada Pacific Salmon Treaty, the coast-wide management of fisheries for Chinook salmon is abundance-based, which means that managers are required to increase harvest when Chinook survival is high and restrict harvest when it is low. As a result, managers are actively modifying harvests in just the right way to obscure any survival fluctuations attributable to the dams. Because biologists seeking to improve survival back to the river work independently of the managers and are not accounting for what happens at sea, they may actually be responding more to imperfections in the harvest management system rather than identifying how the dams really affect survival.

This previously unrecognised limitation of PIT tagging methodology is critical to current management efforts in the Columbia River basin, which largely rely on studies using PIT tags. Fortunately, the Kintama team was able to collate sufficient survival data for Columbia River populations using alternative tagging methodology used elsewhere in the Pacific northwest to allow coastwide survival comparisons to be carried out.

CREDIT: *Curtis Smith, Coastal Wilderness Adventures*

The Way Forward for Salmon Conservation

'Evidence that Chinook salmon smolt-to-adult returns have decreased to roughly 1% in many regions along the West Coast of North America is both surprising and important,' says Dr Welch. 'These decreases in survival have occurred despite governments' best attempts to increase salmon populations through harvest regulation, construction of hatcheries, and freshwater habitat restoration.'

A major assumption underlying these efforts is that regional factors such as habitat degradation or salmon farms significantly contribute to declining Chinook populations. However, the similar decline across the whole study region suggests a different view is likely. 'At the broadest level, the major implication of our results is that most of the salmon conservation problem is likely determined in the ocean by common processes,' explains Dr Welch. 'Nobody really knows why salmon survival is dropping in the ocean – there is much speculation and some correlation-based analysis, but nothing definitive.'

If this view is correct, then developing a better understanding of the relationship between the ocean-phase of the Chinook salmon lifecycle and population survival rates will be central to successful efforts to restore their populations. This has significant implications for current policies for salmon conservation and management. 'Attempts to improve smolt-to-adult return rates by addressing region-specific issues such as freshwater habitat degradation are unlikely to be successful,' says Dr Welch. 'Given the geographically widespread collapse in survival, the research community needs to reassess several core conservation assumptions.'

In terms of the Snake River populations, the theory of dam-induced delayed mortality still plays an important role in Columbia River salmon management. Another of the Kintama team's current results is of direct interest here, as the broad range of populations they studied showed no consistent evidence that migrating through more dams reduced survival – the hallmark of the delayed mortality theory. Therefore, expensive changes to hydropower operations intended to improve survival may have little impact.

The Kintama team recommends that in future better coordination will be necessary between fisheries managers controlling a wide range of ocean and river fisheries and research biologists working in the Columbia River to improve salmon returns, to ensure that the role of fisheries is incorporated into future analyses and not ignored. However, there is also a critical need to move away from correlation-based studies that compare just a few populations to much broader studies which recognise that the contributing factors may be both complex and beyond our ability to control.

Dr Welch believes that closer attention needs to be directed to how smolt-to-adult return rates are quantified and how salmon rebuilding targets are defined in North America. His team is calling for a systematic review by funding agencies to address consistency and comparability of the smolt-to-adult return rate data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast.

Overall, the policy implications of Chinook salmon survival converging to similar levels nearly everywhere along the west coast of North America are profound. The findings of Dr Welch and his team indicate that current salmon fisheries management and population rebuilding strategies both need to be re-evaluated. This could involve moving away from strategies based on historical theories around human-induced freshwater habitat degradation and looking more towards factors driving population decline in the ocean-phase. The way survival data are collated and interpreted is critically important, as is correctly incorporating the impact of fisheries on salmon survival.

Meet the researchers

Dr David Welch
President and CEO
Kintama Research Services Ltd
Nanaimo, British Columbia
Canada

After gaining his BSc in Biology and Economics from the University of Toronto, Dr David Welch went on to study for a PhD in Oceanography at Dalhousie University, Nova Scotia. He joined the Canadian Department of Fisheries and Oceans in 1985 and was appointed head of the High Seas Salmon Program in 1990. Dr Welch is President and CEO of Kintama Research Services Ltd, a company he founded in 2000 to research and develop the technical infrastructure and array geometries necessary to develop continental-scale acoustic tracking technology. It is intended that this technology will facilitate the efficient tracking of individual marine animals (especially salmon) to measure their survival directly in the ocean. Dr Welch has written more than 300 primary scientific papers and technical reports and received an array of awards for his work contributing to fisheries management and salmon conservation. These include both the *Prix de Distinction* (2007) and *Prix d'Excellence* (2008) from Fisheries & Oceans Canada, the *J. P. Tully Medal* in Oceanography from the Canadian Society for Meteorology & Oceanography (2012), and the *Award of Excellence—Fisheries Management* from the American Fisheries Society (2012).

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Kintama Research Services Ltd
US Department of Energy – Bonneville Power Administration

From: David Welch

Sent: Mon Oct 05 13:34:40 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Time for a call?

Importance: Normal

Hi Christine—

Next week I will be out of touch in a remote area from 11-17 October. If possible, it would be good to have a call with you and Jody prior to then.

Is that possible?

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) [redacted]

From: David Welch

Sent: Thu Oct 15 12:09:10 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Automatic reply: License was successfully submitted! Thank you!

Importance: Normal

I am diving in a remote area off northern Vancouver Island and will have little access to email until my return on 18 October 2020.

For work-related issues, please contact Dr Erin Rechisky during my absence: erin.rechisky@kintama.com Tel: + 1 (250) 667-6951

For urgent issues, you can try sending me a text or contact my wife.

Thanks, David Welch

Cell: [redacted]

From: Erin Rechisky

Sent: Tue Oct 20 14:43:13 2020

To: Lofy,Peter T (BPA) - EWU-4

Subject: [EXTERNAL] Automatic reply: BPA is hiring: Fish and Wildlife Administrator (COR/PM), GS-0480-13, (Portland OR)

Importance: Normal

Hello and thank you for your e-mail. I am out of the office until Monday, Oct. 26th. During this period I will have access to email but will be out in the field and slow to respond.

Please contact David Welch at david.welch@kintama.com if you need immediate assistance.

Kind regards,

Erin

From: Lofy,Peter T (BPA) - EWU-4

Sent: Tue Oct 20 14:46:18 2020

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Subject: BPA is hiring: Fish and Wildlife Administrator (COR/PM), GS-0480-13, (Portland OR)

Importance: Normal

Hi Folks,

BPA is advertising for a Fish and Wildlife Contracting Officer Technical Representative (COTR)/Project Manager with a fish culture emphasis.

This is a 480 series, for federal employee applicants.

The Announcement title in USAJOBS (link below) will be “Fish and Wildlife Administrator”.

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If you know of anyone who might be interested, please forward this email to them.

Thanks

Peter Lofy

BPA Supervisor

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Cc:
Subject: Announcement Posted: Fish and Wildlife Administrator, GS-0480-13, (EWU)

Fish and Wildlife Administrator, GS-0480-13, (EWU) – Portland, OR

DOE-BPA-21-14223-MP: https://www.usajobs.gov/GetJob/ViewDetails/582164200

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From: Lofy,Peter T (BPA) - EWU-4

Sent: Tue Oct 20 14:57:45 2020

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Subject: BPA is hiring: Fish and Wildlife Administrator (COR/PM), GS-0480-13, (Portland OR)

Importance: Normal

Hi Folks,

BPA is advertising for a Fish and Wildlife Contracting Officer Technical Representative (COTR)/Project Manager with a fish culture emphasis.

This is a 480 series, for federal employee applicants.

The Announcement title in USAJOBS (link below) will be “Fish and Wildlife Administrator”.

Duty station is Portland, OR.

If you know of anyone who might be interested, please forward this email to them.

Thanks

Peter Lofy

BPA Supervisor

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Sent: Tuesday, October 20, 2020 10:59 AM
To: ADL_NHQ_ALL <ADL_NHQ_ALL@BPASite1.bpa.gov>
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Subject: Announcement Posted: Fish and Wildlife Administrator, GS-0480-13, (EWU)

Fish and Wildlife Administrator, GS-0480-13, (EWU) – Portland, OR

DOE-BPA-21-14223-MP: https://www.usajobs.gov/GetJob/ViewDetails/582164200

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From: Lofy,Peter T (BPA) - EWU-4

Sent: Tue Oct 20 14:57:45 2020

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Subject: BPA is hiring: Fish and Wildlife Administrator (COR/PM), GS-0480-13, (Portland OR)

Importance: Normal

Hi Folks,

BPA is advertising for a Fish and Wildlife Contracting Officer Technical Representative (COTR)/Project Manager with a fish culture emphasis.

This is a 480 series, for federal employee applicants.

The Announcement title in USAJOBS (link below) will be “Fish and Wildlife Administrator”.

Duty station is Portland, OR.

If you know of anyone who might be interested, please forward this email to them.

Thanks

Peter Lofy

BPA Supervisor

From: Feller,Cheri M (BPA) - NHQ-1 <cmfeller@bpa.gov>
Sent: Tuesday, October 20, 2020 10:59 AM
To: ADL_NHQ_ALL <ADL_NHQ_ALL@BPASite1.bpa.gov>
Cc:
Subject: Announcement Posted: Fish and Wildlife Administrator, GS-0480-13, (EWU)

Fish and Wildlife Administrator, GS-0480-13, (EWU) – Portland, OR

DOE-BPA-21-14223-MP: https://www.usajobs.gov/GetJob/ViewDetails/582164200

OPEN: 10/20/2020

CLOSE: 10/29/2020

Cheri Feller

Human Resources Specialist

Recruitment & Placement (NHQ-1)

Bonneville Power Administration

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Veterans: veterans@bpa.gov

Recruitment Events: recruiter@bpa.gov

Contract Positions: Supplaborjobs@bpa.gov

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Oct 20 16:42:17 2020

To: 'David Welch'

Subject: RE: License was successfully submitted! Thank you!

Importance: Normal

Hi,

I spoke with Jody today. [redacted] I reminded her of the open access questions, and she should be looking into that and also hopefully setting up a phone call to discuss.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, October 15, 2020 1:54 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] Re: License was successfully submitted! Thank you!

Hi Christine—

No, Jody hasn't. As my out of office reply indicates, I'm away this week on holidays, but as it happens, I have better connectivity than I had anticipated and have been able to keep up with my emails.

It would be good to touch base. We have managed to find the funds to pay for the open access option, and are working on a press release (which I am happy to share). I anticipate that our paper will make waves and generate significant dialogue for the obvious reasons, so I think it would be useful to BPA staff to chat about this PR effort with us as I don't want people feeling blind-sided. I'm back Saturday night and I think the paper might be published by as early as sometime next week, or the week after at the latest, so time is tight.

Please also remind Jody that we are pretty well setup to do a fast turn around of a re-assessment of Steve Haeseker's original analysis (and subsequent FPC derivatives thereof) that predict large increases in SARs with increased spill. However, as SARs don't account for the change in harvest over time it could very well be that that statistical correlation between spill/TDG and adult SARs may be completely different once the complex changes in harvest levels are taken into account. Given the high economic cost of foregone power generation that is occurring, it should be in everyone's interest to get that original, foundational, analysis by Dr Haeseker quickly re-assessed.

David

David Welch, Kintama Research

Tel: +[redacted]

On Oct 15, 2020, at 12:09, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Hi,

Has Jody Lando been able to contact you to potentially set up a call to discuss this, and other matters related to the paper? I had forwarded this to her. She was preparing to include the final paper in a briefing to management a week ago.

My initial feeling on the open access question is that we would be unlikely to pay the extra fee, even though we desire to have good promotion or advertisement of the study. In general, I favor giving a little more for open access. As a testimonial, even in government, many of us are effectively locked out from some studies because it would be time consuming to obtain the paper behind a barrier even if there is some mechanism of contacting a librarian in the agency who is able to pay for it or they have a subscription. But I find that studies that gain some attention tend to get pdfs circulated via email. It just gets tricky when staff involved in documenting writing, legal, or other activities have to go back and find a copy of something that was cited in text. It can be hard to retrieve again except by asking around.

Also, I have found that the function on Google Scholar that provides links to personal or private copies of pdfs on researchgate or even previous governmental exercises that must provide the references in the administrative record, is really invaluable. This is the way probably most papers are available these days, and I think government and private industry would have to obtain library subscriptions otherwise, (or go back onto campus libraries, as was common 15 years ago).

By the way – both NOAA and PNNL have had studies highlighted with press releases this week, which gets them airing in the government/policy arena that wouldn't occur as quickly if a paper just appeared in the journal and slowly go out through word of mouth. Lisa Crozier et al's paper did go in PLOS, so it is accessible. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0238886

But this dam active tag survival study is not. https://www.pnnl.gov/news-media/taking-stock-salmon-survival-dams-and-science

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, October 7, 2020 8:50 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] FW: License was successfully submitted! Thank you!

Hi Christine—

Just a quick note—our paper is going into production, and the permanent doi to the paper is indicated below for your records. As part of signing the licensing agreement I was offered the opportunity to make the paper open access (i.e., free for anyone to read at no charge), but I regretfully declined that option, as it was $4,300 US.

The past year of additional mostly unfunded work while we worked to sort out what the Fish Passage Center's PIT tag-based survival estimates were actually measuring has made that option too rich for my blood.

However, apparently I still have the option to make the paper open access if I want. I'm not sure if BPA has a budget to pay for the open access charge, but it might be a sensible move for BPA to do so to foster free and open discussion on what we found. I leave that decision up to you—I suspect that your bureaucracy is too multi-layered to allow you to easily do this, but I thought I would raise the possibility.

Regards, David

From: cs-author@wiley.com <cs-author@wiley.com>
Sent: October 7, 2020 8:34 PM
To: David Welch <David.Welch@Kintama.com>
Subject: License was successfully submitted! Thank you!

Dear DAVID WELCH,

Article ID: FAF12514
Article DOI: 10.1111/faf.12514
Internal Article ID: 16903309
Article: A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae)
Journal: Fish and Fisheries

You've successfully completed license signing for your article – thank you! You can view your signed agreement at any time by visiting <SNIP>.

Sincerely,

From: Pisces

Sent: Thu Oct 29 10:33:26 2020

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good morning Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- BPA CORs can view the list of Work Orders (PW-5191)
- Create BiOp annual progress report (PW-5166)
- Add more info to the Land Acquisition Details page (PW-5111)
- Capture Remote Monitoring Information (PW-5095)

Display Photos Based on their Geographic Location (PW-4930)

Organize existing alerts into "My Alerts" on new Dashboard (PW-2919)

Important bug fixes include:

- Total calculation discrepancy in Land Acquisition Report (PW-5199)
- PW Help Center doesn't dismiss list upon selection (PW-5106)

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always...

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Pisces

Sent: Fri Oct 30 11:31:51 2020

To: Pisces

Subject: RE: Pisces Web Release Tonight

Importance: Normal

Happy Friday Pisces Users,

Issues found in last night's release:

Some new functionality described in the release notes did not make it into last night's Pisces Web Release. Thus, we will be offline again this evening to update the systems. Please save your work and log out before 5 PM today.

Thank you for your understanding,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Pisces
Sent: Thursday, October 29, 2020 7:40 AM
To: Pisces <pisces@bpa.gov>
Subject: Pisces Web Release Tonight

Good morning Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- BPA CORs can view the list of Work Orders (PW-5191)
- Create BiOp annual progress report (PW-5166)
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- Capture Remote Monitoring Information (PW-5095)

- Display Photos Based on their Geographic Location (PW-4930)
- Organize existing alerts into "My Alerts" on new Dashboard (PW-2919)

Important bug fixes include:

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For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: David Welch

Sent: Fri Oct 30 17:05:15 2020

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] RE: Article is made Online Open. AID: FAF12514

Importance: Normal

Hi Christine—

Absolutely no feedback as yet—but it only came out at about 11 am PST, so that is not a surprise.

In essence it is coming out only one business day (Monday) ahead of your presidential election, so it will be interesting to see what coverage there is. FYI, I did give Lynda Mapes (Seattle Times) & K.C. Mehaffey (Clearing Up) advance copies a few days ago, on the condition that they honor the journal's embargo. I told them about the same time I told you that the paper is out.

No idea at all what coverage may ensue from that.

Have a good weekend–(b)(6) [redacted]

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: October 30, 2020 3:07 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Article is made Online Open. AID: FAF12514

Hi,

That is wonderful that you did go ahead and do the Open access option. I like the effort to do the Youtube video to help explain it in a short, straightforward presentation. This is exactly the sort of thing you need to get discussion going outside of the academic community. Have you heard any feedback yet? I suppose the paper has to actually come out in the journal form.

I have forwarded this to coworkers to distribute. Next week I need to talk to Jody to see about next steps and what her thoughts are.

Have a nice weekend.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Friday, October 30, 2020 12:19 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: Article is made Online Open. AID: FAF12514
Importance: High

Hi Christine—

Our paper is just published; we made the decision to make it Open Access so that it can be widely accessed.

I will leave it to you to pass the message on to your colleagues.

I have also made the paper available via a Twitter feed, which includes links to short text and animation "explainers" for policy folks (see below). Despite the importance of the delayed mortality issue in the Columbia, we didn't even discuss the delayed mortality issue in the summary for policy makers because we just focussed on the two most important findings (similar SARs up and down the coast & how lack of harvest monitoring compromises PIT tag-based SARs).

Regards, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Here are the links:

Twitter #1:

Our new paper is out. Disturbing findings: Chinook salmon survival similar everywhere, raising questions about current conservation approaches. We also found big problems with Columbia River survival data. https://onlinelibrary.wiley.com/doi/epdf/10.1111/faf.12514

Twitter #2:

We prepared a short animation and summary for policy makers on two key findings.

Animation: https://youtu.be/FN7yp3FefB8

Text: https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

From: cs-onlineopen@wiley.com <cs-onlineopen@wiley.com>
Sent: October 30, 2020 11:00 AM
To: David Welch <David.Welch@Kintama.com>
Subject: Article is made Online Open. AID: FAF12514

Dear Author,

We are pleased to let you know that your article below has been published as OnlineOpen.

Journal Title - Fish and Fisheries
Article Title - A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae)
AID - FAF12514
Manuscript ID - FaF-20-Jun-OA-162.R1

Please feel free to contact us if you have any questions or comments, and thank you for publishing with Wiley.

Sincerely,
Wiley OnlineOpen
cs-onlineopen@wiley.com

*********NOTE*********
This is an auto generated mail. Please don't reply to mail.

From: donotreply@cbfish.org

Sent: Mon Nov 02 09:59:11 2020

To: Erin Rechisky

Cc: Christine Petersen

Subject: [EXTERNAL] Cost Share Plan Confirmed

Importance: Normal

Hello,

This is an automated notification from Pisces.

A Cost Share Plan of project 2003-114-00 (https://www.cbfish.org/ProjectCostShare.mvc/ManageProjectCostShare/2003-114-00) has just been confirmed. If required, the next Cost Share Plan may now be worked on.

Email support@cbfish.org if you have any questions.

Thank you,
Pisces Support

From: Petersen,Christine H (BPA) - EWP-4

Sent: Mon Nov 02 11:43:34 2020

To: 'Erin Rechisky'

Subject: RE: Cost Share Plans Require Attention (FY2013)

Importance: Normal

Hi – okay – I think I did a work around where I was able to enter a zero value and then accept the plans without being registered as the COR, through 2015.

It is exciting that your paper has come out. I really like the press release information that you put together.

Jody Lando is going to brief our upper management, and I hope that she can follow up with a phone call too.

– I will forward the '60 day intention to sue' that Crystal sent out. This is part of a fairly long pattern, where there has been a lawsuit after each Biological Opinion for the hydrosystem. This one seems to have a special emphasis on temperature and climate change, which might be interesting from a legal aspect.

Christine

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Monday, November 2, 2020 9:08 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: Cost Share Plans Require Attention (FY2013)

Hi Christine,

I still get messages regarding a cost share plan from 2013. Can you update/delete this?

Thank you.

I hope you are well.

Erin

From: donotreply@cbfish.org <donotreply@cbfish.org>
Sent: November 1, 2020 6:15 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: Cost Share Plans Require Attention (FY2013)

Dear Erin Rechisky,

You are a contact for 1 project(s) which have cost share plans that are not yet confirmed. These are from Fiscal Years: FY2013.

Projects where you are the Project Lead:

- 2003-114-00

Warmest Regards,
The CBFish Team

From: Erin Rechisky

Sent: Mon Nov 02 12:18:57 2020

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: Cost Share Plans Require Attention (FY2013)

Importance: Normal

Hi Christine,

I received a couple of automated messages from cbfish so hopefully whatever you did worked. Thanks.

It's exciting, but I am a bit anxious about the press release and media coverage.

Erin

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 2, 2020 11:44 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Cost Share Plans Require Attention (FY2013)

Hi – okay – I think I did a work around where I was able to enter a zero value and then accept the plans without being registered as the COR, through 2015.

It is exciting that your paper has come out. I really like the press release information that you put together.

Jody Lando is going to brief our upper management, and I hope that she can follow up with a phone call too.

– I will forward the '60 day intention to sue' that Crystal sent out. This is part of a fairly long pattern, where there has been a lawsuit after each Biological Opinion for the hydrosystem. This one seems to have a special emphasis on temperature and climate change, which might be interesting from a legal aspect.

Christine

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Hi Christine,

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Thank you.

I hope you are well.

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Subject: Cost Share Plans Require Attention (FY2013)

Dear Erin Rechisky,

You are a contact for 1 project(s) which have cost share plans that are not yet confirmed. These are from Fiscal Years: FY2013.

Projects where you are the Project Lead:

- 2003-114-00

Warmest Regards,
The CBFish Team

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Nov 03 10:37:43 2020

To: 'David Welch'; Erin Rechisky

Subject: RE: Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

Importance: Normal

Hi,

Yes, as of today I have heard quite a few people mentioning it (so the press release worked), and someone at the Corps reached out to our management asking about whether there is a plan to promote or distribute it. I still have to hear from more people on this, and I should be able to talk to Jody later today.

Talk to you soon,

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, November 2, 2020 12:23 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] RE: Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

Thanks, Christine-- Interesting reading! I am, yet again, struck by how so much of the claims are interpretative rather than grounded in a rigorous quantitative analysis of how much it actually affects survival.

I wonder—was Judy Lando actually still planning to have a meeting with us? I have heard nothing as yet.

Also, has there been any feedback on our publication—particularly as to the credibility of our work? Or is that too soon and are people just keeping their collective heads down waiting to see what the reaction is?

Regards, David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 2, 2020 12:05 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch <David.Welch@Kintama.com>
Subject: FW: Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

Hi,,

Below is the notice of intent to sue (a regular pattern, as you know). There is a suggestion that water temperatures (e.g. summer of 2015) will be a theme, or part of what reservoir managers will be held liable for mitigating. If you follow the embedded links, I was interested in the Washington Dept Ecology blog post. It has some mistakes in it.

(b)(5)

[redacted]

There will, of course, be other themes in the lawsuit – last time the depositions had many pages of claims.

Christine

From: Ball,Crystal A (BPA) - EW-4 <caball@bpa.gov>
Sent: Friday, October 23, 2020 10:21 AM
To: ADL_EW_ALL <ADL_EW_ALL@BPASite1.bpa.gov>
Subject: FW: Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

Earthjustice on behalf of a coalition of fishing and conservation groups sent a 60-day notice of their intent to return to court to challenge the latest federal plan for hydropower operations on the Snake and Columbia Rivers.

From: Peacock Williamson,Julie (BPA) - DIR-7 <jxpeacockwilliamson@bpa.gov>
Sent: Friday, October 23, 2020 9:58 AM
To: ADL_DIR_ALL <ADL_DIR_ALL@BPASite1.bpa.gov>; Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>; Armentrout,Scott G (BPA) - E-4 <sgarmentrout@bpa.gov>; Welch,Dorothy W (BPA) - E-4 <dwwelch@bpa.gov>; Ball,Crystal A (BPA) - EW-4 <caball@bpa.gov>; Cogswell,Peter (BPA) - DI-7 <ptcogswell@bpa.gov>; Kaseweter,Alisa D (BPA) - DI-7 <alkaseweter@bpa.gov>; James,Daniel M (BPA) - D-7 <dmjames@bpa.gov>; Sweet,Jason C (BPA) - PGB-5 <jcsweet@bpa.gov>; Koehler,Birgit G (BPA) - PG-5 <bgkoehler@bpa.gov>
Subject: Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

https://www.commondreams.org/sites/default/files/organizations/screen_shot_2020-08-25_at_2.19.42_pm.png

For Immediate Release

Friday, October 23, 2020

Organization Profile:

Earthjustice

Contact:

Maggie Caldwell, mcaldwell@earthjustice.org, (347) 527-6397, Brett VandenHeuvel, bv@columbiariverkeeper.org

Fishing, Conservation Groups Take Step to Renew Legal Challenge to Columbia-Snake Hydropower Operations

The long legal battle continues after latest federal plan fails to restore endangered salmon.

WASHINGTON - Today, Earthjustice on behalf of a coalition of fishing and conservation groups sent a 60-day notice of their intentto return to court to challenge the latest federal plan for hydropower operations on the Snake and Columbia Rivers. This would be the sixth incarnation of a long legal fight focused on restoring endangered salmon and steelhead. The groups sending the notice have won the previous five challenges but theTrump administration continues to pursue essentially the same strategy courts have consistently rejected.

Earthjustice represents American Rivers, Idaho Rivers United, Institute for Fisheries Resources, NW Energy Coalition, Northwest Sportfishing Industry Association, Natural Resources Defense Council, Pacific Coast Federation of Fishermen's Associations, Sierra Club, National Wildlife Federation, Columbia Riverkeeper, and Idaho Conservation League.

In the notice, the fishing and conservation groups will also challenge recent Trump administration rollbacks to the Endangered Species Act regulations, changes that a coalition of states and conservation organizations have also challenged in separate cases. The latest federal plan for dam operations relies on these new weakened regulations to support its conclusions.

The following are statements from the lawyers and plaintiff groups:

"Hundreds of thousands of people in the region—including tribes, scientists, energy experts, and fishing businesses—told the agencies to remove the four dams that are causing the most harm to the fish and to our communities. But the Trump administration did not listen and rubber-stamped a plan that yet again fails to take the legally-required actions necessary to protect salmon and steelhead. So we have no choice but to begin the process of going back to court again. What we need more urgently than ever is for our senators and members of Congress to step forward and develop a comprehensive solution that will secure a future with abundant salmon, clean energy and prosperous communities." —Todd True, Earthjustice attorney representing the groups.

"The oversight of the federal courts has been critical to ensure that our agencies and political leaders commit to salmon recovery in the Columbia Basin. Restoring the magnificent runs of salmon in the Columbia and Snake Rivers remains one of the National Wildlife Federation's highest priorities."—Tom France, Regional Executive Director, National Wildlife Federation

"Covid has proven that people in this region harbor a deep need to get outdoors and feel safe while doing so. We've seen more families out on the rivers sportfishing than ever before. When we go out and fish, we're expressing hope. If we lose the salmon, then we lose that hope. The federal plan is dangerous and does a grave disservice to the people who love to fish these rivers, and we could not let it go unchallenged." —Liz Hamilton, Executive Director, Northwest Sportfishing Industry Association.

"The once great, but now damaged, salmon runs of the Columbia Basin, originally the largest in the world, still support valuable ocean commercial salmon fisheries from central California to Southeast Alaska. Studies have shown that about 25,000 family wage jobs, and more than $500 million/year in economic benefits, could be restored to the west coast economy by recovering the Columbia's damaged salmon runs. In short, restoring salmon means restoring jobs and dollars to our economy. The illegal Trump administration salmon plan, however, blatantly ignores those restoration benefits."—Glen Spain, Northwest Regional Director, Pacific Coast Federation of Fishermen's Associations (PCFFA)

"The latest federal plan for dams on the Snake and Columbia Rivers completely fails Idaho. It isn't good enough for the many guides, outfitters, river businesses, and communities in Idaho that depend on healthy runs of fish. We want to restore wild salmon and steelhead in ecological and economically significant numbers. We want abundant, healthy and harvestable runs, meaningful populations that allow people to harvest wild fish and for wild fish to fulfill their role supporting wildlife and the ecology of Idaho."—Justin Hayes, Executive Director, Idaho Conservation League

"We are returning to court because the Trump administration has failed Northwest salmon, tribes, fishing business, and orcas. Like past plans, this one will not recover abundant salmon runs or comply with the Endangered Species Act. While legal action is necessary to protect our iconic species from extinction, we desperately need Members of Congress from Oregon, Washington, and Idaho to get off the bench and secure an inclusive, regional solution."

—Brett VandenHeuvel, Executive Director, Columbia Riverkeeper

"The failure of this federal plan to adequately address the rapid extirpation of salmon and steelhead in Idaho and the Snake River Basin cannot be overstated. Instead of proposing solutions that get us to an abundance of wild fish, this continues down the decades long path of failed recovery efforts. This plan fails Idaho, the angling and guiding communities, the Tribal treaty rights, and the ecological integrity of this system that depend upon healthy and increasing populations of what was once one of the greatest Chinook fisheries in the world." —Nic Nelson, Executive Director, Idaho Rivers United

Online version of this press release.

BACKGROUND:

The Columbia River Basin was once among the greatest salmon-producing river systems in the world. But all remaining salmon on its largest tributary, the Snake River, are facing extinction. Four aging dams in Washington—Ice Harbor, Little Goose, Lower Monumental, Lower Granite —block passage along the lower Snake River, a major migration corridor linking pristine cold-water streams in central Idaho to the mighty Columbia River and out to the Pacific Ocean. Scientists say restoring the lower Snake River by taking out the dams is the single best thing we can do to save the salmon.

Migrating through the dams is difficult for the fish, but rising water temperatures caused by the slackwater reservoirs make the passage increasingly deadly. In 2015, some of the earliest and hottest weather on record produced warm river temperatures that killed more than 90% of all adult sockeye salmon returning to the Columbia Basin. In years since, state agencies have had to limit or cancel entire fishing seasons to protect the dwindling fish.

The district court in 2016 found the operations of the hydropower systems in violation of the Endangered Species Act and the National Environmental Policy Act and ordered the federal agencies to prepare a new biological opinion and environmental impact statement. The federal action agencies—the Army Corps of Engineers, the Bureau of Reclamation, and the Bonneville Power Administration—issued their Final Environmental Impact Statement for dam operations in July 2020, and the National Oceanic and Atmospheric Administration issued a companion Biological Opinion that found the proposed plan would not jeopardize salmon, steelhead, or orcas.

On September 28, 2020, the action agencies issued a joint Record of Decision, opting to continue a course of action the court has previously found inadequate to comply with the Endangered Species Act.

Independent researchers who have studied the economics of restoring a free-flowing lower Snake River and renewable power replacement options favor dam removal.

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https://www.commondreams.org/newswire/2020/10/23/fishing-conservation-groups-take-step-renew-legal-challenge-columbia-snake?cd-origin=rss

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Julie Peacock

Oregon Liaison | Regional Relations

Bonneville Power Administration
bpa.gov | Desk: 503.230.3100 | Cell: [redacted]

From: David Welch

Sent: Tue Nov 03 12:09:37 2020

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky

Subject: [EXTERNAL] FW: Scientia - editorial process complete

Importance: Normal

Attachments: Kintama Chinook SARs Comparison-Print Version.pdf; Kintama Chinook SARs Comparison-Low Res Version.pdf

Hi Christine—

Thanks for your email. This wrap-up email (below) came in this morning, the relevant parts of which I am sharing with you—attached are two versions of the same summary article (the 12 MB one is intended for print, the small (2 MB) one for distributing in emails). The article will be included in a soon-to-be released compendium of environmental science stories when other articles are done.

Feel free to pass on either of the two attached versions of the article as appropriate inside or outside of BPA. Everything is in the public domain and freely available including, of course, the animation hosted on YouTube (https://youtu.be/FN7yp3FefB8).

In the paper (& the animation/policy summary) I have treated the fact that two arms of the US government were unwittingly acting in opposition to one another as lightly as I could. However, the reality is that what we identified is [redacted]

[redacted]

[redacted]

[redacted]

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

From: nelly@sciencediffusion.com <nelly@sciencediffusion.com>
Sent: November 3, 2020 3:15 AM
To: David Welch <David.Welch@Kintama.com>
Subject: Scientia - editorial process complete

Dear David,

The editorial process for the article is now complete, and your audiobook will follow soon! I'd like to thank you so much for your input – we have enjoyed working with you immensely.

We are currently working with some of the other participants to be featured in this edition; once their articles are complete we can release the full edition. In the meantime, please find attached your finished article in high and low resolution formats.

In addition to the link to the HTML and pdf that I've already sent you (https://www.scientia.global/dr-david-welch-rethinking-strategies-for-increasing-salmon-survival ; https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf), here is the DOI: https://doi.org/10.33548/SCIENTIA574

We suggest some of the following ways to personally utilise the article:

- Print the article locally
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We have also started the twitter campaign with your article, we encourage you and your colleagues to get involved and re-tweet, like and share the link:

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Kind regards,

Nelly

Dr Nelly Berg

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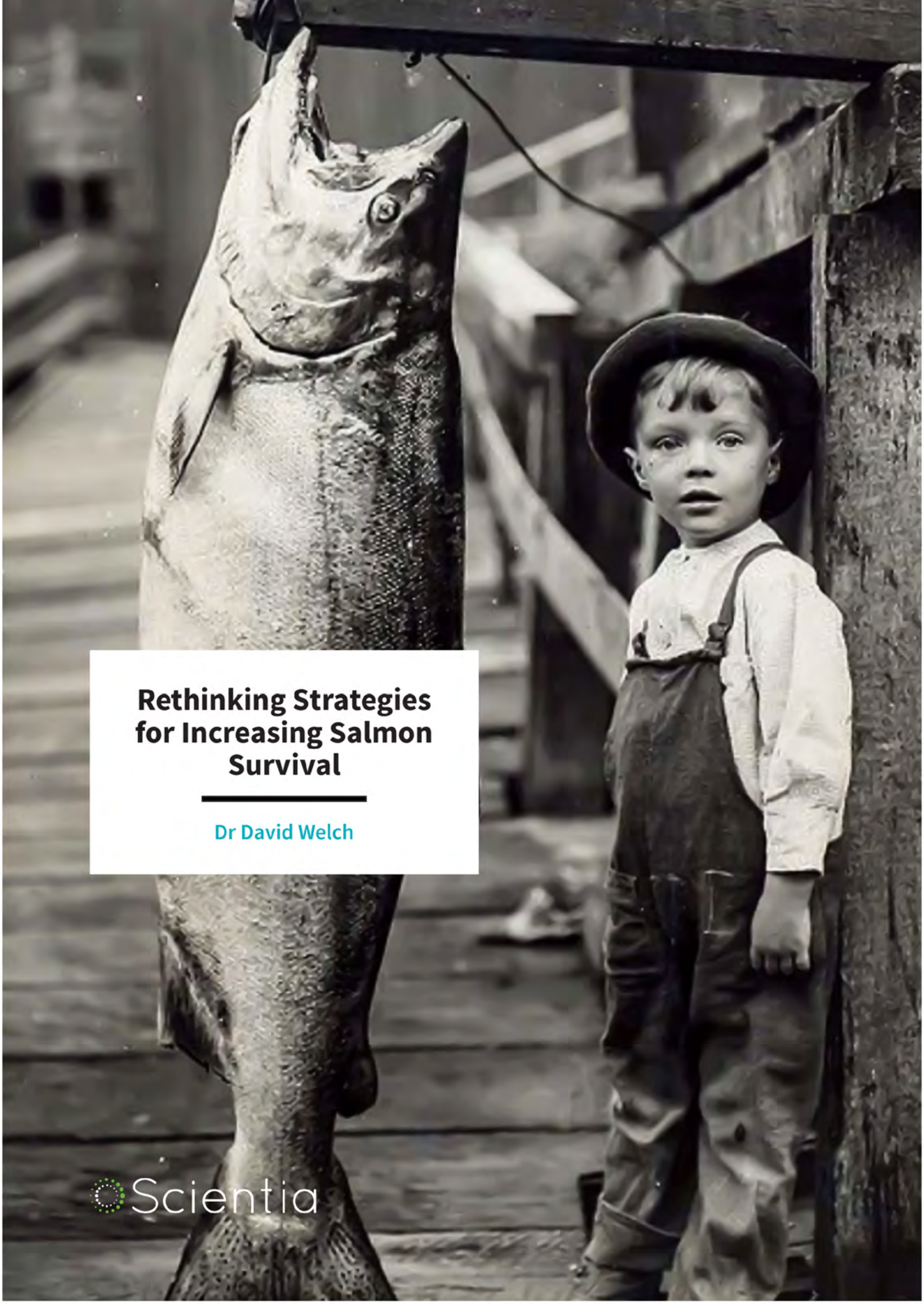

Rethinking Strategies for Increasing Salmon Survival

Dr David Welch

Scientia

RETHINKING STRATEGIES FOR INCREASING SALMON SURVIVAL

It's a long-held belief that a series of dams in the Snake River in Northwest USA constructed nearly 50 years ago has led to serious declines in Chinook salmon populations. However, new research by **Dr David Welch** and his team from Kintama Research Services Ltd shows that survival of Chinook salmon measured by a wide range of government agencies has fallen by 65% along the whole North American West Coast over this period. These results have significant implications for informing conservation strategies to protect and restore this important species.

Salmon Populations in Trouble

The abundance of salmon in the North Pacific has reached record levels. However, most of this increase is in just two species – pink and chum salmon – in far northern regions, attributed in part to ocean ranching – a type of fish farming where juvenile fish reared in hatcheries are released into the ocean to grow before harvest.

In contrast, all West Coast North American Chinook salmon populations are experiencing serious declines. The situation is similar for most southern populations of coho, sockeye, and steelhead salmon. These dwindling species are of higher economic value and are the focus of many indigenous, sport, and commercial fisheries.

Chinook salmon are native to the North Pacific Ocean and the river systems of western North America, ranging from California to Alaska. They are born in freshwater and can undertake complex movements among a variety of freshwater habitats to find food before migrating to the sea as 'smolts'. They then spend multiple years at sea before returning to their natal freshwater habitat to spawn and die.

In North America, declines in salmon populations since the 1970s were originally assumed to be caused by humans modifying freshwater habitats in the populous southern regions, which initially saw the greatest decrease. On the Snake River, the largest tributary of the Columbia River, many dams have been constructed between its headwaters in the Rocky Mountains to where the Snake joins the Columbia River mainstem. It is widely believed that these dams are a major factor behind population declines in Chinook salmon in the Columbia River Basin. The poor survival of Snake River Chinook salmon has resulted in them being listed under the US Endangered Species Act.

In order to examine the large-scale patterns of Chinook salmon survival from the Snake River and other regions, Dr Welch and his colleagues at Kintama Research Services Ltd have been analysing government data to compare the 'smolt-to-adult return rate' for Chinook salmon from central California to southeast Alaska. The team used the results to examine existing theories around population decreases, and to question whether current management practices are appropriate.

'We were shocked to discover that the survival of salmon across British Columbia or in Puget Sound is now as low or lower than the reported survival of Snake River populations, which everyone thought had terrible survival because of the dams.'

Challenging Existing Theories

One long-held theory is that the survival of Snake River Chinook is low because poor survival at sea is caused by 'delayed mortality'. In a nutshell, the theory argues that ocean survival is bad partly because of the many dams the young fish had to migrate through to get there. However, the new data analysis by Dr Welch and his team indicates that Chinook salmon declines are similar from California to Alaska – and most of these river basins have no dams.

'Our analysis of all the available data shows that survival everywhere is low – and has fallen by three-fold, or 65%, across the board over the last 50 years,' says Dr Welch. 'We were shocked to discover that the survival of salmon across British Columbia or in Puget Sound is now as low or lower than the reported survival of Snake River populations. Everyone thought that Snake River populations had terrible survival because of the dams.'

Dr Welch is keen to point out that this doesn't mean that the dams aren't causing problems for the salmon; rather, the team's results suggest that the dams' influence could be minor and they aren't a major factor affecting salmon productivity.

'The existence of this same decline in Chinook returns across essentially all of Alaska and the Canadian portion of the Yukon River, where human-induced freshwater habitat impacts are negligible, is an example of how simple explanations are potentially wrong,' says Dr Welch. 'If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon.'

Another key issue identified by the team was a problem with the Passive Integrated Transponder (PIT) tagging system used to record adult salmon survival in the Columbia River. Many millions of dollars are spent each year on this system and in analysing the data from it. However, when Dr Welch and his team looked closely at the system, they found that the harvest of PIT tagged salmon in the fisheries was unaccounted for and was large and variable. This omission introduces major biases into the many survival studies using PIT tags, which assume that harvest in fisheries is negligible.

In fact, the use of the PIT tagging system for studying salmon survival could be even more problematic. Under the terms of the US-Canada Pacific Salmon Treaty, the coast-wide management of fisheries for Chinook salmon is abundance-based, which means that managers are required to increase harvest when Chinook survival is high and restrict harvest when it is low. As a result, managers are actively modifying harvests in just the right way to obscure any survival fluctuations attributable to the dams. Because biologists seeking to improve survival back to the river work independently of the managers and are not accounting for what happens at sea, they may actually be responding more to imperfections in the harvest management system rather than identifying how the dams really affect survival.

This previously unrecognised limitation of PIT tagging methodology is critical to current management efforts in the Columbia River basin, which largely rely on studies using PIT tags. Fortunately, the Kintama team was able to collate sufficient survival data for Columbia River populations using alternative tagging methodology used elsewhere in the Pacific northwest to allow coastwide survival comparisons to be carried out.

CREDIT: Curtis Smith, Coastal Wilderness Adventures

The Way Forward for Salmon Conservation

'Evidence that Chinook salmon smolt-to-adult returns have decreased to roughly 1% in many regions along the West Coast of North America is both surprising and important,' says Dr Welch. 'These decreases in survival have occurred despite governments' best attempts to increase salmon populations through harvest regulation, construction of hatcheries, and freshwater habitat restoration.'

A major assumption underlying these efforts is that regional factors such as habitat degradation or salmon farms significantly contribute to declining Chinook populations. However, the similar decline across the whole study region suggests a different view is likely. 'At the broadest level, the major implication of our results is that most of the salmon conservation problem is likely determined in the ocean by common processes,' explains Dr Welch. 'Nobody really knows why salmon survival is dropping in the ocean – there is much speculation and some correlation-based analysis, but nothing definitive.'

If this view is correct, then developing a better understanding of the relationship between the ocean-phase of the Chinook salmon lifecycle and population survival rates will be central to successful efforts to restore their populations. This has significant implications for current policies for salmon conservation and management. 'Attempts to improve smolt-to-adult return rates by addressing region-specific issues such as freshwater habitat degradation are unlikely to be successful,' says Dr Welch. 'Given the geographically widespread collapse in survival, the research community needs to reassess several core conservation assumptions.'

In terms of the Snake River populations, the theory of dam-induced delayed mortality still plays an important role in Columbia River salmon management. Another of the Kintama team's current results is of direct interest here, as the broad range of populations they studied showed no consistent evidence that migrating through more dams reduced survival – the hallmark of the delayed mortality theory. Therefore, expensive changes to hydropower operations intended to improve survival may have little impact.

The Kintama team recommends that in future better coordination will be necessary between fisheries managers controlling a wide range of ocean and river fisheries and research biologists working in the Columbia River to improve salmon returns, to ensure that the role of fisheries is incorporated into future analyses and not ignored. However, there is also a critical need to move away from correlation-based studies that compare just a few populations to much broader studies which recognise that the contributing factors may be both complex and beyond our ability to control.

Dr Welch believes that closer attention needs to be directed to how smolt-to-adult return rates are quantified and how salmon rebuilding targets are defined in North America. His team is calling for a systematic review by funding agencies to address consistency and comparability of the smolt-to-adult return rate data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast.

Overall, the policy implications of Chinook salmon survival converging to similar levels nearly everywhere along the west coast of North America are profound. The findings of Dr Welch and his team indicate that current salmon fisheries management and population rebuilding strategies both need to be re-evaluated. This could involve moving away from strategies based on historical theories around human-induced freshwater habitat degradation and looking more towards factors driving population decline in the ocean-phase. The way survival data are collated and interpreted is critically important, as is correctly incorporating the impact of fisheries on salmon survival.

Meet the researchers

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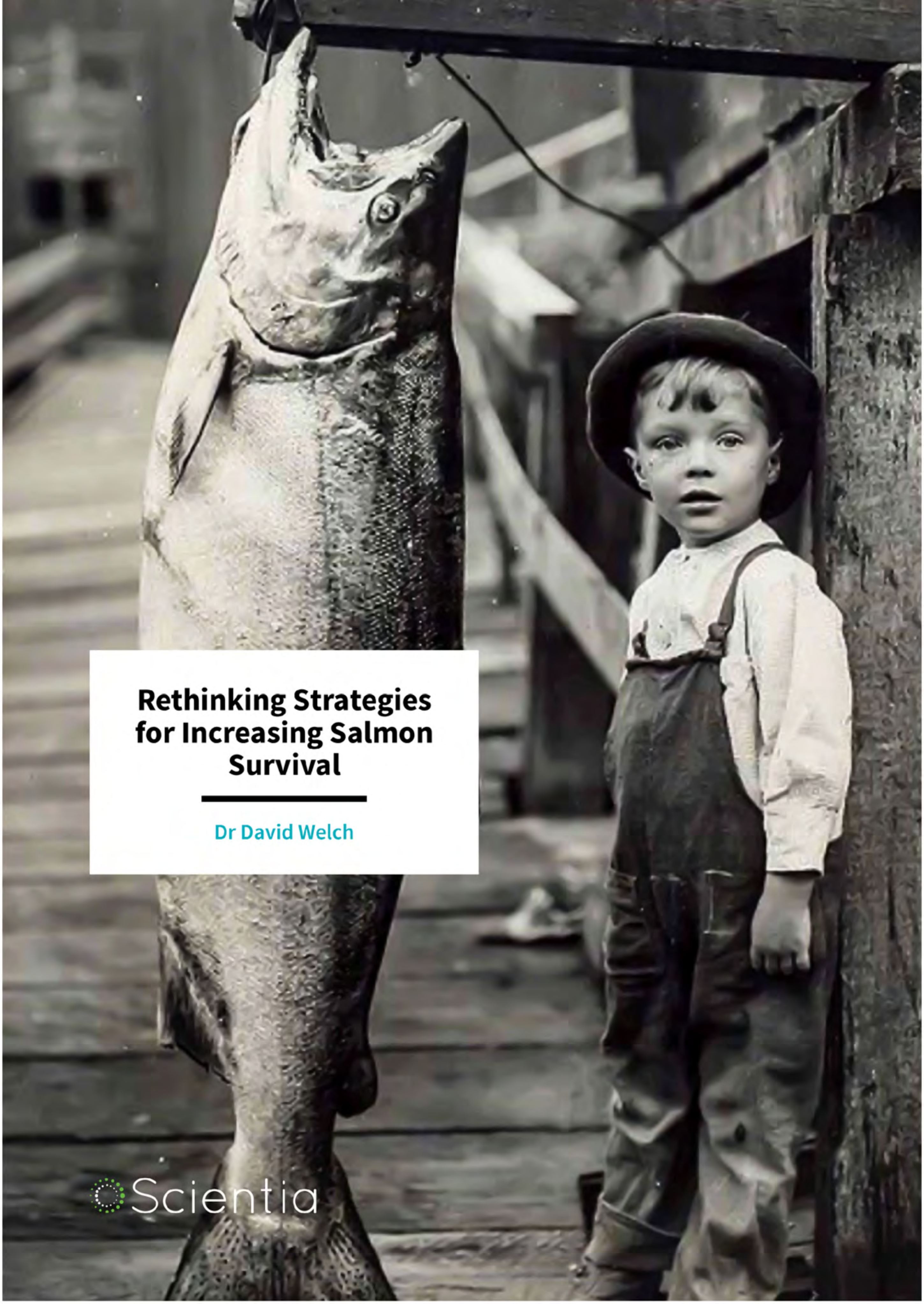

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Kintama Research Services Ltd
US Department of Energy – Bonneville Power Administration

KINTAMA

From: Petersen,Christine H (BPA) - EWP-4

Sent: Wed Nov 04 11:53:06 2020

To: Erin Rechisky; 'David Welch'

Subject: FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Importance: Normal

Attachments: Faulkner_etal_2020_TAFS_response_to_comment_accepted.10280.pdf; Storch et al. 2020.pdf; Faulkner 2019.10200.pdf

Hi,

I'm watching at Wisconsin and Michigan pull ahead this morning?

Anyway, I am forwarding the FPC review and Faulkner et al. rebuttal to their paper at TAFS. Sort of interesting how involved this was getting. SARs and delayed mortality are at the center of it. I have been interested in the phenomenon of CSS study hatchery fish having higher mean SAR than the NOAA LGR tagged study smolts. They assert that this has to be due to a tremendous effect of going through a single bypass at Lower Granite, however the difference between CO and C1 (no detections at Lower Granite, Goose or Monumental vs one or more) is only 10% for Chinook and steelhead, (and no difference for subyearlings), so that just doesn't add up.

I will hopefully reach Jody later this afternoon

Christine

From: Sullivan,Leah S (BPA) - EWP-4 <lssullivan@bpa.gov>
Sent: Tuesday, October 27, 2020 1:46 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Christine, Scott – Have you heard much about this "dance?" See attachments. I'm going to try to review and digest as time permits tomorrow.

Leah

From: Studebaker, Cynthia A CIV (USA) <Cynthia.A.Studebaker@usace.army.mil>
Sent: Tuesday, October 27, 2020 10:26 AM
To: Sullivan,Leah S (BPA) - EWP-4 <lssullivan@bpa.gov>
Subject: [EXTERNAL] FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

DR. JAMES ROBERT FAULKNER (Orcid ID : 0000-0003-4478-5113)

Article type : Comment

Corresponding author mail id: jim.faulkner@noaa.gov

Associations among Fish Length, Dam Passage History, and Survival to Adulthood in Two At-Risk Species of Pacific Salmon: Response to Comment

James R. Faulkner[1], Blane L. Bellerud[2], Daniel L. Widener[1], Steven G. Smith[1], and Richard W. Zabel[1]

[1]Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic & Atmospheric Administration, 2725 Montlake Boulevard East, Seattle, WA 98112, USA

[2]West Coast Region, National Marine Fisheries Service, National Oceanic & Atmospheric Administration, 1201 Northeast Lloyd Boulevard, Suite 1100, Portland, OR 97232, USA

The management of Snake River spring/summer Chinook Salmon and Snake River steelhead is a major concern for several federal, state, and tribal agencies. A primary issue is the effect of the Federal Columbia River Power System (FCRPS), composed of eight dams and reservoirs in the Snake and Columbia rivers, on adult return rate. Management decisions have been influenced by the hypothesis that the passage route that juveniles take through dams (i.e., through spillway, turbines, or juvenile bypass system) strongly influences adult return rate. The main hypothesized mechanism

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for differential survival rates is differences in latent mortality – mortality suffered due to passage through the FCRPS that is expressed outside of the FCRPS. Because this latent mortality is not directly measurable, it must be indirectly inferred. Two patterns have been observed in, or inferred from data analyses in the past, and have become generally accepted during decades of debate: (1) smaller fish are more likely than larger fish to pass dams on the Snake and Columbia Rivers via the juvenile bypass system passage route, and (2) among fish that complete migration through the entire hydropower system, those that passed more dams via juvenile bypass systems return as adults at lower rates. This has led to increased spill to prevent juveniles passing through bypass systems and turbines with a hypothesized decrease in latent mortality. The most important question to address is whether lower survival is *caused* by increased numbers of bypass-system encounters, or whether that pattern results because both increased encounters and decreased survival might be explained by another causative factor.

Faulkner et al. (2019) presents an analysis that addresses this question by examining the relationship between fish length and the probability of entering a bypass system and between fish length and probability of returning as an adult. We found that after accounting for other important sources of variation, smaller fish were more likely to enter bypass systems than larger fish and smaller fish were less likely to return as adults. We also found that evidence for apparent effects of bypass passage on adult return diminished or disappeared when fish length was taken into account, suggesting that much of the apparent bypass effect could be explained by length. We went on to conclude that length was an important factor that should not be ignored, but we also concluded that more research was needed into effects of route of passage at dams on ocean survival.

Storch et al. (2020) take issue with several aspects of Faulkner et al. (2019) in their comment. We welcome the criticisms raised by Storch et al. since we believe it is constructive to debate the merits of scientific analyses, especially when the outcomes are used to support management decisions. However, we believe that Storch et al. mischaracterized some of our results and conclusions. In particular, Storch et al. state in their first sentence that "Faulkner et al. (2019) presents data and analyses to support a hypothesis that bypass encounters by juvenile Chinook Salmon and steelhead at hydropower dams are not harmful…" This choice of wording seems to imply that the motivation of our investigation was "to support" a preconceived position. This is not correct. One might plausibly say that one objective was to test a classically constructed null hypothesis that bypass passage had no effect on adult return probability after accounting for other sources of variation, but that is not the same as saying we set out trying to support a hypothesis of no harm. Furthermore, in reporting results we never stated that bypass encounters are not harmful in general, only that the evidence for an effect of bypass passage on adult return probability was not strong after accounting for fish length. Storch et al. also state that "Faulkner et al. (2019) fit a suite of mixed effects models to assess their hypothesis that fish length largely explains variation in bypass probability." This is another mischaracterization of "our hypothesis," and this time it is not even defensible as a loose statement of a classic null hypothesis. Moreover, our results simply showed that there was strong evidence for length effects on bypass probability after accounting for other sources of variation, and we made no such claim that fish length "largely explains variation." Storch et al. go on to make statements like "If the assertion of Faulkner et al. (2019) that variation in adult returns can be best explained by fish size is credible…", and "This brings into question the veracity of an argument, as in Faulkner et al. (2019), that suggests size upon ocean entry is the principal driver of differential survival." Neither assertion or argument was ever made in Faulkner et al. (2019). Instead, we showed that there was strong evidence for an association between length and adult return probability after accounting for other sources of variation, but never made the assertion that length was the primary factor affecting survival.

Storch et al. (2020) put forth several concerns with the data, methods, and conclusions of Faulkner et al. (2019) and provide some additional analyses meant to support their arguments. Although we agree with some of their concerns, we find weaknesses in their arguments and shortcomings in their supporting analyses that undermine many of their conclusions. In brief, our responses to the 5 specific concerns raised by Storch et al. are: (1) we agree that survival was lower for fish tagged at Lower Granite Dam, but we disagree that there was a survival bias and we conclude that convincing evidence was not provided that would nullify the use of those data; (2) we agree that power was lower for detecting the specified bypass effect sizes on adult return probability for fish tagged upstream of Lower Granite Dam, but power was sufficient for fish tagged at Lower Granite Dam; (3) we disagree that models for bypass probabilities needed additional variables since our models adequately captured temporal variation and provided reasonable estimates for length effects; (4) arguments against size-selective ocean mortality based on fish from the John Day River were not supported and were mostly irrelevant to our paper; and (5) aggregating individual measurements can result in substantial loss of information and using their suggested annual indices of freshwater out-migration can potentially lead to spurious conclusions.

Below, we provide detailed responses to the 5 concerns raised by Storch et al. (2020). Note that all data and relevant computer code used in the analyses presented here can be found online at `https://github.com/jrfaulkner/bypass-length-sar`.

Negative survival bias for fish tagged at Lower Granite Dam

Storch et al. note that fish tagged at Lower Granite Dam (LGR) had lower adult return probabilities than those tagged upstream. They contend that this difference is caused by bypass passage, handling, and tagging. They argue that results that use fish tagged at LGR are misleading, because their lower survival potentially masks effects of subsequent bypass events on adult return. To support their assertion, they use a plot based on adult returns pooled across years.

We acknowledge that fish tagged at LGR had lower return probabilities in many years. The survival difference is not a problem in itself; a model could easily account for it using a term for tagging location. In Faulkner et al we explained why we chose to analyze the tagging locations separately: mainly because all fish tagged at LGR pass via the bypass system, creating a strong confounding of bypass history and tagging location in the joint model. Modeling locations separately avoids this confounding, while preserving the relationship between bypass experience after release and adult return within each group.

We disagree with labeling the lower return probabilities of fish tagged at LGR as a "negative survival bias." The upstream traps, especially the Grande Ronde Trap, do not sample passing populations in the same proportions as LGR. Therefore, we would not necessarily expect them to have equal survival after leaving the hydropower system. Differences in survival due to population of origin or passage timing cannot be labeled as biases. Storch et al. ignore these sampling differences and assume that the only reason for the difference in survival is due to tagging, handling, and bypass. Fish are also collected, handled, and tagged at the smolt traps. Tagging protocols are followed at both LGR and the traps to minimize stress and post-release mortality. We would expect any lingering handling effects to be minimal and similar in general among these tagging locations. Lastly, a sample can be said to be "biased" if it is not representative of the population from which it was taken, and to which inference is to be made. This sort of bias would be of concern if, with respect to the effects of interest, our modeling approach required survival of fish tagged at LGR to be representative of survival of fish tagged upstream. It does not.

Whatever the reason for lower survival for LGR-tagged fish, we are not convinced that it would in turn invalidate inference from patterns of subsequent migration experience and adult return within the group, or would "mask" effects in a particular way. In particular, we are not persuaded by the argument for which Storch et al. provided their Figure 1. If one bypass event causes harm, then additional bypass events should cause more harm, and if fish are damaged by handling and tagging, then bypass events following release would also be expected to cause more harm. Also, if the first bypass event was the most detrimental, then one would expect a large drop in survival between zero bypass events and one event.

We see several problems with the analysis and conclusions of Storch et al. in relation to their Figure 1. First, the return probability estimates are the result of pooling returns across years and ignoring tagging site (for fish tagged upstream of Lower Granite Dam), day of year, rearing type, and length effects, when all had been shown in Faulkner et al. to be important predictors of adult returns. Storch et al. even confirm that some of these variables, such as length, rearing type, and year are important in the paragraphs prior to introducing their Figure 1. Unfortunately, pooling makes it impossible to determine the contribution of these sources of variation to the patterns seen in their Figure 1; i.e., the patterns cannot be attributed solely to the effect of bypass experience.

Second, there is no data point plotted for zero bypass events to use as a reference point for comparison, and the points at zero and those for the highest number of bypass events (7 events for Chinook Salmon and 6-7 for steelhead) appear to have been deleted when their smoothers were fit, which could change the trajectory of the fitted lines. Third, the data used to produce the plots is not the same data used by Faulkner et al. for analyses on adult returns. The result of all of these choices is an exaggerated visual that is striking but tells a misleading story.

A more appropriate way to graphically represent the relationship between number of bypass events and adult return probability is to plot the predicted return probabilities from a model that takes the various sources of variation into account, as in our Figure 1. We used the models that included covariates and the categorical bypass variable shown in Table 2 of Faulkner et al. to generate the predicted values in Figure 1. However, for fish tagged upstream of Lower Granite Dam we expanded the categorical bypass variable by splitting the category with four or more bypasses into a category for four bypasses and one for five or more. We added the category because we used the convention of Storch et al. that all fish tagged at Lower Granite Dam had at least one bypass event and wanted the two tagging groups to have the same categories. We also used the categorical bypass variable instead of the continuous variable so that the estimates and uncertainty at each number of events could be seen. For each tagging group, we calculated predicted values for wild fish of average length exiting the hydropower system on the average day during an average year (year effect of zero). In addition, for the fish tagged upstream of Lower Granite Dam, the predicted values were for fish tagged at the combined Snake and Clearwater River traps.

A few things stand out in the plots in our Figure 1. One is that for Chinook Salmon tagged upstream of Lower Granite Dam, there is little to no difference in the predictions between 0-2 bypass events.

For those fish, the predictions for 3-7 events are lower, but uncertainty is higher. For Chinook Salmon tagged at Lower Granite, there is no difference between 1-4 bypass events, but predictions are lower but not significantly so for 5-7 bypass events. Chinook Salmon tagged at Lower Granite Dam did have lower survival than their counterparts tagged upstream. Based on these plots, it appears there could be an effect of multiple bypass events on Chinook Salmon, but more data is needed.

For steelhead, there does not appear to be any pattern in the predictions that is dependent on number of bypass events, for either tagging site. The predicted return probabilities are not much different between the tagging locations for steelhead, either.

A plausible explanation for the patterns seen in the plots is that there is little to no effect of bypass passage on adult return after accounting for length and other variables and this becomes apparent with the larger sample size and more accurate measures of current length as fish pass Lower Granite Dam.

Although we agree that lingering effects of handling should be a concern, we do not have direct evidence that handling effects remain after the fish are released. If handling effects remained after release from Lower Granite Dam and after survival past Bonneville Dam, then one would expect that fish tagged at smolt traps upstream of Lower Granite Dam would also express lingering handling effects. Given that, we do not agree that lower ocean survival for fish tagged at Lower Granite Dam is sufficient to invalidate all of the results reported in Faulkner et al. for those fish. One of the biggest benefits of the data set from LGR is that every fish had a measured length as it began its subsequent downstream migration. Storch et al. appear to want to eliminate all of those fish from consideration, leaving very few fish with quality length measurements remaining.

Insufficient sample size to detect bypass effects on survival

Storch et al. note that sample sizes for fish tagged upstream of LGR were relatively small, and suggest that they were not sufficient to detect a bypass effect. They present results from an analysis of expected power based on simulated data sets in which effect sizes were equal to those estimated in a report by Tuomikoski et al. (2010), derived from models that included year effects but not fish length. They conclude that with the sample sizes of upstream-tagged in Faulkner et al., expected power to detect bypass effects was low. Storch et al. did not conduct a power analysis based on groups of fish tagged at LGR.

We agree that sample sizes for fish tagged upstream of LGR were relatively small. As explained in Faulkner et al., our purposes required fish with reliable length measurements shortly before entering the hydropower system, which limited available sample sizes. We acknowledge that a possible reason that we did not find a statistically significant bypass effect for steelhead tagged upstream of LGR is low power associated with small sample size, and that we should have stated that in Faulkner et al.

However, the values for expected power Storch et al. reported were surprisingly low. Accordingly, we conducted independent analyses of expected power, including fish tagged at LGR, for comparison. We used the per-bypass-event effect sizes derived from Tuomikoski et al. (2010) of -0.117 for Chinook Salmon and -0.127 for steelhead that were used by Storch et al. We also included effect sizes from McCann et al. (2016) of -0.125 for Chinook Salmon and -0.116 for steelhead, along with a smaller effect size of -0.10 and a larger one of -0.15. Exponentiation of these effect sizes gives the multiplicative change in the odds of survival associated with each bypass event.

For each species and tagging location, we simulated binomial return data using the specified effect sizes for the number of bypass events and intercepts and year effects obtained from our models of the original data and using the same number of fish in each year and within each number of bypass events. We simulated 1,000 data sets for each species, tagging location, and effect size. For each simulated data set we fit binomial logistic regression models for adult return probability that included the fixed effect for number of bypass events and random effects for years. We calculated power to detect the specified effect sizes using test levels of $\alpha = 0.05$ and $\alpha = 0.10$ and using change in Akaike information criterion of $\Delta AIC \geq 2$ and $\Delta AIC \geq 0$. These different methods of determining strength of evidence for an effect were used because similar criteria were used by Faulkner et al. and they provide information on how power varies under different criteria.

Our results confirmed that power was low for both species tagged upstream of LGR, but not as reported by Storch et al. (Table 1). Power was much higher for the fish tagged at LGR; mostly above the 0.80 level suggested by Storch et al.

We also attempted to reproduce the power curves shown in Figure 2 of Storch et al. by repeating the simulations for multiples of the original sample sizes for fish tagged upstream of Lower Granite Dam. We ran 500 simulations for each sample size. To be able to inflate the sample sizes for each number of bypass events we separately estimated the proportion of fish in each category and year using multinomial likelihoods and assuming a shared detection probability across dams within each year. For each simulated data set the number of fish within each bypass category was sampled from a multinomial distribution as in Storch et al. We fit models with a fixed effect for number of bypass events and random effects for year (as done by Faulkner et al.). The power values we obtained were substantially higher than those reported by Storch et al. (Figure 2). Investigation of the computer code supplied by Storch et al. revealed that they erroneously used fixed effects for year, which increased the number of fitted parameters and decreased power. They also did not allow the number of fish in the high bypass categories (6+) that had zero fish in the original data to increase with increasing sample sizes. This likely reduced power further due to a weakened association between adult return and high numbers of bypass events. A link to the computer code used for our power simulations is included in the Supporting Information section.

Drivers of bypass probability

Storch et al. argue that we did not explicitly include covariates such as spill and flow in our models for bypass probability in Faulkner et al. and therefore the main drivers of bypass probability were not identified. They also demonstrate that the effect of length on bypass probability was small compared to that of spill. This criticism appears to be based on the false premise that our hypothesis was that “fish length largely explains variation in bypass probability,” and that the objective of Faulkner et al was to build a model of the drivers of bypass probability.

Correctly stated, the objective of the analysis of bypass probabilities in Faulkner et al. was to investigate whether bypass probability was associated with fish length after accounting for other sources of variation. Those sources of variation included tagging location and rearing type as well as temporal effects of year and day within year, where day effects were allowed to be linear or quadratic and vary by year.

It is well known that the proportion of water passing through spillways is one of the major drivers of variation in numbers of fish passing through each of the different routes of passage at a dam. More water flowing through spillways results in more fish passing through spillways and less fish passing through bypass systems. That fact is not disputed and we never stated that factors like spill do not explain variation in bypass probabilities. To answer the question we were actually interested in, we simply used temporal surrogates for spill and other factors that contribute to variation in bypass probabilities.

We contend that those temporal surrogates captured much of the temporal variation in the data. To illustrate, using the model for Chinook Salmon at Little Goose Dam, we generated predicted values of bypass probabilities by year and day within year for wild fish tagged at the Snake River Trap. Figure 3 shows lines for fish of mean length and for fish in the first and 99th percentiles of length for the set of years highlighted by Storch et al. and for two additional years. The results indicate that appropriate interannual variation in bypass probabilities was captured in our models, and that some variation due to changing conditions within season was also captured. It is clear that the range of bypass probabilities at the extremes of spill shown in Figure 3 of Storch et al. were captured.

We acknowledge that our use of temporal surrogates has the disadvantage of losing some of the within season variation in bypass probabilities that results from rapid fluctuations in spill operations, but the effect of that loss in variation on the estimates of length effect were likely minimal. Estimates of the length effect were robust to variation in the set of variables in the model. For example, for Chinook Salmon at Little Goose Dam, the estimated length parameter was -0.210 in the best model from Faulkner et al., which contained year, tagging site, rearing type, and linear and quadratic day effects that varied by year. When day effects were removed the estimate changed to -0.195, and when both day effects and year effects were removed it was -0.231. Given that the best models for bypass probability in Faulkner et al. always contained random year effects and day effects that varied by year, we believe that our models captured enough of the interannual and within-season variation to adequately estimate effects of length on bypass probabilities

While we reiterate our rejection of the assertion that our "hypothesis" was that "fish length largely explains variation in bypass probability," we acknowledge that length actually does not explain a large amount of variation in bypass probability. It is in fact not a large effect, but the statistical evidence for it is strong and is consistent across multiple dams.

This suggests a biological phenomenon is occurring that requires more study and attention. It would be inappropriate to simply ignore this fact because length is not the largest driver of bypass probability. What is important is that length is also associated with adult returns and when length was included in models for adult returns in Faulkner et al. the effect of bypass passage was diminished in most cases. This suggests that much of the signal contained in the bypass variable in terms of its effect on return probability was actually due to the component of that signal explained by length.

Differences in survival among populations in the Columbia River Basin

Storch et al. contend that a population-level comparison of survival between salmonid populations from different basins somehow invalidates individual-level patterns observed within a single one of those populations. Because fish from the John Day River are slightly smaller on average than fish from the Snake River, but have higher survival, they conclude that results from Faulkner et al. that relate fish size to return probability must be incorrect. They also make the argument that the difference in returns between the two populations is due to the number of dams they pass.

As in the previous section, the apparent belief that our results have been refuted is based on a false premise. This section of Storch et al. begins with this sentence: "If the assertion of Faulkner et al. (2019) that variation in adult returns can be best explained by fish size is credible, one should expect that the effect would apply across multiple populations within the Columbia River Basin." That is, they represent their work here as generating a prediction from a hypothesis and then checking whether the prediction holds. So far, so good, except for the fact that Faulkner et al. does not make the assertion they claim.

Faulkner et al. concluded that there was strong evidence for an association between length and probability of adult return when other important sources of variation were accounted for in their models. Those other variables explained a large amount of variation in the data. There was no claim that length was the most important predictor or that length "best explained" variation in returns. We stated that there was evidence that length was an important predictor; not that it was the most important predictor.

Population-level comparisons of Snake River stocks to those from other basins potentially contribute to the general understanding of salmonid populations in the Pacific Northwest. However, given the true objectives of our investigation, such comparisons really have no place in a critique of our individual-based analyses of fish within the Snake River populations. Storch et al. state "one should expect that *the effect* would apply across multiple populations" (emphasis ours). But the effect that Faulkner et al. assert is a relationship between individual length and individual survival. We see no reason that evidence of the individual-level effect necessarily predicts the population-level pattern they looked for.

Data from John Day River populations might be used as a check on our methods and results, but such an analysis should surely include an attempt to determine whether there was a relationship of individual fish size to survival within the John Day population (i.e., the effect that the actual assertions in Faulkner et al. would predict would apply within other populations). If a comparison is to be made with another population, the statistical model should account for fish size and other covariates, including those related to migration timing and time of tagging. Having misstated our intentions, Storch et al. appear not to have even considered these issues.

Faulkner et al. (2019) provided references for multiple studies that found support for size-selective mortality in salmonids, but none of the citations in Storch et al. in support of their population-level arguments included length as a covariate. Without direct evidence against a length effect, what they provide is not evidence that size-selective mortality does not occur in Snake River salmon stocks.

There are many reasons that ocean survival might differ between populations, one of which could be the number of dams they pass. However, Storch et al. conflate the number of dams passed with route of passage taken at dams. The existence of dams and their effect on ocean survival of fish is a different topic from the difference in survival associated with different routes of passage at dams. Arguments regarding number of dams passed go beyond the scope of Faulkner et al. and are not relevant to the content of the paper.

Importance of hydropower system passage condition

Storch et al. argue that "measures of passage experience at the aggregate scale are likely more appropriate indicators of population-level impacts than bypass history considered at the scale of individuals." They contend that mean water transit time needs to be included in models and that mean number of bypass events better represents conditions experienced by individual fish during their river migration than number of bypass events experienced by individuals. They claim that by excluding those variables from our models, Faulkner et al. exaggerated effects of length on ocean survival.

We see three problems with the arguments of Storch et al. and models they fit in support of those arguments:

1) averaging of measured variables results in substantial loss of information;

2) using annual average number of bypass events breaks the association between length and number of bypass events in the data; and

3) annual average values of some variables can become correlated with other processes operating on annual or seasonal level that are not included in the models.

There is no ecological or mechanistic reason to conclude that averages of measurements of a process experienced at the individual level are a more appropriate indicator of the experience of the collection of individuals than the individual measurements themselves. It is always better to construct models that represent data at the smallest measured observational unit for which unique information is available and for which processes of interest can be most directly represented.

Given that, it is unclear why one would prefer to explain ocean survival of any individual fish using the mean number of bypass events experienced by all fish migrating in a year. The number of bypass events experienced by each of those individual fish is a known and measured variable. If it is in fact the act of passing through a bypass system that is detrimental to ocean survival, then it is much more informative to relate the bypass history of an individual to the survival of that individual.

Similarly, it is not clear why a seasonal average measure of water travel time would be preferred over the time it takes each individual fish to travel through the system, when that is a measured variable. If time spent in the hydropower system is the important determinant, then one would want to know which fish went through faster and which slower, and relate those measures to survival of the individuals.

Finally, it is perplexing why the mean of fish lengths would be used in place of the individual lengths themselves. There is much more variation in lengths of individuals migrating within a year than there is in mean lengths across years. With averaged variables, all fish migrating in the same year get the same values, diluting the information contained in the individual measurements. Preserving individual variation in the data allows the statistical models to estimate parameters that represent the range of individual experience in the population.

We illustrate how averaging results in loss of information for the data used in Faulkner et al. and by Storch et al. using length at tagging. Variation of annual mean length is substantially less than variation in lengths within years, for both species and tagging locations (Figure 4). In fact, much of the variation in annual mean length results from variation in the percentage of wild fish in each year, as wild fish are smaller than hatchery fish on average. Using annual means in this data set, any length effect would be confounded with differences between wild and hatchery fish. If analysis were restricted to hatchery fish, there would likely be very little variation in mean length, and it would be difficult to detect an effect of length on adult return, even if there were large differences in survival related to individual lengths.

The second problem is that using annual average number of bypass events breaks the association between length and number of bypass events in the data. In their first set of models, Storch et al. use individual fish lengths, but assign each individual the annual average number of bypass events. Because the bypass variable is no longer an individual measurement, no correlation with any other individual characteristic can be assessed, e.g. with length, rearing type, or tagging location. A key finding of Faulkner et al. was that number of bypass events was associated with fish length and when both variables were included, the apparent effect of bypass events on adult return probability was diminished. Using annual mean bypass events makes it impossible to uncover this phenomenon, so the results of Storch et al. were inevitable.

Using the annual average changes the meaning of number of bypass events, making it correlated with annual processes and not individual fates, which is the third problem with averaging. When some individual-level measurements are averaged across the year, they become correlated with other processes operating on annual or seasonal level, which may or may not be included in the models.

We illustrate this problem using variables related to ocean conditions that have been used by Burke et al. (2013) and others to model ocean survival of salmon. We retrieved annual summaries of a set of ocean variables from the Northwest Fisheries Science Center website (NWFSC, 2020) for the years 2004-2014. We calculated Pearson correlation coefficients and associated *P*-values for correlations between those ocean variables and a few variables representing river conditions, including average annual spill proportion, flow (kcfs), water particle travel time (days), and number of bypass events. We also fit binomial logistic regression models for adult return probabilities (calculated separately by tagging location) for standardized versions of each of these variables alone, with random year effects, and recorded slope parameters and associated *P*-values for Chinook Salmon, where hatchery and wild fish were combined as in Storch et al. The results indicate that many of the ocean variables had significant correlations with the freshwater variables and many of those were also associated with adult return probabilities (Table 2).

The presence of these correlations makes it difficult to determine which variables are actually affecting survival. It makes more sense from an ecological perspective that processes occurring in the ocean and estuary will directly impact ocean survival and provide mechanistic explanations for variation in ocean survival. Processes during river passage are more likely to affect survival in the river and less likely to affect survival in the ocean. That does not mean that number of bypass events and time spent in the hydropower system cannot affect ocean survival. However, using annual averages of these variables disconnects the association between them and the fates of individual fish and results in serious confounding between them and ocean variables associated with ocean survival. This confounding can lead to a conclusion that the relationships between river variables and ocean survival are causative when in fact they are due to correlations with ocean variables.

For many variables, measurements on individual fish are not available. In those cases, the only option is to use some kind of average or single measurement for all fish within the time period of the average. When measurements are available for individuals, however, it is appropriate to use them. The Storch et al. argument that aggregate measures are more appropriate is not convincing and the assertion that the methods of Faulkner et al. resulted in exaggerated length effects is not supported by the evidence.

Conclusions

Storch et al. provide a set of concerns and issues with the findings of Faulkner et al. in their comment. Although we agree with some of their concerns, we find that many of their arguments are based on mischaracterized statements and the evidence in support of their claims is often weak. Therefore, we believe that the conclusions of Faulkner et al. are relevant to understanding passage and survival of juvenile salmon through the Snake and Columbia rivers and latent mortality associated with dam passage route. Nonetheless, competing hypotheses have not yet been fully resolved, and more research is still needed.

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Supporting Information

All data and relevant computer code used in the analyses presented here can be found online at `https://github.com/jrfaulkner/bypass-length-sar`.

Table 1. Statistical power values for various parameter values for effect of number of bypass events on adult return probabilities under various methods of determining significance for Chinook Salmon and steelhead separately by tagging site. Tagging sites are at Lower Granite Dam (LGR) and upstream of LGR (ULGR). Parameter values are ordered from smallest to largest within each tagging site. Parameter values marked (a) are from Tuomikoski et al. (2010), and (b) are from McCann et al. (2016), and the other two values were set for contrast. Methods of determining significance are α-levels for cutoffs for two-sided P-values of 0.05 and 0.10 and change in Akaike information criterion (ΔAIC) of ≥ 2 and of ≥ 0 when the bypass variable is removed from the model.

			Power			
Species	Site	Parameter	α = 0.05	α = 0.10	ΔAIC ≥ 2	ΔAIC ≥ 0
Chinook	ULGR	-0.100	0.359	0.470	0.340	0.572
		-0.117[a]	0.417	0.551	0.404	0.649
		-0.125[b]	0.451	0.586	0.446	0.681
		-0.150	0.559	0.685	0.546	0.763
	LGR	-0.100	0.725	0.828	0.711	0.879
		-0.117[a]	0.839	0.904	0.836	0.935
		-0.125[b]	0.869	0.921	0.866	0.947
		-0.150	0.958	0.981	0.953	0.985
Steelhead	ULGR	-0.100	0.511	0.633	0.501	0.720
		-0.116[b]	0.606	0.737	0.597	0.791
		-0.127[a]	0.652	0.761	0.645	0.829
		-0.150	0.764	0.847	0.759	0.912
	LGR	-0.100	0.770	0.852	0.757	0.911
		-0.116[b]	0.879	0.932	0.869	0.961
		-0.127[a]	0.910	0.962	0.905	0.977
		-0.150	0.979	0.989	0.976	0.994

Table 2. Associations between variables representing freshwater and ocean conditions and between those variables and proportion of adults returning for Chinook Salmon for migration years 2004-2014. Pearson correlation coefficients are shown for relationships between freshwater and ocean variables and slope estimates from binomial regressions including random year effects are shown for associations between each variable and adult return probabilities (Adult). Estimates significant at the α = 0.05 level are in bold. Definitions of column headings for columns 2-5 are in the final four rows of column 1.

Variable	Flow	Spill	WTT	Bypass	Adult
Pacific Decadal Oscillation (Dec-Mar)	**-0.55**	**-0.50**	**0.52**	0.25	-0.37
Pacific Decadal Oscillation (May-Sep)	**-0.52**	**-0.68**	0.39	0.40	**-0.43**
Oceanic Niño Index (Jan-Jun)	**-0.71**	**-0.60**	**0.68**	0.10	**-0.45**
Sea surface temp. (May-Sep)	-0.28	**-0.54**	0.32	0.41	**-0.51**
Upper 20 m temp. (Nov-Mar)	**-0.51**	**-0.53**	0.40	0.19	**-0.46**
Upper 20 m temp. (May-Sep)	**-0.45**	**-0.61**	**0.46**	0.39	**-0.59**
Deep temperature (May-Sep)	-0.14	-0.22	0.09	0.19	-0.27
Deep salinity (May-Sep)	0.06	0.06	-0.04	0.01	0.23
Copepod richness (May-Sep)	**-0.52**	**-0.63**	0.38	0.30	-0.35
N. copepod biomass (May-Sep)	0.58	**0.79**	**-0.48**	**-0.44**	0.36
S. copepod biomass (May-Sep)	-0.54	**-0.73**	**0.52**	**0.44**	**-0.53**
Biological transition	-0.37	**-0.58**	0.35	0.39	**-0.42**
Ichthyoplankton nearshore (Jan-Mar)	0.35	**0.65**	-0.28	**-0.49**	**0.41**
Ichthyoplankton community (Jan-Mar)	**-0.79**	**-0.75**	**0.80**	0.20	**-0.49**
Chinook Salmon juvenile catches (Jun)	0.12	**0.51**	-0.15	**-0.51**	**0.55**
Coho Salmon juvenile catches (Jun)	-0.18	0.41	0.22	**-0.58**	**0.45**
Physical spring transition UI	0.10	-0.39	-0.07	0.57	-0.31
Physical spring transition hydrographic	**-0.46**	**-0.65**	**0.47**	**0.34**	**-0.50**

Upwelling anomaly (Apr-May)	-0.09	0.25	-0.03	-0.37	0.36
Length of upwelling season	-0.09	0.08	-0.10	-0.22	0.19
Copepod community index (May-Sep)	-0.42	**-0.71**	0.36	0.51	**-0.50**
Mean river flow (Apr-Jun)	1.00	**0.68**	**-0.88**	**0.14**	**-1.02**
Mean spill proportion (Apr-Jun)	**0.68**	1.00	**-0.54**	**-0.53**	0.25
Mean water transit time (Apr-Jun)	**-0.88**	**-0.54**	1.00	**-0.21**	**0.89**
Mean number of bypass events	0.14	**-0.53**	-0.21	1.00	**-0.66**

FIGURE CAPTIONS

Figure 1. Predicted probabilities of adult return and associated 95% confidence intervals by number of bypass events from models including covariates, length, and categorical number of bypass events by species and tagging location. Tagging locations are Lower Granite Dam (LGR) and upstream of LGR (ULGR). Five or more bypass events are combined. Horizontal lines extend the predicted values and associated 95% confidence interval limits for zero bypass events for fish tagged ULGR. Predicted values are for wild fish of mean length exiting the hydropower system on the mean passage day during an average year (random year effect of zero). Predicted values for ULGR fish were for those tagged at the combined Snake and Clearwater River traps.

Figure 2. Statistical power to detect an effect of number of bypass passage events on adult return probabilities in relation to increasing sample size for fish tagged upstream of Lower Granite Dam. Observed sample sizes are shown with open symbols.

Figure 3. Predicted probabilities of bypass passage at Little Goose Dam by day of passage at Lower Granite Dam for a set of fish lengths and for a select set of years for wild Chinook Salmon tagged at the combined Snake and Clearwater River traps. Separate lines are shown for fish of mean length and those in the 1st and 99th percentiles of length. Predictions are shown for time intervals when 98% of fish in the data passed Lower Granite Dam in each year.

Figure 4. Loss of variation in lengths at tagging due to averaging length within year for Chinook Salmon and steelhead by tagging location. Tagging locations are Lower Granite Dam (LGR) and upstream of LGR (ULGR). Percentages of wild fish (vs. hatchery) within each migration year are shown above the length measurements for each year. Filled circles are mean lengths and intervals are ranges of lengths observed for each year.

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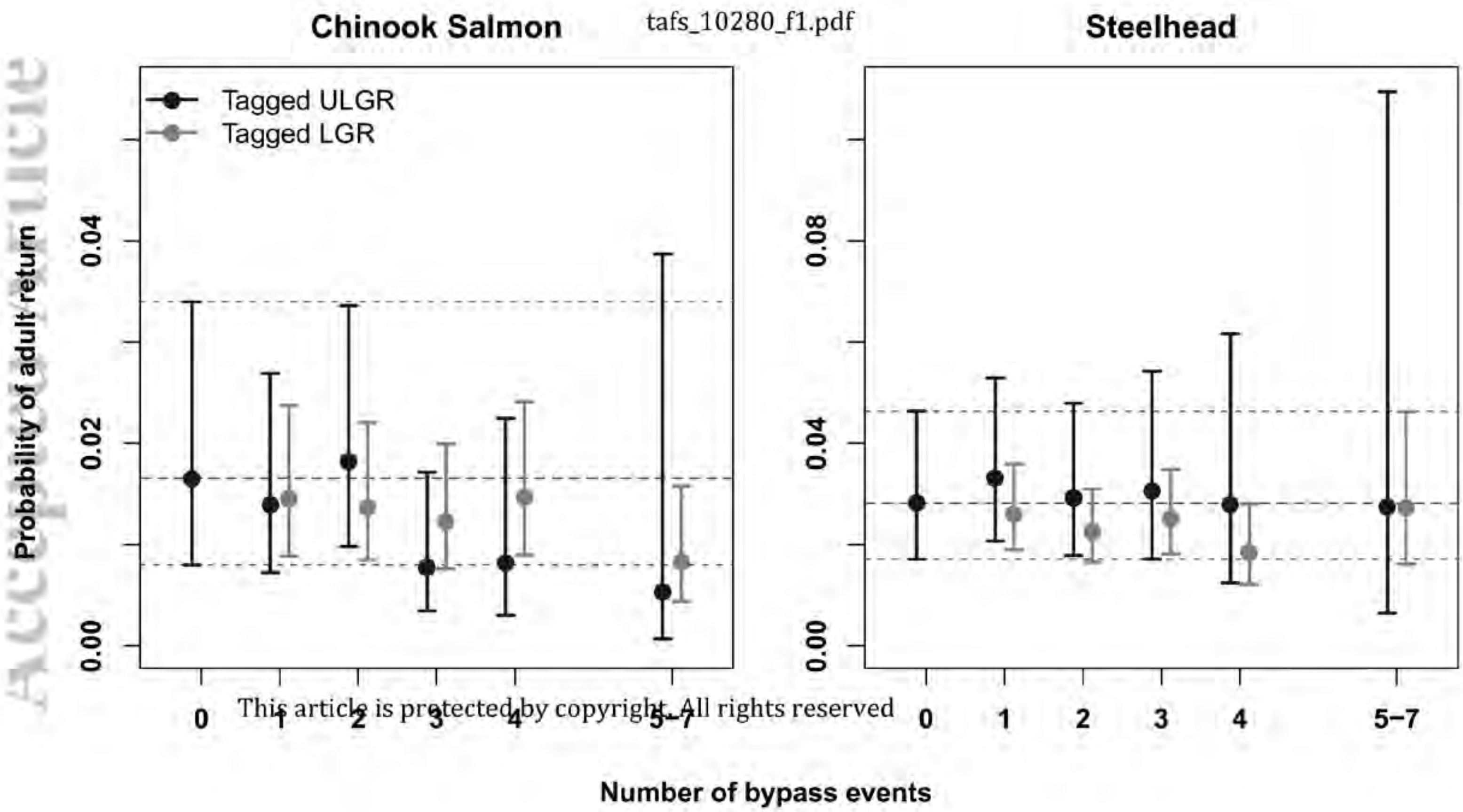

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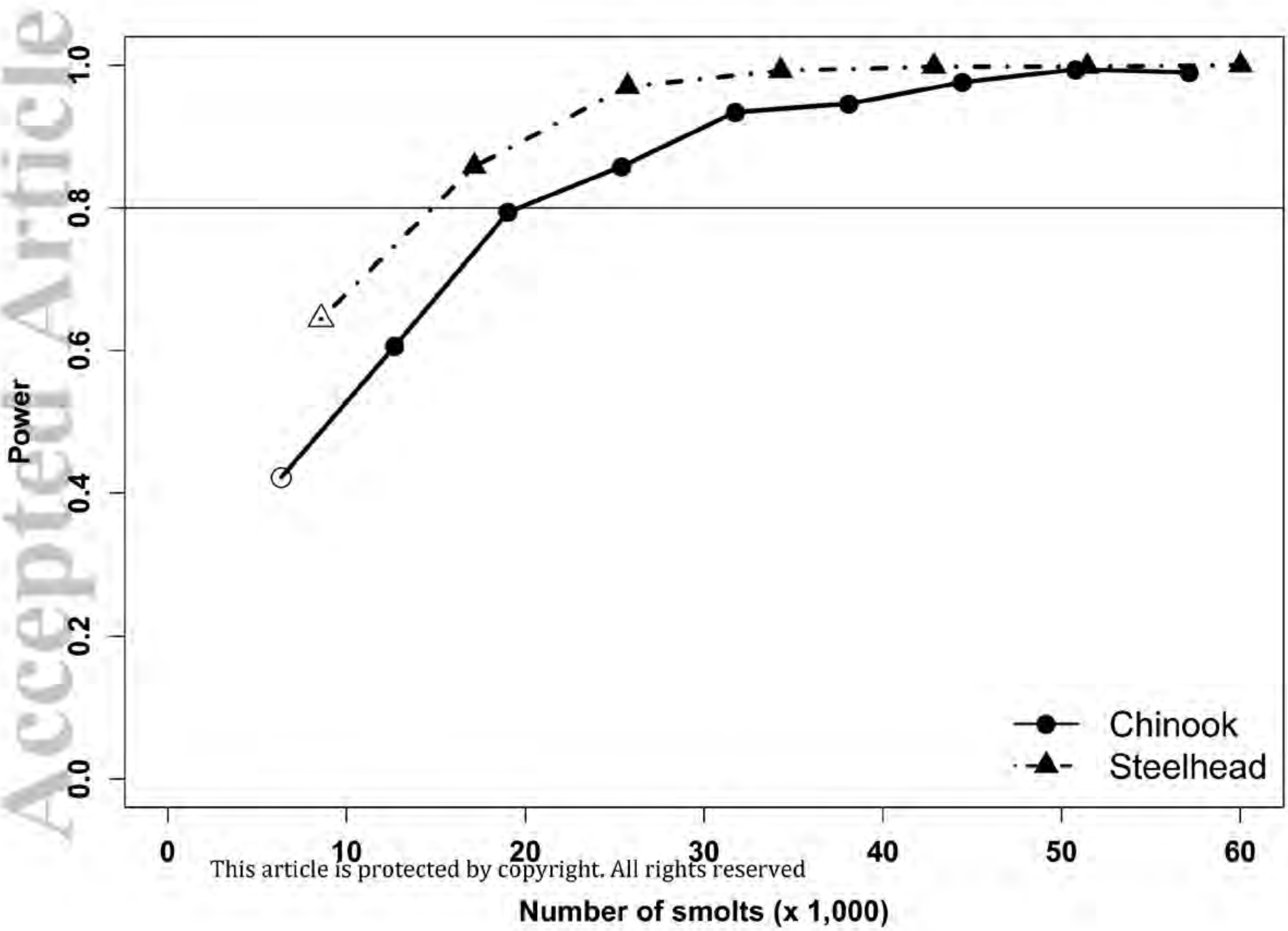

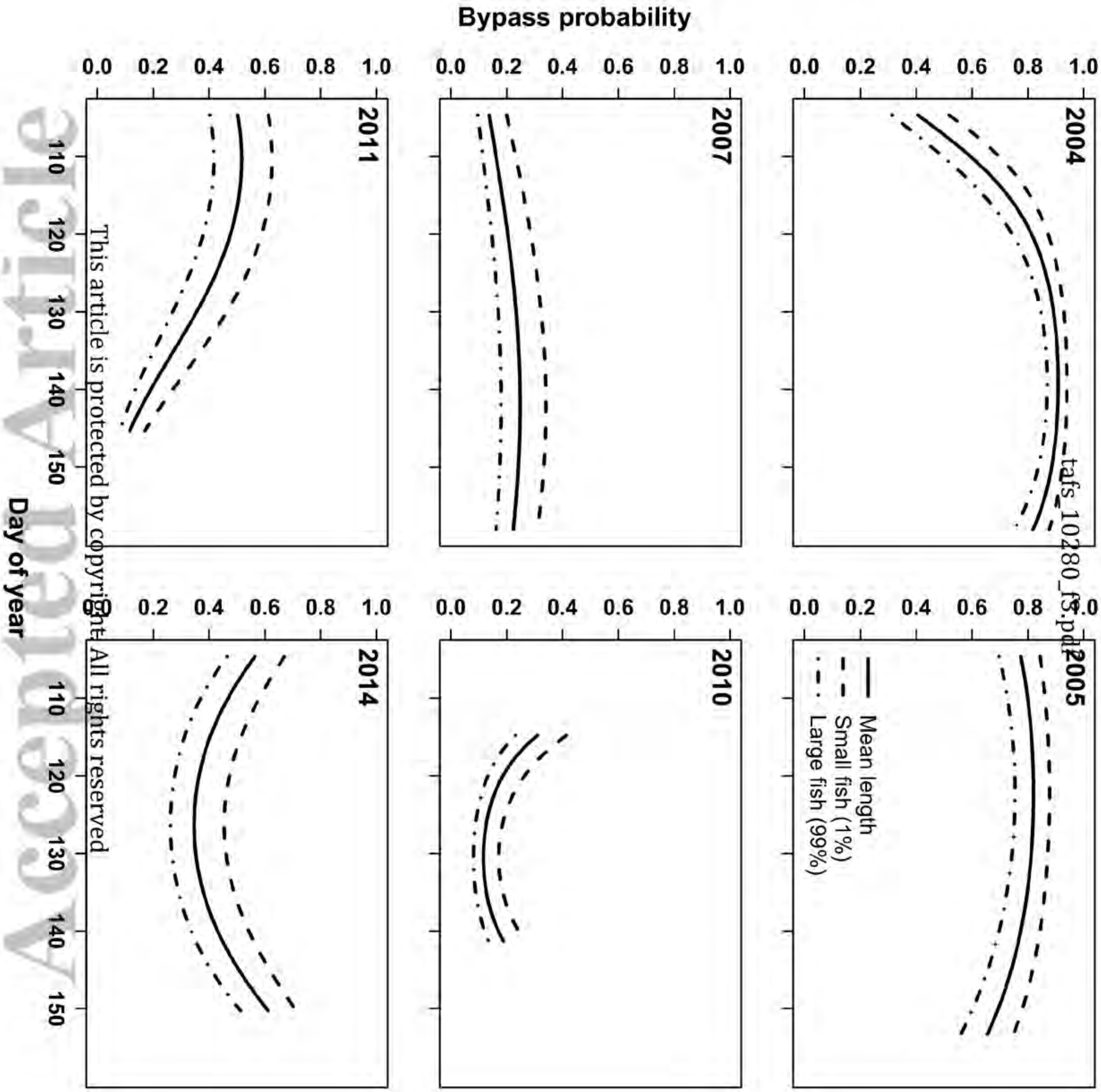
Bypass probability
Day of year
2004
2005
2007
2010
2011
2014
Mean length
Small fish (1%)
Large fish (99%)
0.0
0.2
0.4
0.6
0.8
1.0
110
120
130
140
150

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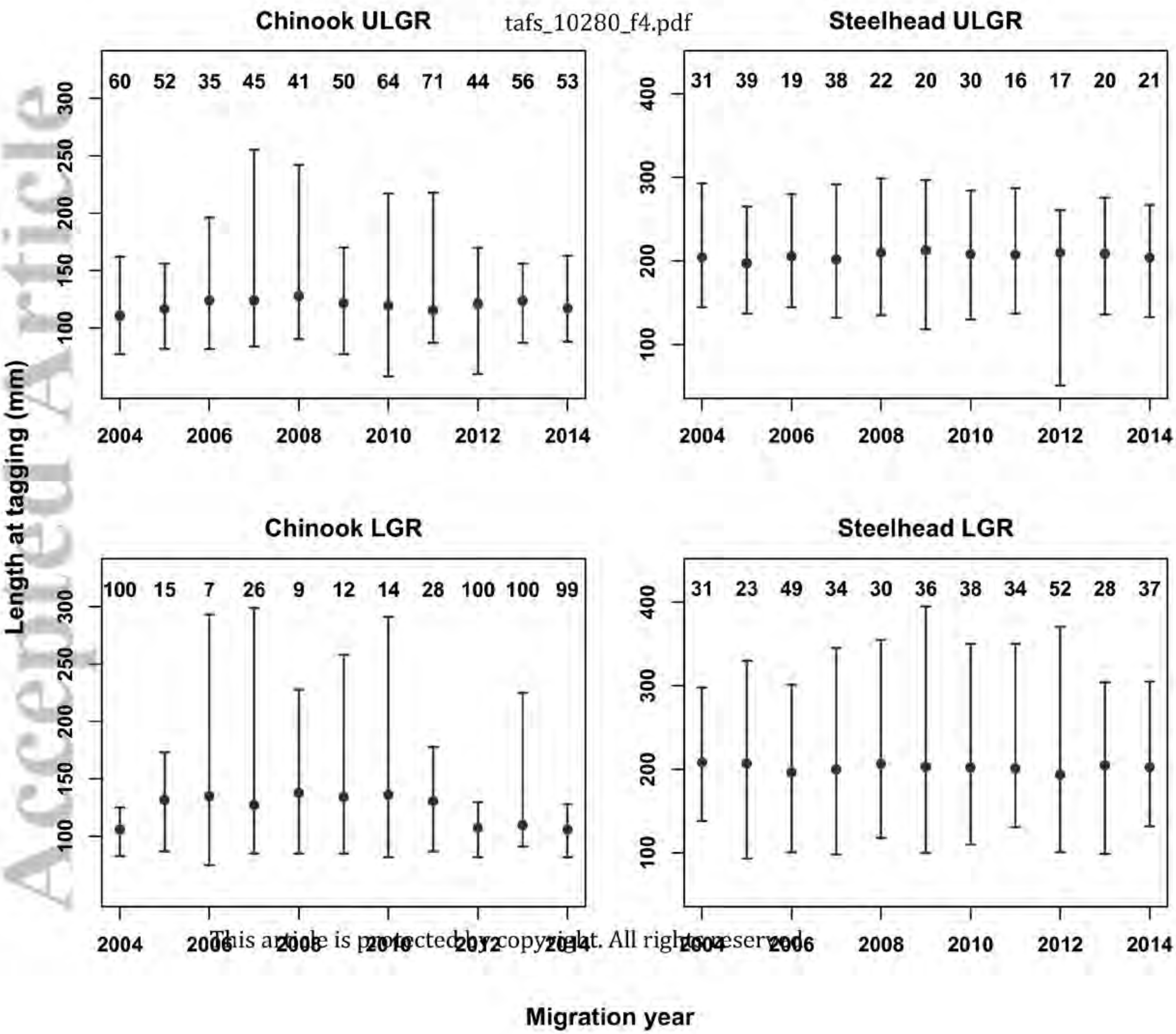

Article type : Comment

Comment: Associations among fish length, dam passage history, and survival to adulthood in two at-risk species of Pacific salmon.

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Faulkner et al. (2019) presents data and analyses to support a hypothesis that bypass encounters by juvenile Chinook Salmon and steelhead at hydropower dams are not harmful (e.g., "Our results suggest that after fish leave the hydropower system, bypass passage history has little effect on mortality"), and any difference in life-cycle survival among bypassed and non-bypassed fish is largely an artifact of variation in body size, where smaller fish that are inherently less likely to survive are bypassed at rates disproportionately greater than their larger counterparts. Under this hypothesis, it may be reasonably interpreted that poor ocean survival–and consequently depressed rates of adult return–is not due to deleterious outmigration conditions (that can be indexed by bypass histories), but results rather from the size of individuals upon ocean entry. We take issue with their conclusions, finding substantive flaws in the basis for this hypothesis related to both the data and methods of analysis. Faulkner et al. (2019) has been publicized widely throughout the region (e.g., NOAA Fisheries West Coast Region, 25 November 2019), with reference at times pointing to the article as a matter of fact. Yet, little attention has focused on the approach or the data underlying their basic conclusions. Given the relevance of this topic to management objectives, both regionally and, for that matter, wherever impounded rivers exist, we believe it is essential to illustrate where the data and methods have led to erroneous conclusions; we are concerned indiscriminant acceptance of Faulkner et al. (2019) may mislead important decisions surrounding management and conservation.

Our concerns surrounding Faulkner et al. (2019) are associated with five primary issues: (1) evidence of a negative bias in survival associated with the fish tagged at Lower Granite Dam versus those tagged upstream, (2) inadequate sample sizes to test for bypass effects on survival for fish tagged above Lower Granite Dam, (3) major drivers of bypass probability at dams were ignored, (4) length does not explain differences in survival among disparate population groups in the Columbia River Basin, and (5) indices of freshwater out-migration conditions continue to explain patterns of marine survival with or without information on individual length. The first two issues represent components of one of our primary arguments. Specifically, given (1) salmon and steelhead tagged at Lower Granite Dam are unrepresentative of the overall population, and thus analyses based on these fish are likely misleading or spurious and (2) analyses in Faulkner et al. (2019) using fish tagged above Lower Granite Dam likely suffered from an inability to detect an effect of bypass encounters where one exists (due to sample size constraints), we question the veracity of their broader claims. Below, we address our five primary issues by examining the underlying data, methods and conclusions using primarily the same data as in the Faulkner et al. (2019) analyses, provided online by the authors.

Negative survival bias for fish tagged at Lower Granite Dam compared to upstream locations

Faulkner et al. (2019) considered two main groups of fish in their analyses: (1) juveniles marked with passive integrated transponder (PIT) tags at traps upstream of Lower Granite Dam and (2) smolts marked with PIT tags at that dam. Their dataset included records from 71,171 yearling Chinook and 29,077 steelhead smolts tagged at Lower Granite Dam and 6,348 yearling Chinook and 8,572 steelhead smolts tagged at traps upriver from the dam. All fish were detected subsequent to tagging at Bonneville Dam or at a towed PIT tag array in the Columbia River Estuary. Ocean survival probabilities were estimated using detections of returning adults at Bonneville Dam. A critical assumption of mark-recapture studies is that the tags and tagging processes do not influence survival probabilities. Under this assumption, we would expect ocean survival probabilities to be similar among smolts tagged at Lower Granite Dam and those marked upstream. To assess whether these two groups of fish had similar ocean survival probabilities, we combined data for the groups and fit a simple logistic model:

$$logit(s_i) = \beta_0 + b_{0,y} + \beta_1 \cdot length_i + \beta_2 \cdot day_i + \beta_3 \cdot rear_i + \beta_4 \cdot site_i,$$

where s_i is the probability of adult return, $length_i$ is standardized length, day_i is standardized day of juvenile detection at Bonneville Dam or the estuary array, $rear_i$ is rear-type (hatchery or wild), and $site_i$ is tagging location (at Lower Granite Dam or upriver traps) for individual i. Estimated parameters include the intercept β_0 and covariate effects β_1,...,β_4. Like Faulkner et al. (2019), we modeled all inter-annual variation in freshwater and marine factors on survival as random year effects $b_{0,y} \sim N(0, \sigma_y^2)$. We used the Akaike Information Criterion (AIC) to assess the equivalent survival assumption for the two tagging locations.

Consistent with results from Faulkner et al. (2019), our full model showed a positive association between survival and length, a negative association between the day of juvenile detection and survival, and that wild smolts have higher rates of survival than hatchery-reared smolts. Yet, we also found models accounting for tagging site of individuals were substantially better supported than models that ignored that effect. Including tagging site as a covariate reduced AIC values by 15 units for Chinook Salmon and 20 units for steelhead, suggesting strongly that survival was dissimilar across tagging sites. Estimates from models that accounted for tagging site showed yearling Chinook Salmon and steelhead tagged at Lower Granite Dam survived at rates, respectively, 61% (95% CI: 48%–76%) and 70% (95% CI: 61%–81%) of those that were tagged at upstream traps. These findings indicate there is a significant, negative survival bias associated with the smolts tagged at Lower Granite Dam compared to those tagged upstream. Evidence of this differential suggests fish tagged at Lower Granite Dam are not likely misrepresent population-level survival. Given survival was estimated after smolts passed Bonneville Dam, our results further reflect that effects of smolt collection, handling, tagging or bypass can manifest long after the release of smolts at Lower Granite Dam. These findings do not appear to be related to strong selectivity of the collection and bypass system at Lower Granite Dam. Specifically, after accounting for year and rear-type effects, yearling Chinook Salmon tagged at the dam were 2-mm larger than those tagged upstream and steelhead tagged at Lower Granite Dam were 1-mm shorter than those tagged at upriver sites. We argue, analyses of bypass effects in Faulkner et al. (2019) that rely on information associated with fish tagged at Lower Granite Dam are unreliable and likely misrepresent survival at the population level. Further, we submit tagging effects may also mask the influence of one or more bypass events on rates of adult return.

To illustrate how marking and bypass through at least Lower Granite Dam could suppress the effect of subsequent powerhouse encounters, we plotted aggregate SARs (2000–2014) for yearling Chinook and steelhead (wild and hatchery combined) estimated directly across a number of bypass encounters. We found striking differences among trends in SARs with increases in the number of bypass events. Fish marked above Lower Granite Dam showed an obvious decrease in SARs as the number of bypass encounters accrued, while Chinook Salmon and steelhead marked at Lower Granite Dam showed little discernable effect (Figure 1).

Insufficient sample sizes to detect bypass effects on survival

Previous studies have associated bypass experience with a reduction in ocean survival. (e.g., Buchanan et al. 2011, Haeseker et al. 2012, Schaller et al. 2014). To quantify these associations, Tuomikoski et al. (2010) examined bypass effects using a dataset comprising information for 94,267 yearling Chinook and 26,845 steelhead smolts tagged above Lower Granite Dam during out-migration years 2000–2008, opting to include only fish marked above the dam given a putative bias associated fish tagged at the dam (demonstrated above). The authors found that each bypass experience reduced ocean survival by approximately 11% for Chinook Salmon and 12% for steelhead. Similarly, analyzing records for 118,819 yearling Chinook Salmon and 83,187 steelhead smolts also tagged upstream of Lower Granite Dam during out-migration years 2006-2013, McCann et al. (2016) estimated that each bypass experience reduced ocean survival by roughly 12% and 11% for Chinook Salmon and steelhead, respectively. In examining bypass effects using fish tagged at sites above Lower Granite Dam, Faulkner et al. (2019) restricted their dataset to include only records for individual fish that had recent estimates of length at tagging. Regardless of their rationale for doing this, the number of fish tagged above Lower Granite Dam included in the dataset analyzed in Faulkner et al. (2019) was recognizably small, and limited sample sizes likely precluded detection of an unambiguous bypass effect as in Tuomikoski et al. (2010) and McCann et al. (2016). To put the sample size constraints of Faulkner et al. (2019) in perspective, in 12 of the 22 species-years included in their dataset, fewer than 10 adults returned and in three of those years, zero adults returned. Low numbers of adult detections make estimating bypass effects, or any effect, highly uncertain because there is little contrast in the response variable (i.e., adult return) across individuals with variable numbers of bypass experiences.

We conducted a power analysis to evaluate whether the sample sizes of Faulkner et al. (2019) were sufficient to detect the bypass effects estimated by Tuomikoski et al. (2010) and McCann et al. (2016). We focused analyses on smolts tagged at traps above Lower Granite Dam to ameliorate the negative survival bias introduced by including fish marked at the dam (again, discussed above). We simulated data sets with random, multinomial bypass event frequencies (0-6) based on the observed, year-specific, proportions in each category and applied an 11.7% (Chinook Salmon) or 12.7% (steelhead) reduction in survival, per Tuomikoski et al. (2010). We parameterized the baseline (zero bypass) annual survival estimates using observed rates of ocean survival for each species and year.

For years that had zero adult detections (e.g., 2004 and 2005), we used estimates of ocean survival from McCann et al. (2019, Tables B.126 and B.127). Adult returns were random Bernoulli trials using simulated survival rates based on the baseline survival and the number of bypass events for each individual. We multiplied the number of smolts in each year by a factor ranging from 1 (i.e., the original sample size) to 9 to simulate a range of sample sizes. We ran 100 simulations at each sample size and fit a generalized linear model with year and bypass event effects to each simulated data set and recorded the number of simulations where a significant ($p < 0.05$) bypass effect was estimated. Power was assessed at each sample size as the proportion of simulations where a significant effect was detected.

At the sample sizes analyzed in Faulkner et al. (2019), there was 20% and 40% power to detect bypass effects for Chinook Salmon and steelhead, respectively (Figure 2). The higher power for steelhead compared to yearling Chinook Salmon appeared to be due to greater numbers of steelhead analyzed and higher baseline rates of ocean survival. To achieve 80% power to detect a bypass effects, we estimate that five times as many Chinook Salmon (approximately 30,000) and 2.5 times as many steelhead (approximately 21,000) would be required. These results indicate that sample sizes for the upriver-tagged smolts were likely insufficient to reliably detect bypass effects on survival when those effects are present. As such, results and conclusions from Faulkner et al. (2019) concerning fish marked above Lower Granite Dam–where no compelling bypass effect was detected–are tenuous, if not unsurprising.

Drivers of bypass probability

Faulkner et al. (2019) fit a suite of mixed effects models to assess their hypothesis that fish length largely explains variation in bypass probability (i.e., smaller fish are predisposed to bypass). In doing so, they modeled the presumed driver of bypass probability, length of individuals, as a fixed effect but all other environmental or operational factors known to have large and confounding effects on bypass probability–for example, spill proportion or flow–are subsumed in temporal random effects. The rationale for their approach seems to stem, in part, from their argument that "variation in detectability at dams due to river conditions and dam operations that vary with time…are difficult to measure and summarize for individual fish that are not detected". Detection, however, is not a *treatment* randomly applied to individuals, as Faulkner et al. (2019) suggests. Detection is a *response* to spill proportion (primarily) and flow (secondarily); the two principal drivers affecting bypass probability at each dam (Zabel et al. 2008; McCann et al. 2015; Hance et al. 2019). The approach of Faulkner et al. (2019) effectively precludes any direct examination of the primary drivers affecting bypass probability, leading the authors to overemphasize the importance of fish length and discount other important factors.

Consider, for example, bypass probability of wild yearling Chinook at Little Goose Dam. To visualize variation in bypass probability owing to contrasts in specific drivers, we fit a simple logistic function relating bypass probability to fish length, flow and spill proportion using detections of fish marked at Lower Granite Dam from the Faulkner et al. (2019) dataset. This effectively describes how model predictions behave across a range of fish lengths and spill proportions during a low flow year. As in Faulkner et al. (2019), fish length was significant in our model. Yet, when we examine predictions for the 10th, 50th and 90th percentiles in fish length across a range of spill proportions (Figure 3), we see little separation in bypass probability among the length categories at any given level of spill (up to $\pm$ 0.035). In contrast, model predictions of bypass probability across spill levels ranged widely from approximately 0.10 at high spill proportion (i.e., 0.40) to approximately 0.83 when spill is curtailed completely. We found, while length was statistically significant in our model, there was very little difference in bypass probability from the largest to smallest fish in the population, and a marked response to changes in spill proportion. The response to increasing spill proportion is further substantiated when considering bypass probabilities estimated directly. Using again data from Faulkner et al. (2019), we estimate detection probabilities in excess of 0.82 during 2004 and 2005; years when little or no spill was provided. During years with high spill, such as 2007 and 2010, detection probability at Little Goose Dam fell to approximately 0.22; a range in detection probability of 0.60 owing primarily to variation in the proportion of flow spilled (Figure 3). Our principal argument is that a statistically significant effect does not necessarily indicate the main drivers of a response have been identified, particularly when the most important factors have been discounted in the statistical framework.

Differences in survival among populations in the Columbia River Basin

If the assertion suggested in Faulkner et al. (2019), that variation in adult returns can be best explained by fish size, is credible, one should expect that the effect would apply across multiple populations within the Columbia River Basin. Considerable evidence in the literature suggests this is not the case. In-river migrants from the Snake River inevitably pass eight dams on their way to the Pacific Ocean whereas fish from the John Day River encounter only three. Schaller et al. (2007) found, when outmigration timing of smolts originating from the Snake and John Day rivers overlapped at Bonneville Dam, rates of adult return were consistently higher for John Day fish, despite no clear evidence of a systematic size difference between the two groups. More recently, Schaller et al. (2014) again compared the performance of Snake and John Day river populations of Chinook Salmon. The authors considered two approaches: one, updating Schaller et al. (2007), assessed differences in life-cycle survival among fish that encounter three dams (John Day) versus those that encounter eight (Snake River) and a second examined the differential response of John Day and Snake river populations to completion of the Federal Columbia River Power System (FCRPS). Echoing the findings of Schaller et al. (2007), John Day fish performed dramatically better, in terms of life-cycle survival, than the Snake River counterparts, despite the similar conditions these population groups experience during outmigration and in early ocean residency (see Petrosky et al. 2020). Further, their results showed the response of John Day fish to completion of the FCRPS was noticeably more muted than that of Snake River salmon. These and other studies (notably, Petrosky et al., 2020) demonstrate the negative impact of dam passage on survival after fish have exited the hydrosystem. This brings into question the veracity of an argument, as in Faulkner et al. (2019), that suggests size upon ocean entry is the principal driver of differential survival.

To assess further the contrasting arguments of Faulkner et al. (2019) versus other work, highlighted above, we examined size distributions and rates of adult return of John Day and Snake river wild spring/summer Chinook Salmon. Spring migrants measured and tagged in the lower reaches of the John Day River and subsequently detected at Bonneville Dam were compared to smolts tagged in the Snake River at the Grande Ronde, Clearwater, and Snake River traps; the same sites in the Snake River considered by Faulkner et al. (2019). Comparisons of length distributions during 2000–2016 for John Day and Snake river smolts were significantly different in 11 of the 16 years. Of these 11, nine showed John Day fish to be significantly smaller on average than those from the Snake River.

Aggregating among years, John Day Chinook Salmon were approximately 3.2 mm smaller than Snake River fish; a small difference, but nonetheless statistically significant.

Smolt-to-adult returns–from Bonneville Dam as juveniles back to Bonneville Dam as adults–during the same period displayed substantial contrast among John Day and Snake river populations, where John Day River spring Chinook, on average, represented rates of adult return 2.7 times higher than the Snake River fish. If we accept the argument of Faulkner et al. (2019), and acknowledge similarities among these two population groups in terms of conditions experienced during outmigration or early ocean residency (e.g., Petrosky et al. 2020), SARs for Snake River fish should outpace those for John Day salmon. Yet, we find consistently the opposite is true, contradicting at the population level the size-selective mortality hypothesis of Faulkner et al. (2019).

Importance of hydrosystem passage conditions

The decision by Faulkner et al. (2019) to consider only measures of individual bypass histories to describe outmigration conditions and to neglect a direct assessment of covariates shown to be important in explaining variation in survival (e.g., spill proportion, water transit time, powerhouse encounters), leads the authors to exaggerate evidence for the influence of fish size on rates of survival. As with bypass probability, by relegating factors that are known to influence life-cycle survival to random temporal effects, the authors effectively ignore potential effects of hydrosystem passage conditions. Faulkner et al. (2019) asserts "…group-level summary statistics [as opposed to the individual-level framework they apply]…result in loss of important information". However, discounting completely important group-level summary statistics results in a much greater loss of information; a loss that can lead to spurious conclusions. We argue, measures of passage experience at the aggregate scale may be more appropriate indicators of population-level impacts than bypass history considered at the scale of individuals.

To explore these arguments, and to assess the degree to which rates of adult return for Chinook Salmon and steelhead are influenced by length versus other factors, we fit models using data from Faulkner et al. (2019) of the form:

$$logit(s_i) = \beta_0 + b_{0,y} + \beta_1 \cdot length_i + \beta_2 \cdot day_i + \beta_3 \cdot rear_i + \beta_4 \cdot site_i + \beta_5 \cdot WTT_y +$$

$\beta_6 \cdot mean.byp_y$,

where s_i is the probability of adult return, $length_i$ is length, day_i is day of juvenile detection at Bonneville Dam or the estuary array, $rear_i$ is rear-type (hatchery or wild), and $site_i$ is the tagging site (upriver traps or Lower Granite Dam) for individual *i*. Group-level (annual) variables included an index of water velocity through the hydrosystem (water transit time; WTT_y) and the mean number of bypass events ($mean.byp_y$) across individuals in year *y*. Estimated parameters include the intercept β_0, random year effects $b_{0,y} \sim N(0, \sigma_y^2)$, and covariate effects $\beta_1,\ldots,\beta_6$. Compared to models without water transit time and the mean number of bypass events, models that included these variables reduced AIC scores by 6 units for yearling Chinook and 8 units for steelhead and showed a negative effect of the mean number of bypass events on individual survival probabilities. Including these group-level covariates also reduced the variance of the random year effects by 59% for Chinook Salmon and 53% for steelhead. Our results indicate strongly that water transit time and the mean number of bypass events are important factors influencing individual survival probabilities of Chinook Salmon and steelhead, even after accounting for the lengths of individuals.

Positive associations between length and survival at the individual scale may or may not explain patterns of variation at the population level. Faulkner et al. (2019) state in their discussion "when evidence for a negative effect of bypass on return probability remains after accounting for length and other confounding variables, it suggests there could be delayed or long-term effects of multiple bypass events on fish." To assess the importance of length versus other factors on survival at the population level, we fit binomial models of the form:

$$logit(SAR_{y,s}) = \beta_0 + \beta_{0,y} + \beta_1 \cdot \overline{length}_{y,s} + \beta_2 \cdot \overline{day}_{y,s} + \beta_3 \cdot prop.\,wild_{y,s} + \beta_4 \cdot site +$$

$$\beta_5 \cdot WTT_y + \beta_6 \cdot mean\ byp._{y,s},$$

where $SAR_{y,s}$ is the number of returning adults divided by the number of juveniles detected at Bonneville Dam or the estuary trawl, $\overline{length}_{y,s}$ is the mean length of fish released, $\overline{day}_{y,s}$ is the mean day of detection at Bonneville Dam or the estuary trawl, $prop.wild_{y,s}$ is the proportion of the release that was classified as wild rearing type, site is an indicator variable for tagging site (upriver traps or

Lower Granite Dam), WTT_y is water transit time, and $mean.byp_{y,s}$ is the mean number of bypass events for fish migrating in year y from tagging site s. Estimated parameters include the intercept β_0, random year effects $b_{0,y} \sim N(0, \sigma_y^2)$, and covariate effects $\beta_1,\ldots,\beta_6$. When mean length and the other confounding factors were accounted for, including the mean number of bypass events variable reduced the AIC by 9 points for Chinook Salmon and 7 points for steelhead and showed a negative effect of the mean number of bypass events on population-level SARs. So, we agree with Faulkner et al. (2019) on this point: when evidence for a negative effect of bypass on return probability remains after accounting for length and other confounding variables, it suggests that there could be delayed or long-term effects of multiple bypass events. We found that their data, at both the individual- and population-level, strongly support this. By ignoring the effects of water transit time and population-level measures of dam passage experience, results of their analysis provide misleading conclusions surrounding the relative influence of length versus other factors on adult return rates.

Summary

The extent to which the FCRPS exacts deleterious tolls on salmon and steelhead populations in the Columbia Basin has been debated for decades. While there is little question that the hydrosystem negatively impacts iconic anadromous salmonids, what seems to remain a point of contention is the degree to which construction and operation of the hydrosystem, versus other uncontrollable factors, limits productive populations. From the perspective of Faulkner et al. (2019), passage through bypass systems at dams on the Snake and Columbia rivers presents little inherent harm, and any differential response in life-cycle survival among fish that are bypassed versus those that are not is an artifact of fish size. We have demonstrated how the approach of Faulkner et al. (2019) and their treatment of the underlying data may have led to specious conclusions, calling into question the basis for their size-selective mortality hypothesis. Particularly, our assessment focused on five issues: (1) evidence of a negative bias in survival associated with the fish tagged at Lower Granite Dam versus those tagged upstream, (2) inadequate sample sizes to test for bypass effects on survival, (3) major drivers of bypass probability at dams were ignored, (4) length does not explain differences in survival among populations in the Columbia River Basin, and (5) indices of freshwater out-migration conditions continue to explain patterns of marine survival with or without information on individual length; we suggest measures of passage experience at the aggregate scale are likely more appropriate indicators of population-level impacts than bypass history considered at the scale of individuals. Given the importance of this and related topics both regionally and more broadly, we feel it is essential to examine thoroughly the veracity of claims on all sides of the debate. That is our intention here.

Additional information

Code for the power simulations can be found at https://github.com/FishPC/FaulknerReview. Code and data for all other analyses is available upon request to the corresponding author.

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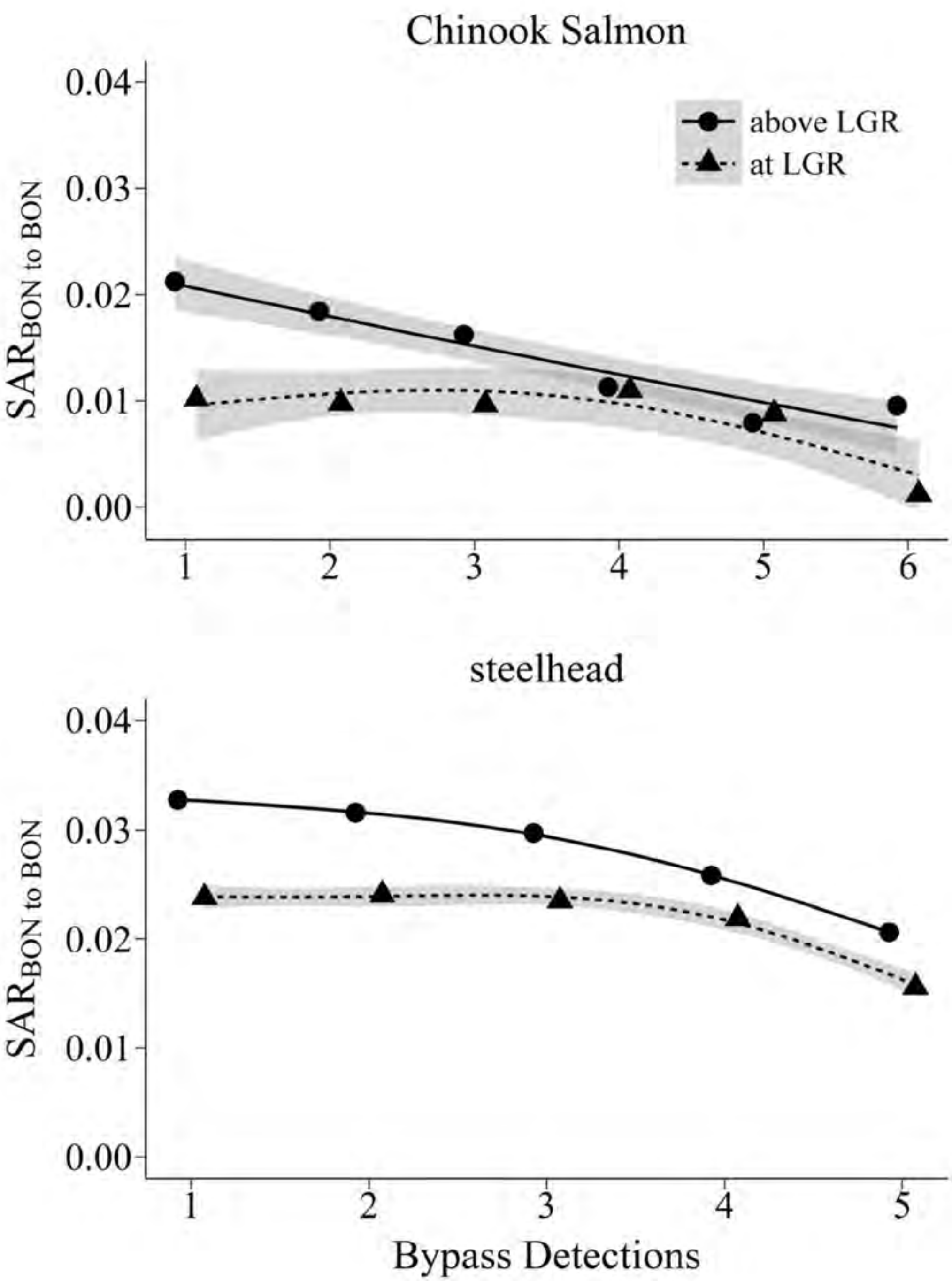
Figure 1. Comparison of aggregate (migration years 2000–2014) smolt to adult return rates according to the number of bypass detections during outmigration for yearling Chinook Salmon (top) and steelhead (bottom) PIT-tagged above (circles) or at (triangles) Lower Granite Dam. Lines represent Generalized Additive Model fits to data for Chinook Salmon (solid) or steelhead (dashed). Shaded areas around lines are 95% confidence intervals. Values are for natural origin and hatchery fish combined.

Figure 2. Power to detect a significant bypass effect versus sample sizes (number of smolt detections). Open symbols indicate the number of smolts included in the Faulkner et al. (2019) dataset for fish tagged at traps above Lower Granite Dam. The horizontal line indicates the level of power (probability) generally accepted as necessary to avoid a Type II error (i.e., failure to detect a significant effect when one exists).

Figure 3. Model-predicted bypass probability at Little Goose Dam for wild yearling Chinook Salmon tagged above Lower Granite Dam as a function of spill proportion. Bypass probabilities are plotted at three different length categories: 10^{th}-percentile, 50^{th}-percentile and 90^{th}-percentile. Bypass probabilities estimated directly during four low flow years (2004, 2005, 2007 and 2010) with varying levels of annual spill are plotted for reference. Predictions were generated based on data from Faulkner et al. (2019).



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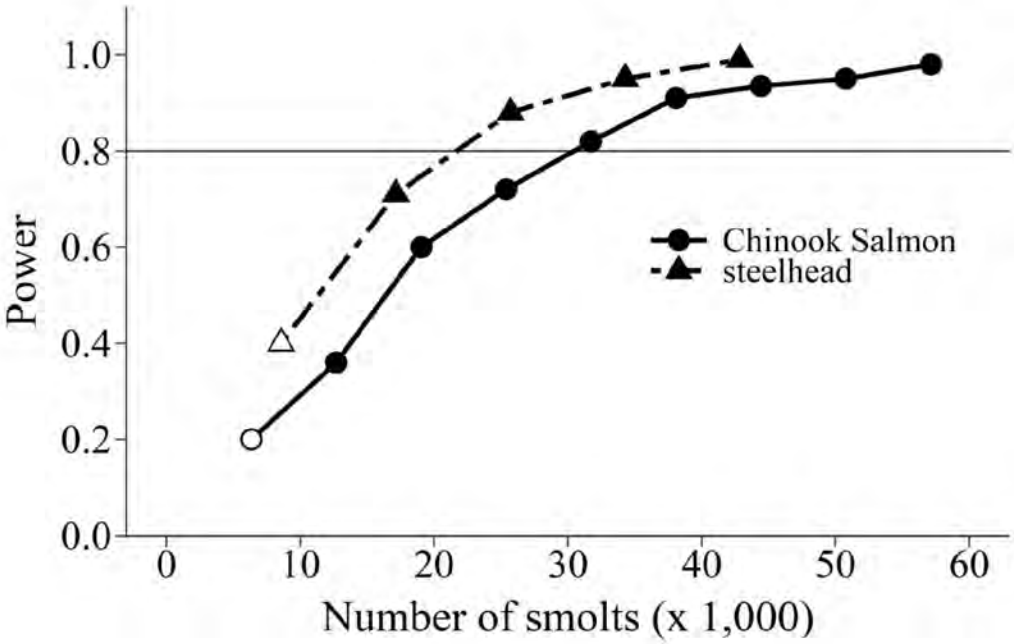

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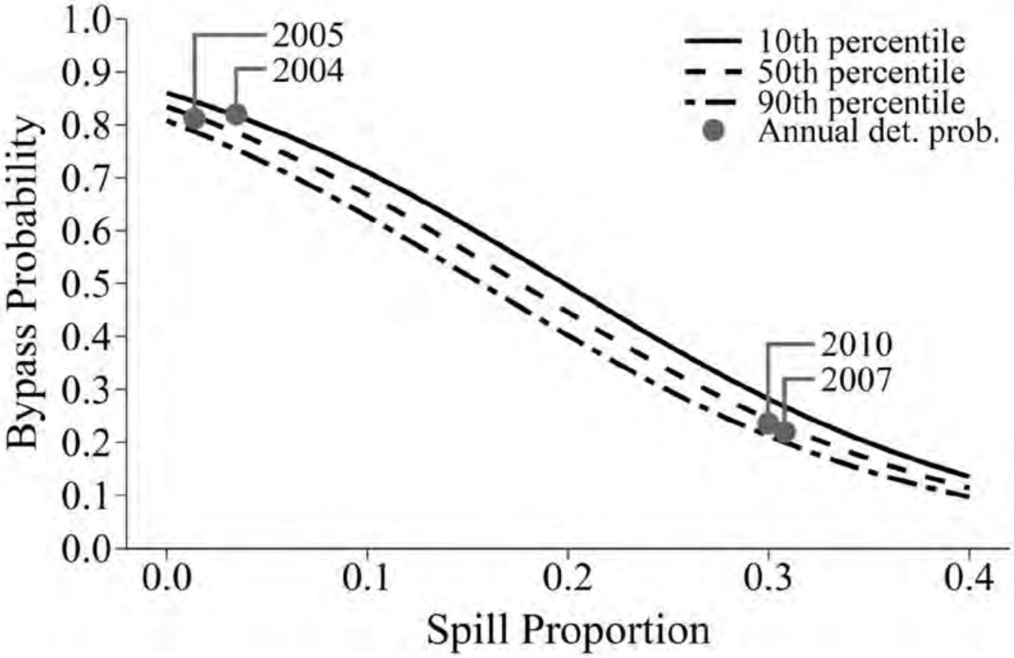

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ARTICLE

Associations among Fish Length, Dam Passage History, and Survival to Adulthood in Two At-Risk Species of Pacific Salmon

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Abstract
Threatened or endangered salmon and steelhead originating in the Snake River basin must pass through a series of eight major hydroelectric dams during their seaward migration. Understanding the effects of specific dam passage routes on lifetime survival for these stocks is essential for successful management. Juvenile fish may pass these dams via three primary routes: (1) spillways, (2) turbines, or (3) juvenile bypass systems, which divert fish away from turbines and route them downstream. Bypass systems may expose fish to trauma, increased stress, or disease. However, numerous studies have indicated that direct survival through bypass systems is comparable to and often higher than that through spillways. Some researchers have suggested that the route of dam passage affects mortality in the estuary or ocean, but this is complicated by studies finding that fish size affects the route of passage. We tested whether passage through bypass systems was associated with the probability of adult return after accounting for fish length and other covariates for two species of concern. We also investigated the association between fish length and the probability of bypass at dams and how this relationship could lead to spurious conclusions regarding effects of bypass systems on survival if length is ignored. We found 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.

Four evolutionarily significant units from the Snake River basin that are listed for protection under the U.S. Endangered Species Act—spring/summer Chinook Salmon *Oncorhynchus tshawytscha*, fall Chinook Salmon, Sockeye Salmon *O. nerka*, and steelhead *O. mykiss*—must pass a series of eight large hydroelectric dams, part of the Federal Columbia River Power System (hereafter, "hydropower system"), on their migrations to the Pacific

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Ocean as smolts and upon their return as adults. A question central to the management of these populations is whether the set of passage routes taken by juvenile salmon as they migrate through dams impacts their survival after they have completed their downstream migration.

Providing safe and effective downstream passage for juvenile salmon through the hydropower system has proven to be more problematic than providing adult upstream passage, which is achieved through the use of fish ladders. Juveniles have several possible routes by which to pass a dam (Figure 1). They can pass through spill, which is water passed directly through spill gates or through spillway weirs. Alternatively, juveniles can pass through the powerhouse, where the hydroelectric turbines are located. However, at seven of eight dams the majority of fish entering the powerhouse are diverted into a juvenile bypass system (hereafter, "bypass system"). Bypass systems are designed to divert fish in powerhouses away from turbine passage by using screens and a system of pipes that lead to a fish sampling and collection facility. From this facility, the fish can be directed into the dam tailrace or (at four of the dams) loaded onto barges or trucks in a transportation program designed to avoid passage through downstream dams.

Numerous studies have been conducted with tagged fish to estimate survival through these various 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% to 100% across eight dams, with a mean of 97% (Axel et al. 2008; Beeman et al. 2008; Ploskey et al. 2011, 2012; Skalski et al. 2013a, 2013b; Weiland et al. 2013, 2015). Differences between estimates of direct survival through the spillway and bypass system (i.e., spill – bypass) from these studies were relatively small, ranging from −5.4 to 5.0 percentage points (mean = −0.8 percentage points) for Chinook Salmon and ranging from −3.9 to 3.0 percentage points (mean = −0.9 percentage points) for steelhead, indicating slightly higher survival on average through bypass systems. Estimated probabilities of bypass system passage from the previously mentioned studies ranged from 6.3% to 31.0% (mean = 18.1%) for yearling Chinook Salmon and from 5.9% to 41.9% (mean = 22.1%) for steelhead, while estimated probabilities of turbine passage at dams with a single powerhouse were much lower, ranging from 3.2% to 8.7% (mean = 5.4%) for yearling Chinook Salmon and from 1.8% to 5.8% (mean = 3.2%) for steelhead.

Although direct passage survival through bypass systems is relatively high, there is concern that delayed or long-term negative effects of bypass system passage are not detected by studies of direct survival. Sandford and Smith (2002) found that smolt-to-adult return probabilities (hereafter, "return probabilities") were frequently lower for fish that passed through a bypass system one or more times than for fish that were never bypassed. This and other studies at the time led to the concept of delayed or latent mortality, which refers to mortality that occurs in the ocean or estuary based on stress, injury, or diminished condition experienced during downstream migration through the hydropower system. This idea was proposed by Schaller et al. (1999) and Deriso et al. (2001) in terms of the effect of dam passage in general. A review by Budy et al. (2002) suggested that the cumulative stress of passing through turbine or bypass systems might result in an increased mortality risk downstream. Petrosky and Schaller (2010) and Schaller et al. (2014) also attempted to incorporate the effects of the specific route of passage in their analyses. They found that ocean survival in Chinook Salmon was negatively correlated with an index of the expected number of times a group of fish passed through turbine or bypass system routes and with longer travel times through the hydropower system. Haeseker et al. (2012) used an index of spill proportion experienced by groups of fish as a surrogate for individual routes of passage and found that it was positively correlated with ocean survival. Buchanan et al. (2011) found that multiple bypass events for individual fish were associated with lower return probability in hatchery yearling Chinook Salmon and steelhead from the Snake River basin, but the timing and location of mortality could not be estimated.

Another possible explanation for reduced return probabilities of bypassed fish is that smaller fish and those in poorer condition tend to enter bypass systems with a higher probability (Zabel et al. 2005; Hostetter et al. 2015), and smaller fish and fish in poorer condition also have a lower return probability (Ward and Slaney 1988; Zabel and Williams 2002; Evans et al. 2014). This suggests that the apparent effects of bypass on return probability could be at least partly due to a correlation between bypass probability and fish size and condition and not due to bypass passage itself.

Even though numerous authors have demonstrated a difference in return probability between fish that experienced one or more bypasses compared to fish that were never bypassed, success in demonstrating a cause-and-effect relationship has been limited. One obvious causal mechanism is that impaired function due to injury or stress caused by bypass system passage could make smolts more susceptible to predation. Hostetter et al. (2012) found that steelhead with injuries or disease were more likely to be preyed upon by piscivorous birds in the Columbia River estuary. Although Budy et al. (2002) and other authors have discussed the potential for injury in fish passing through the pipes and over the screens of the bypass system, recent descaling and injury rates in bypass systems on the Snake and Columbia rivers are reportedly minimal (Ferguson et al. 2005) and much lower than those observed in the 1970s and early 1980s (Williams and

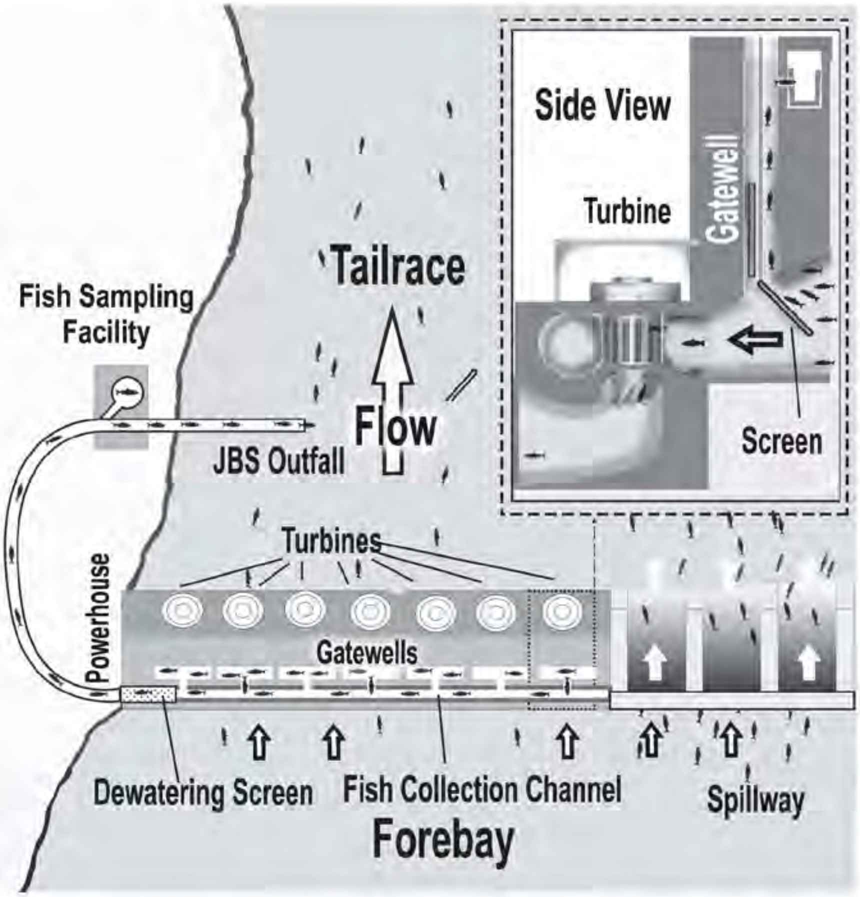

FIGURE 1. Overhead view of a hydroelectric dam with a powerhouse and juvenile bypass system (JBS) on the left and a spillway on the right. Inset shows a turbine intake with a bypass screen and entry into a gatewell and the collection channel for the bypass system.

Matthews 1995). Indeed, Sandford et al. (2012) found no significant difference in survival between bypassed and non-bypassed fish in seawater challenge experiments conducted on fish surviving passage through the hydropower system, suggesting that there was no bypass effect on subsequent survival.

Our main objective for this study was to investigate potential delayed effects of bypass passage on post-hydropower-system survival. We used an extensive data set on juvenile Chinook Salmon and steelhead tagged at or upstream of Lower Granite Dam, the first dam encountered during downstream migration. We attempted to isolate the delayed effects of bypass by only using fish that were known to have survived to downstream of the final dam in the hydropower system (Bonneville Dam). However, we also recognized the need to account for fish size in our investigations, given established associations between fish size and (1) the probability of bypass and (2) the probability of adult return. In this paper, we first investigate the relationship between fish size at tagging and the probability of passage through a juvenile bypass system. We then investigate the association between fish length and return probability. We found that fish with more bypass events tended to have a lower return probability, but evidence of a causal effect of bypass passage was greatly diminished or disappeared when fish length was accounted for. Using simulated data, we also found that associations between bypass probability and fish length could lead to erroneous estimates of the negative effects of bypass passage on return probability when length was not accounted for.

METHODS

Data.— We used data on tagging and detection history for spring/summer Chinook Salmon and steelhead originating in the Snake River basin and implanted with PIT tags (Prentice et al. 1990a) as juveniles. Passive integrated transponder tags allow unique identification of individual fish from juvenile through adult life stages and are used extensively in salmon research. We downloaded the PIT tag data from the PTAGIS database (PSMFC 2017).

Tagging data included locations and times of tagging and release, rearing type (hatchery or wild), and information about the researcher and study associated with each individual fish. We restricted the data to include only those fish with FL (mm) recorded at the time of tagging. Detection data included the location and time of detection of individual fish at any site with PIT tag detection systems (Prentice et al. 1990b), providing information from both juvenile and adult life stages.

Detection of PIT-tagged juveniles is possible at seven of the eight hydroelectric dams on the lower Snake River and lower Columbia River (Figure 2). The Dalles Dam (river kilometer [rkm] 308; rkm 0 = Columbia River mouth) is the only one of these dams without juvenile detection. Lower Granite Dam (rkm 695) is the furthest upstream dam and Bonneville Dam (rkm 234) is the furthest downstream in the hydropower system. The seven dams with tag detection have detectors installed in the bypass systems, but Bonneville Dam has additional detection in a sluiceway known as the "corner collector." The corner collector is located next to one of the two powerhouses and is designed to pass fish via water collected from the surface and directed through a gently sloping flume for several-hundred feet to the tailrace. The final detection site for juveniles is in the Columbia River estuary: a detection array towed behind a pair of boats near rkm 50 (Ledgerwood et al. 2004). We will refer to this detection site as the "estuary towed array." The main sites of adult detection during our study were the fish ladders at Bonneville Dam, McNary Dam (rkm 470), Ice Harbor Dam (rkm 538), and Lower Granite Dam.

Lower Granite Dam is the first dam encountered by fish migrating from upstream, and large numbers of fish are tagged at the dam each year for research studies, with a large proportion of those also measured at tagging. Although many fish that are tagged upstream of Lower Granite Dam are measured at tagging, tagging can occur from weeks to several months before those fish enter the hydropower system. Substantial growth can occur between tagging and entering the hydropower system. We therefore restricted our analyses to include fish that were tagged at Lower Granite Dam and those that were released at sites close enough upstream of Lower Granite Dam to reach the dam in less than 3 weeks on average. We used average travel times from each release location to Lower Granite Dam for fish in our data sets to determine which sites met this criterion. We further restricted the date of tagging to be between March 18 and June 30 and the date of release to be between April 1 and June 30. This restricted the set of fish to spring migrants and reduced the expected amount of growth before passing Lower Granite Dam. Juvenile bypass systems are turned off in the winter months and are typically turned back on around April 1. Restricting the release date to April 1 or later ensured that all fish had an opportunity for detection. The Snake River trap (rkm 747), Clearwater River trap (rkm 756), and Grande Ronde River trap (rkm 795) were the only tagging and release sites upstream of Lower Granite Dam that met the combination of date and travel time restrictions.

We performed two different main analyses: one investigating the association between fish length and the probability of bypass; and the other investigating the associations of fish length and bypass history with the probability of returning as an adult. Additionally, we investigated the association between fish length and detection in the corner collector in comparison to the bypass system at Bonneville Dam. For all analyses, we used only fish that were detected either at Bonneville Dam or the estuary towed array as juveniles and therefore were known to be alive while in the hydropower system. Any mortality experienced by these fish thus occurred after passage through all of the dams.

For comparisons between fish length and the number of bypass events, we used fish that were detected as juveniles at Bonneville Dam or the estuary towed array during the years 2000–2014. This set of years was chosen to be consistent with those used for adult return models (see below) but allowed for a few additional years to increase sample sizes. Juvenile detections were not possible at Ice Harbor Dam until 2005, so data for those models were restricted to 2005–2014. Juvenile detection was not possible in the corner collector at Bonneville Dam until 2006, so all fish that were detected as juveniles at Bonneville Dam prior to that year passed through the bypass system at Bonneville Dam. For specific comparisons between bypass and corner collector passage at Bonneville Dam, we used data from the years 2006–2014.

For return probability modeling, we used fish detected as juveniles at Bonneville Dam or the estuary towed array in 2004–2014. We excluded years prior to 2004 because equipment for PIT tag detection of adults at Bonneville Dam was not consistent with modern configurations and because sample sizes in some years were low. The cutoff of 2014 allowed nearly complete returns at the time of data acquisition in early 2017. Any fish that was detected in a fish ladder (adult fishway) at one or more dams in any year after its juvenile migration year was known to be alive at Bonneville Dam and was recorded as an adult return. Therefore, we defined return probability as survival from the site of the last juvenile detection (Bonneville Dam or the estuary towed array) to Bonneville Dam as an adult. We excluded fish returning in less than 1 year (mini-jacks) from the return probability data because they may never reach the ocean and they experience different conditions than fish returning after one or more years in the ocean.

For all data sets, we excluded fish that were tagged with acoustic or radio tags and those that were known to

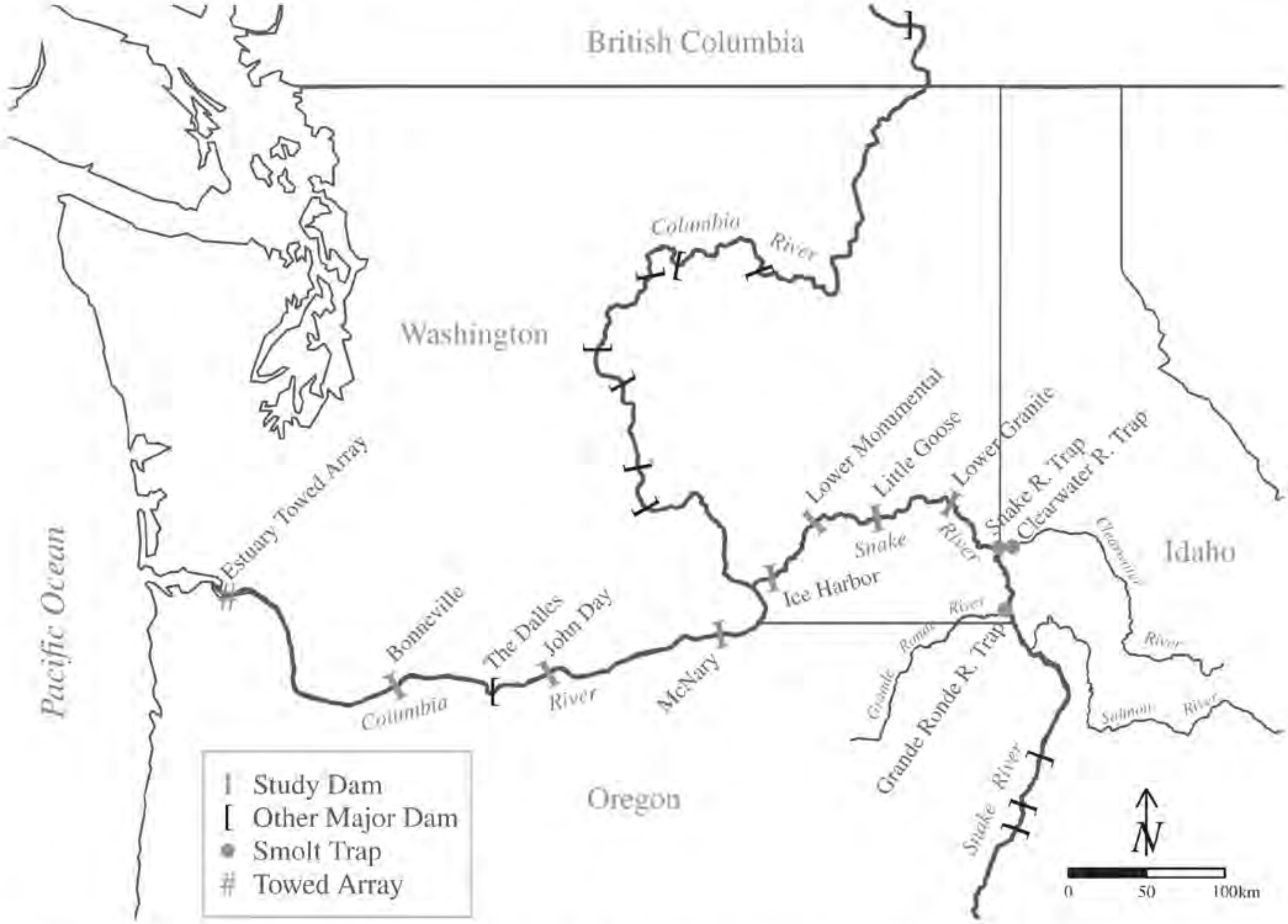

FIGURE 2. Map of the Snake River–Columbia River study area, showing locations of rivers, dams, the estuary towed array, and smolt traps used as tagging and release sites upstream of Lower Granite Dam. Study dams are those dams on the Snake River or lower Columbia River with PIT tag detection.

have been part of experiments involving multiple handling events or anesthetizations. We also excluded fish that were transported on barges since those fish are known to have different survival and have fewer opportunities for detection than fish that remain in the river. Some summaries of the data are provided in Supplemental Tables S1 and S2 available in the online version of this article.

Modeling of bypass probability.— Our objective was to describe relationships between fish length and the probability of passage through a bypass system after accounting for other sources of variation. We used all fish with FL measured at the time of tagging (with the restrictions described previously), where the site of tagging was either Lower Granite Dam or sites upstream. The length variable was standardized across rearing types and tagging locations and separately by species. We fitted separate models for each of the following dams: Lower Granite, Little Goose (rkm 635), Lower Monumental (rkm 589), Ice Harbor, McNary, John Day (rkm 347), and Bonneville dams. We used fish that were tagged upstream of Lower Granite Dam for modeling the bypass probability at Lower Granite Dam. We used fish that were detected at the estuary towed array for modeling the bypass probability at Bonneville Dam. For all other dams, we used the combined set of fish tagged at or upstream of Lower Granite Dam.

We modeled bypass probability with binary logistic regression, where a fish was given a 1 for bypass system passage (bypassed) or a 0 for passage through another route (not bypassed). We used two classes of model, which were distinguished by their representation of time in the season. The first model class used standardized day of passage at Lower Granite Dam (*pday*) and was used for dams on the Snake River (Lower Granite, Little Goose, Lower

Monumental, and Ice Harbor dams). The second model class used standardized day of detection (*dday*) at Bonneville Dam or the estuary towed array, where days of passage or detection were measured continuously to account for the time of detection or passage. This model class was only used for dams on the Columbia River (McNary, John Day, and Bonneville dams). For fish tagged upstream of Lower Granite Dam, *pday* was (1) the day and time of last detection at Lower Granite Dam if a fish went through the bypass system or (2) the release day and time plus the predicted travel time to Lower Granite Dam for the particular release site, release day, and year if the fish was not detected at Lower Granite Dam. Predicted travel times were generated from linear models fitted to observed travel times (see Supplemental Materials for details). For fish tagged at Lower Granite Dam, *pday* was the day and time of release. The variable *pday* was therefore a mixture of observed and estimated days of passage at Lower Granite Dam for the fish tagged upstream of Lower Granite Dam. For the fullest possible models of each class, the probability (p_i) of being bypassed at a dam for individual fish *i* was assumed to be a logit-linear function of the day variables, release site (*rsite*), an indicator variable for wild rearing type (*wild*), and standardized length at tagging (*length*) with random intercepts by year and random slopes for date variables by year:

$$\text{logit}(p_i) = (\beta_0 + b_{0,j}) + \beta_1 length_i + \beta_2 wild_i + \beta_{3,h_i} rsite_{h_i} + (\beta_4 + b_{4,j}) pday_i + (\beta_5 + b_{5,j}) pday_i^2, \quad (1)$$

$$\text{logit}(p_i) = (\beta_0 + b_{0,j}) + \beta_1 length_i + \beta_2 wild_i + \beta_{3,h_i} rsite_{h_i} + (\beta_6 + b_{6,j}) dday_i + (\beta_7 + b_{7,j}) dday_i^2, \quad (2)$$

where β_0 is the fixed intercept; and β_1, β_2, and $\beta_{3,h}$ are the fixed effects of *length*, *wild*, and the *h*th level of *rsite*, respectively. The fixed effects for the continuous *pday*, $pday^2$, *dday*, and $dday^2$ are represented by β_4 through β_7, respectively. The coefficients $b_{0,j}$ and $b_{4,j}$ through $b_{7,j}$ are random effects for the migration year *j* in which fish *i* migrated. The sum of $\beta_0 + b_{0,j}$ amounts to a separate intercept for each year, and the sum of slope coefficients such as $\beta_4 + b_{4,j}$ allows the slopes to vary by year. The random effects were assumed to be independent and normally distributed with mean of zero and a separate constant variance for each variable. The year and day effects and their combinations allowed us to account for variation in detectability at the dams due to river conditions and dam operations that vary with time but are difficult to measure and summarize for individual fish that are not detected. Models were constructed separately for each species and dam. Each model contained year, length, rearing type, and release site and differed only in the inclusion of the various combinations of the fixed and random day variables, which resulted in six possible models per dam and species (see Supplemental Table S3).

We performed additional analyses for Bonneville Dam that involved a comparison between bypass system and corner collector passage only, which excluded spill and turbine routes. For these models, we were able to use all fish that were detected in the bypass system or corner collector at Bonneville Dam whether or not they were detected at the estuary towed array. The purpose of these models was to test whether the probability of passing through the bypass system relative to the corner collector was dependent on fish size. The response variable was 1 for fish entering the bypass system and 0 for fish entering the corner collector. We used the same set of explanatory variables as was used in the main analyses of bypass probability for Bonneville Dam.

We should note that we originally modeled bypass probabilities separately for each rearing type. We found that relationships between length and bypass probability were very similar between the rearing types, so in the interest of simplifying the analyses we decided to combine the data and include an indicator variable for rearing type without interactions. This improved the power to estimate a length relationship while still allowing the rearing types to differ in their bypass probabilities.

Modeling of adult return probability.— Our objective was to test for associations between the probability of returning as an adult and bypass history after accounting for fish length and other factors that account for variation in return probability over time. We investigated three alternative variables to describe bypass system passage (bypass) history: (1) a binary variable for detection in any bypass system (yes or no); (2) a categorical variable with categories for 0, 1, 2, 3, or 4 or more bypass events; and (3) a continuous variable for the number of bypass events. The first bypass variable allowed us to assess whether one or more bypass events had a different effect than zero events. The second bypass variable allowed each number of events to have a different effect, which could capture nonlinear or threshold effects of the number of bypass events. The third bypass variable targeted linear effects of the number of bypass events. Data were from fish detected as juveniles at Bonneville Dam or the estuary towed array, and potential covariates included a categorical indicator variable for detection at the estuary towed array. Fish detected at both Bonneville Dam and the estuary towed array were included only once in the data set, and the date at the estuary towed array was used as the detection date covariate for those fish. The time variables were a categorical variable for juvenile migration year and a continuous variable for day of year at either Bonneville Dam or the estuary towed array, which were standardized separately for each location. Hatchery and wild fish were modeled together using an indicator variable for wild fish. Models were fitted separately for each species.

We also fitted separate models for fish that were tagged at Lower Granite Dam and those that were tagged upstream of Lower Granite Dam. All fish that were tagged at Lower Granite Dam go through the bypass system, but no non-bypassed fish are tagged or measured at Lower Granite Dam. This causes the data to be unbalanced due to the large number of fish tagged at Lower Granite Dam and makes bypass effects related to bypass at Lower Granite Dam almost completely confounded with effects related to fish tagged at Lower Granite Dam if data from all tagging sites are combined. Fitting separate models by tagging site thus allowed us to avoid potential bias due to confounding between bypass effects and potential effects associated with fish tagged at Lower Granite Dam (e.g., population of origin, tagging effects, tag loss, and fish condition). For models with fish tagged upstream of Lower Granite Dam, we included a categorical variable for tagging site. Fish tagged upstream of Lower Granite Dam had a maximum of seven possible bypass events, and those tagged at Lower Granite Dam had six; the exception was in 2004, when there were six and five possible bypass events, respectively, due to no detection at Ice Harbor Dam. We combined data from the Clearwater River trap with that from the Snake River trap due to small sample sizes at the Clearwater River trap and the close proximity of the two traps (10 km apart). The length variable was standardized separately by species and main tagging location (upstream of or at Lower Granite Dam), across rearing types, and across smolt trapping locations (for fish tagged upstream of Lower Granite Dam).

We assumed that the binary variable for adult return followed a binomial distribution where the probability of return was a logit-linear function of the explanatory variables. For the fullest possible model, the logit of the probability of returning as an adult (s_i) for individual fish i was

$$\begin{aligned}\text{logit}(s_i) = {} & (\beta_0 + b_{0,j}) + (\beta_1 + b_{1,j})day_i + (\beta_2 + b_{2,j})day_i^2 \\ & + \beta_3 wild_i + \beta_4 \text{ETA}_i + \beta_{5,h_i} rsite_{h_i} + \beta_6 length_i \\ & + \beta_7 bypass_i,\end{aligned}$$

where β_0 is the fixed intercept; and β_1 through β_6 are the fixed effects of standardized day at Bonneville Dam or the estuary towed array (*day*), associated day squared (*day*^{2}), indicator for wild rearing type (*wild*), indicator for last detection at the estuary towed array (ETA), hth level of release site (*rsite*), length at tagging (*length*), and bypass history (*bypass*), respectively. The bypass variable here is generic for one of the three possible bypass variables (binary, categorical, or continuous) and would have one level for either the binary or continuous version and four levels for the categorical version. The random effects $b_{0,j}$, $b_{1,j}$, and $b_{2,j}$ are associated with the migration year j for fish i for the intercept, *day*, and *day*^{2} variables, respectively. Similar to the models for bypass probability, the random effects allow separate values of the coefficients for the intercept, *day*, and *day*^{2} variables by year. The random effects were assumed to be independent and normally distributed with a mean of zero and a separate constant variance for each variable.

We used Akaike's information criterion (AIC; Akaike 1973; Burnham and Anderson 2002) as a measure of the relative predictive ability of a set of competing models. For the bypass probability analysis, we fitted a set of six models for each dam and species, where each model contained the variable for length (see Supplemental Materials for the set of models). For the return probability analyses, we first constructed a set of models based on possible combinations of the fixed covariates and random effects that did not include the fish length or bypass variables (we will refer to these as "covariate models"). For each species, there were 12 possible covariate models for fish tagged upstream of Lower Granite Dam and 12 possible covariate models for fish tagged at Lower Granite Dam (see Supplemental Materials for the model sets). For both the bypass probability and return probability analyses, we selected the best model within each set based on AIC, where lower AIC values indicate better performance. For the return probability analysis, we then added the variables of interest (length and/or bypass) to the best covariate models. In all cases, we recorded AIC and the *P*-values associated with the length and/or bypass variables. Our objectives were to test whether the parameter estimates for the variables of interest were different from zero and to assess whether the variables of interest improved the predictive ability of the models. We interpreted the strength of evidence in favor of particular models or variables by using a combination of the size of differences in AIC between models, associated Akaike weights (Burnham and Anderson 2002), and the degree of *P*-values of individual effects. We used 95% CIs to express uncertainty in parameter estimates.

We used the R computing environment (R Core Team 2017) for all aspects of the analyses; we specifically used the R package lme4 (Bates et al. 2015) for fitting the generalized linear mixed models. The data and R code used in the analyses for this paper are available online at https://github.com/jrfaulkner/bypass-length-sar.

Simulations.— The association between fish length and the probability of entering bypass systems makes it difficult to separate the individual effects of these variables on the probability of returning as an adult. If length truly did have an association with return probability but the number of bypass events did not, we wanted to know whether the number of bypass events would still come up as a significant predictor in return probability models due to its correlation with fish length. One way to address this question is by simulating data with both the number of bypasses and the return probability associated with length—but with no independent effect of the number of bypass events on return probability. If the number of bypass events then appeared as a significant predictor in models fitted to such simulated data, where fitted models did not include length, this would suggest that an apparent bypass effect on return probability in real data could actually be explained by the association with fish length alone. Conversely, if the bypass effect was not significant in return probability models fitted to the simulated data but was significant in models fitted to real data, this would suggest (1) an effect of bypass passage that was separate from length or (2) an association between bypass and some other unmeasured variable that was also associated with return probability.

To address these questions, we used simulations to assess the chance of detecting a bypass effect on return probability if one did not actually exist. We did this by generating data from the best return probability models of observed data that contained length and other covariates but no bypass effects; we then fitted models with a term for the number of bypasses to those simulated data and recorded the results. For each species and tagging location, we generated 1,000 simulated data sets. We fixed the data for the observed number of bypasses, length, and other measured covariates and only simulated the adult return data for each fish. By fixing these covariates, the observed association between length and the number of bypasses was preserved.

We simulated data by first drawing a set of model parameter values from a multivariate normal distribution for which the mean was the vector of parameter estimates (both fixed and conditional random effects) from the best model with length and covariates (but no bypass effect) fitted to the real data and the covariance matrix was the estimated joint covariance of the associated model parameters (see Supplemental Materials for details). Using the random draw of model parameters and the static covariate data, we then calculated predicted probabilities of adult return for each fish. Adult return data (0 or 1) were simulated for each fish by drawing from Bernoulli distributions given the set of predicted adult return probabilities. This process was replicated for a second set of simulations in which the data-generating model was the best covariate-only model within each species and tagging location. This second set of simulations was used for testing the effect of the number of bypass events when there was no true association between return probability and bypass or return probability and length.

For each simulated data set, we fitted three models. The null model (M0) contained just the fixed and random covariate terms. The second model (M1) added the term for number of bypass events, and the third model (M2) added the length variable to M1. A fourth model (M3), which was M0 with length added, was also fitted for comparison. For each model, we recorded the parameter estimate for the number of bypasses and associated *P*-values and the model AIC values. For M1 and M2, we recorded the proportion of simulations in which the parameter estimate for the number of bypasses was negative and had a *P*-value less than 0.05. For the model with number of bypasses and no length, we also recorded the proportion of simulations in which the parameter estimate for the number of bypasses was negative and the AIC was lower than that of the null model. We also calculated the mean and 0.025 and 0.975 quantiles of the parameter estimates for the number of bypasses across simulations.

If there was no association between the number of bypasses and the return probability, then we would expect the bypass variable to have a negative estimate approximately 50% of the time and we would expect it to be both negative and significant at the 0.05 level (two-sided test) approximately 2.5% of the time when models including the bypass variable were fitted to return probability data simulated using a length effect but no bypass effect. These percentages are those expected by chance alone when there is no bypass effect on return probability. We would also expect that any apparent effect of bypass would be diminished when length was also included in the fitted model.

RESULTS

Bypass Probability

For both Chinook Salmon and steelhead at most dams, we found strong evidence that the probability of entering the bypass system at a dam was negatively associated with fish length after accounting for the other variables (Table 1; Figure 3). The addition of the length variable to these models greatly reduced the model AIC (and, equivalently, resulted in small *P*-values for length) for each species at most dams (Table 1). For Chinook Salmon at Lower Granite Dam, there was only weak to moderate evidence for an association with length ($P = 0.07$; AIC dropped by 1.2). There was no evidence for an association with length for either species at Bonneville Dam when bypass system passage was compared to all other routes. However, when bypass system passage was compared to only the corner collector route at Bonneville Dam, there was strong evidence that the probability of entering the bypass system was negatively associated with length for each species (Table 1; Figure 3). The strongest associations between bypass probability and length (based on

TABLE 1. Estimated slope parameters and associated 95% CIs, change in Akaike's information criterion (AIC; dAIC), and *P*-values for standardized length variables from models for bypass probability by species and dam (see text for definitions). Parameter values represent the estimated change in log odds of bypass at a dam associated with a 1-SD increase in standardized length after accounting for other variables in the models. Estimates are from the best models with length selected by AIC. Here, dAIC represents the change in AIC associated with adding the length variable to the corresponding model without length for each dam. The sample size (*n*) is also shown for each data set. Dams are Lower Granite Dam (LGD), Little Goose Dam (LGSD), Lower Monumental Dam (LMD), Ice Harbor Dam (IHD), McNary Dam (MCD), John Day Dam (JDD), and Bonneville Dam (BVD); BVCC represents BVD when non-bypassed fish are from the corner collector only.

Dam	*n*	Estimate	95% CI	dAIC	*P*-value
			Chinook Salmon		
LGD	8,231	−0.066	−0.138, +0.006	−1.2	0.0729
LGSD	88,393	−0.210	−0.237, −0.184	−249.6	<0.0001
LMD	88,393	−0.179	−0.209, −0.149	−138.0	<0.0001
IHD	76,604	−0.221	−0.263, −0.179	−107.2	<0.0001
MCD	88,393	−0.226	−0.250, −0.202	−343.6	<0.0001
JDD	88,393	−0.329	−0.361, −0.297	−413.2	<0.0001
BVD	14,729	0.015	−0.078, +0.107	1.9	0.7548
BVCC	62,970	−0.230	−0.257, −0.203	−282.7	<0.0001
			Steelhead		
LGD	11,036	−0.112	−0.175, −0.049	−10.3	0.0005
LGSD	52,409	−0.161	−0.186, −0.136	−162.4	<0.0001
LMD	52,409	−0.174	−0.202, −0.146	−148.6	<0.0001
IHD	37,075	−0.203	−0.250, −0.157	−72.0	<0.0001
MCD	52,409	−0.260	−0.292, −0.229	−268.3	<0.0001
JDD	52,409	−0.293	−0.326, −0.259	−293.9	<0.0001
BVD	8,437	−0.057	−0.179, +0.065	1.2	0.3617
BVCC	31,220	−0.069	−0.105, −0.033	−12.1	0.0002

magnitude of the parameter for length) occurred at McNary and John Day dams for both species. For each species, the form of the best model for bypass probability varied by dam, but most included random slopes for the effects of *day* and *day*^{2} (see Supplemental Table S4).

Return Probability

For Chinook Salmon that were tagged upstream of Lower Granite Dam, the best return probability model without length or bypass effects included fixed effects for rearing type, release site, site of last detection, and day of year and included random year effects for the intercept (Supplemental Table S6). Adding the length variable resulted in a decrease in AIC of 4.6 and a *P*-value of 0.005, thus providing moderate to strong evidence of an association between length and return probability (Table 2). When length was not included in the model, adding the binary bypass variable increased AIC, adding the categorical bypass variable decreased AIC by 1.5 with an associated *P*-value of 0.039, and adding the continuous number of bypasses decreased AIC by 2.5 with a *P*-value of 0.036. This suggests moderate evidence of an association between return probability and the number of bypass events when length was not in the model. When length was included in the model, adding the binary bypass variable resulted in an increase in AIC, adding the categorical bypass variable reduced AIC by 1.1 with a *P*-value of 0.060, and adding the continuous variable for number of bypasses reduced AIC by 1.3 with a *P*-value of 0.074. This suggests weak to moderate evidence of an association with the number of bypasses after accounting for length. For the model with length and a continuous number of bypasses, the odds of adult return increased by an estimated multiplicative factor of 1.35 for every 1-SD increase in length (16.1 mm; 95% CI = 1.07–1.70) and the odds of return decreased by a multiplicative factor of 0.85 for each additional bypass event (95% CI = 0.71–1.02; Figure 4).

For Chinook Salmon tagged at Lower Granite Dam, the best model for just the covariates included fixed effects for rearing type and day and random year effects for the intercept and the slope of day. Adding length to this model reduced AIC by 20.8 with $P < 0.0001$, indicating strong evidence of an association between length and return probability. In contrast, when length was not in the model, adding the binary bypass variable increased AIC, while adding the categorical bypass variable decreased AIC by 1.2 with an associated *P*-value of 0.056 and adding the continuous number of bypasses decreased AIC by 1.7 with a *P*-value of 0.053. These results indicate weak to

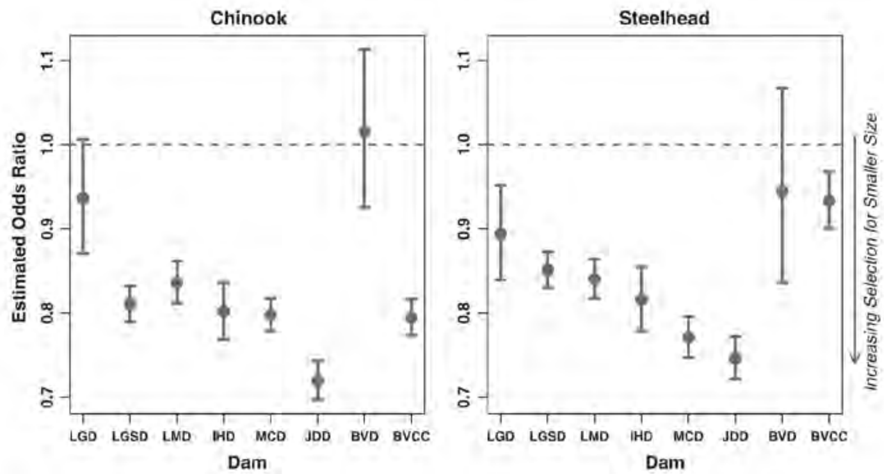

FIGURE 3. Parameter estimates (with associated 95% CIs) for multiplicative effect of a 1-unit increase in standardized length on the odds of entering the bypass system at a dam. Results are shown for each dam and each species (Chinook Salmon and steelhead). The horizontal line at 1.0 is used as a reference to assess difference of the estimates from 1.0. An odds ratio less than 1.0 indicates that smaller fish are more likely to pass through a bypass system than through other routes. Dams are Lower Granite Dam (LGD), Little Goose Dam (LGSD), Lower Monumental Dam (LMD), Ice Harbor Dam (IHD), McNary Dam (MCD), John Day Dam (JDD), and Bonneville Dam (BVD); BVCC represents BVD where bypass is compared to the corner collector only.

moderate evidence of an association between bypass history and return probability when not accounting for length. After length was included in the model, adding either the binary variable ($P = 0.329$) or the categorical variable ($P = 0.111$) for bypass did not improve AIC but adding the continuous variable for the number of bypasses decreased AIC by 0.1 with a P-value of 0.147. These results suggest that any association between a bypass variable and return probability could potentially be explained by length, but there is still weak evidence for a bypass effect beyond that due to length. For the model with length and a continuous number of bypasses, the odds of adult return increased by an estimated multiplicative factor of 1.30 for every 1-SD increase in length (15.3 mm; 95% CI = 1.17–1.45) and the odds of return decreased by a multiplicative factor of 0.94 for each additional bypass event (95% CI = 0.87–1.02; Figure 4).

For steelhead that were tagged upstream of Lower Granite Dam, the best model built from only the covariates included fixed effects for rearing type, tagging site, the site of last detection, *day*, and day^2 and a random year effect for the intercept. Adding length to the model resulted in a decrease in AIC of 14.4 and $P < 0.0001$, thereby providing strong evidence that return probability was associated with length. Adding any of the bypass variables resulted in increases in AIC whether or not length was included in the model ($P > 0.40$ for each bypass variable), suggesting no evidence that return probability for steelhead was associated with bypass history. For the model with length and a continuous number of bypasses, the odds of adult return increased by an estimated multiplicative factor of 1.38 for every 1-SD increase in length (27.6 mm; 95% CI = 1.18–1.61) and the odds of return increased by a multiplicative factor of 1.00 for each additional bypass event (95% CI = 0.89–1.13; Figure 4).

For steelhead tagged at Lower Granite Dam, the best covariate model included fixed effects for rearing type and day of year and included random year effects for the intercept and slope on day of year. Adding length to this model resulted in a reduction in AIC of 116.5 and $P < 0.0001$, thus presenting very strong evidence for an association between length and return probability. When length was not included in the model, adding the binary bypass variable decreased AIC by 3.6 with an associated P-value of 0.017, adding the categorical bypass variable decreased AIC by 1.6 with a P-value of 0.048, and adding the continuous number of bypasses decreased AIC by 3.5 with a P-value of 0.019. These results suggest moderate to strong evidence for an association between bypass history and return probability when not accounting for length. However, when length was incorporated into the model, adding the binary bypass variable decreased AIC by 0.1 with a P-value of 0.144, adding the categorical bypass variable increased AIC by 2.1 with a P-value of 0.207, and adding the continuous number of bypasses increased AIC by 0.8 with a P-value of 0.271. This indicates that after accounting for length, there was weak to no evidence remaining for an association between bypass history and return probability. For the model with length and a continuous number of bypasses, the odds of adult return increased by an estimated multiplicative factor of 1.64 for every 1-SD increase in length (30.7 mm; 95% CI = 1.50–1.79) and the

TABLE 2. Results for return probability models by species and tag site, where tag sites are Lower Granite Dam (LGD) or sites upstream of LGD (ULGD). Also shown are the number of individuals (smolts) and number of adult returns for each data set used for model fitting. Each row gives the terms in the model and the number of parameters (*np*), the difference in Akaike's information criterion (AIC; ΔAIC) compared to the model with lowest AIC, the model Akaike weight (*w*), and *P*-values associated with respective length (*len*) or bypass variables in the model. Each model had a set of covariates (*covs*; described in the text) that were common to all models within a particular species and tag site. The bypass variables are the binary bypass indicator (*byp*), the categorical number of bypasses (*byp.cat*), and the number of bypasses (*n.byp*).

								P-value	
Species	Tag site	Smolts	Returns	Model	*np*	ΔAIC	*w*	Length	Bypass
Chinook Salmon	ULGD	6,348	100	*covs*	6	5.9	0.02		
				covs + len	7	1.2	0.18	0.005	
				covs + byp	7	7.1	0.01		0.349
				covs + byp.cat	10	3.9	0.05		0.039
				covs + n.byp	7	3.5	0.06		0.036
				covs + byp + len	8	2.8	0.08	0.006	0.527
				covs + byp.cat + len	11	0.1	0.30	0.010	0.060
				covs + n.byp + len	8	0.0	0.32	0.011	0.074
Chinook Salmon	LGD	71,171	638	*covs*	6	20.9	0.00		
				covs + len	7	0.1	0.29	<0.001	
				covs + byp	7	21.3	0.00		0.192
				covs + byp.cat	10	19.7	0.00		0.056
				covs + n.byp	7	19.2	0.00		0.053
				covs + byp + len	8	1.2	0.17	<0.001	0.329
				covs + byp.cat + len	11	0.6	0.23	<0.001	0.111
				covs + n.byp + len	8	0.0	0.31	<0.001	0.147
Steelhead	ULGD	8,572	295	*covs*	7	14.4	0.00		
				covs + len	8	0.0	0.52	<0.001	
				covs + byp	8	16.1	0.00		0.537
				covs + byp.cat	11	20.8	0.00		0.800
				covs + n.byp	8	16.3	0.00		0.738
				covs + byp + len	9	1.3	0.27	<0.001	0.400
				covs + byp.cat + len	12	6.5	0.02	<0.001	0.827
				covs + n.byp + len	9	2.0	0.19	<0.001	0.980
Steelhead	LGD	29,077	659	*covs*	6	116.4	0.00		
				covs + len	7	0.1	0.33	<0.001	
				covs + byp	7	112.9	0.00		0.017
				covs + byp.cat	10	114.9	0.00		0.048
				covs + n.byp	7	112.9	0.00		0.019
				covs + byp + len	8	0.0	0.34	<0.001	0.144
				covs + byp.cat + len	11	2.2	0.11	<0.001	0.207
				covs + n.byp + len	8	0.9	0.22	<0.001	0.271

odds of return decreased by a multiplicative factor of 0.95 for each additional bypass event (95% CI = 0.88–1.04; Figure 4).

We note that rearing type was important for both species in all of the models that included length, where wild fish had a higher probability of return than hatchery fish. Since hatchery fish are longer on average than wild fish, the effect of rearing type was masked and seemingly unimportant in some models without length. However, retaining rearing type in the models with length helped to more accurately estimate the length effect.

Simulations

Our simulations showed that a spurious bypass effect could arise more frequently than by chance, whether fish length was accounted for in the fitted model or not (Table 3). When the covariate-only model (M0) was the data-generating model, there were more negative estimates and more significant negative estimates than expected, with larger differences from expected occurring for the groups tagged upstream of Lower Granite Dam. This effect was likely induced by a combination of small sample sizes for groups with multiple bypass events and low overall return probabilities.

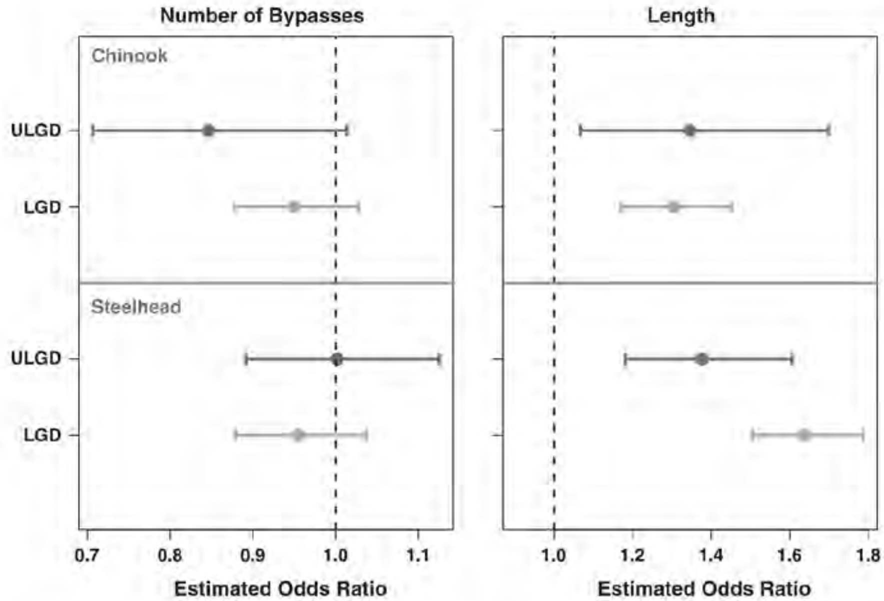

FIGURE 4. Parameter estimates (with associated 95% CIs) for the multiplicative effects of the number of bypass events and standardized length on the odds of adult return. Estimates are from models that included both the number of bypass events and fish length. Results are shown by species (Chinook Salmon and steelhead) and tagging location (at Lower Granite Dam [LGD] or upstream of LGD [ULGD]). The vertical lines at 1.0 are used as a reference to assess difference of the estimates from 1.0. A parameter estimate less than 1.0 for the number of bypasses indicates that fish with more bypass events are less likely to return as adults, and a parameter estimate greater than 1.0 for length indicates that larger fish are more likely to return.

TABLE 3. Simulation results, showing the percentage of simulations with indicated outcome by species and tagging location. Tagging locations are Lower Granite Dam (LGD) or sites upstream of LGD (ULGD). Models are as follows: M0 = covariates (*covs*); M1 = *covs* + number of bypass events (*n.byp*); M2 = *covs* + *n.byp* + fish length (*len*); and M3 = *covs* + *len*. Data models are those used to generate the simulated data, and fitted models are those fitted to the simulated data. Outcomes include a negative parameter estimate for the effect of *n.byp* (*n.byp*[−]) and whether the associated *P*-value was also less than 0.05 or whether Akaike's information criterion (AIC) for the specified fitted model was less than that from the corresponding model without *n.byp* fitted to the same data. Shown for comparison is the expected percentage of times each outcome would be true given the data-generating model and no association between length and *n.byp*.

Data model	Fitted model	Outcome	Expected (%)	Chinook Salmon ULGD (%)	Chinook Salmon LGD (%)	Steelhead ULGD (%)	Steelhead LGD (%)
M0	M1	*n.byp*(−)	50.0	60.9	57.2	63.5	58.6
		n.byp(−) and $P < 0.05$	2.5	4.9	3.5	5.8	3.1
		n.byp(−) and lower AIC vs. M0	7.8	13.0	9.8	14.3	12.0
M3	M1	*n.byp*(−)	50.0	74.8	76.3	74.4	93.8
		n.byp(−) and $P < 0.05$	2.5	10.1	10.1	9.1	34.8
		n.byp(−) and lower AIC vs. M0	7.8	24.1	24.8	22.3	55.3
M3	M2	*n.byp*(−)	50.0	59.5	75.4	59.8	60.0
		n.byp(−) and $P < 0.05$	2.5	3.7	9.9	6.0	5.5
		n.byp(−) and lower AIC vs. M3	7.8	11.8	24.6	12.7	14.8

When the model with covariates and fish length (M3) was the data-generating model, spurious bypass effects occurred more frequently than by chance, especially when length was not accounted for in the fitted model. For the fitted model that did not include length (M1), a negative parameter estimate for the effect of the number of bypasses occurred in greater than 74% of the simulations for each species and tagging location when no bypass effect actually existed; a significant and negative parameter estimate occurred in at least 9% of simulations for each species and tagging location. Additionally, M1 had a lower AIC than M0 when there was also a negative estimate for a bypass effect in greater than 21% of simulations for each species and tagging location. After accounting for length in the fitted model (M2), the proportion of negative estimates and the proportion of negative and significant estimates declined but were still greater than those expected by chance. The simulation results were similar for Chinook Salmon at both tagging locations and for steelhead tagged upstream of Lower Granite Dam. The results for steelhead tagged at Lower Granite Dam indicated that when length was not accounted for, a significant negative estimate of bypass effect was much more likely in comparison with the results for Chinook Salmon and for steelhead tagged upstream of Lower Granite Dam.

Mean parameter estimates across simulations were similar to parameter estimates from models fitted to the observed data for all species and tagging locations except for Chinook Salmon tagged upstream of Lower Granite Dam (Supplemental Figure S2). The estimated effect of bypass from the model fitted to observed data for Chinook Salmon from upstream of Lower Granite Dam was much more negative than the mean of parameter estimates from the simulated data. This suggests that the association between fish length and the number of bypass events does not completely explain the apparent effect of the number of bypass events on return probability seen in the observed data.

DISCUSSION

We investigated associations between fish length and the probability of entering juvenile bypass systems at dams; furthermore, we investigated associations among fish length, bypass history, and the probability of returning as an adult for fish known to have survived through a system of hydropower dams. Our main findings were as follows: (1) there was strong evidence for a negative association between fish length and the probability of bypass at most dams, (2) there was strong evidence for a positive association between fish length and return probability, and (3) there was moderate to weak evidence for a negative association between bypass history and return probability, which weakened further when fish length was included in the models.

We found strong evidence for a negative association between the length of fish at tagging and bypass probability for both steelhead and Chinook Salmon at six of the seven study dams, with smaller fish being more likely to enter a bypass system. There was a negative association with length at Lower Granite Dam for both species, but the evidence was not strong for Chinook Salmon. At Bonneville Dam, there was no evidence for an association with fish length when the bypass system was compared to all other routes combined, but there was strong evidence that the bypass system was more likely to pass smaller fish in comparison to the corner collector alone (see discussion below). One caveat is that Lower Granite and Bonneville dams had much smaller sample sizes, so the statistical power to detect length relationships was diminished for those data sets. The general layout of Bonneville Dam is also very different from the layouts of the other dams in the hydropower system. Each of the other six study dams comprises a continuous structure that spans the river with a powerhouse at one end and a spillway at the other. Bonneville Dam consists of two powerhouses and a spillway, which are separated by natural islands so that each is essentially in its own channel, with no direct route between powerhouses or the spillway. Bonneville Dam also has the corner collector, which collects water and fish from the surface and diverts them away from the second powerhouse. These differences in dam structure can be expected to produce different fish passage behaviors that could depend on size. Finally, it should also be noted that experimental structures designed to guide fish away from the powerhouses were in periodic use at both Lower Granite Dam (2000, 2002, and 2006) and Bonneville Dam (2008–2010), which could have affected bypass size selectivity at those sites during those years.

Our results confirm those of Zabel et al. (2005) and Hostetter et al. (2015), who found that length was an important predictor of bypass probability for Snake River Chinook Salmon and steelhead at Snake River dams, with smaller fish being more likely to enter a bypass system. Brown et al. (2013) also found that the bypass probability of yearling Chinook Salmon released from Lower Granite Dam decreased with increasing FL on average across multiple dams. Buchanan et al. (2011) investigated associations between bypass passage and fish length, but they found mixed results, with significant size selectivity evident in some release groups but not in others. Similar to our study, Buchanan et al. (2011) found no relationship between size and bypass probability at Lower Granite Dam or Bonneville Dam. Buchanan et al. (2011) did not restrict release sites to those closest to Lower Granite Dam, however, and they did not account for time since tagging in their analyses. This likely resulted in a large number of measured lengths that were not representative of true lengths once fish entered the hydropower system.

Two general mechanisms that could explain size selection in bypass systems are the vertical distribution of fish as they approach a dam and the physical ability of fish to escape the bypass screens. 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. The depth at which fish are swimming as they approach a dam will affect their route of passage (Li et al.

2015, 2018). Surface collection structures, such as spillway weirs, sluiceways, or the corner collector, collect fish from the first few meters of the surface of the river. Entrances to standard spillbays are 10–15 m below the surface, while the upper ceilings of entrances to turbine intake bays are 15–25 m below the surface for dams on the Snake and Columbia rivers. Bypass diversion screens extend approximately 6–12 m below the declining turbine intake ceilings and are designed to collect the fish orienting along the ceiling as they enter the intake. This means that fish must reach depths of approximately 20–35 m to escape the screens and enter the turbines. Li et al. (2015) found that (1) yearling Chinook Salmon and steelhead that passed through juvenile bypass systems approached dams significantly deeper than those that passed though spillways and (2) fish that passed through turbines approached deeper than those that passed through bypass systems. If swim depth is related to fish size, then this could explain size differences by passage route.

Li et al. (2015, 2018) did not investigate relationships between length and swim depth but did find that subyearling Chinook Salmon, which are smaller than yearlings, traveled deeper than yearling Chinook Salmon; however, they noted that this could have been due to higher water temperatures occurring when subyearling Chinook Salmon migrated in late spring and summer. Fish size and level of smoltification have been documented to affect buoyancy (Saunders 1965; Pinder and Eales 1969), with larger and more smolted fish being more buoyant and more likely to migrate higher in the water column. This suggests that the larger, more smolted fish are more likely to pass through spill and surface routes than through bypasses or turbines. This is consistent with our findings that smaller fish were more likely to enter bypass systems compared to other routes, especially given that the probability of entering turbines is low at most dams. Our results for bypass system passage in comparison with the corner collector at Bonneville Dam further support this idea, where larger fish were more likely to pass through the corner collector, which is a surface route. The reason we did not find an effect of length on bypass system passage at Bonneville Dam when comparing to all other routes could be related to the higher turbine passage at Bonneville Dam. The probability of turbine passage is approximately 20–30% for both species at Bonneville Dam (Ploskey et al. 2012), which is much higher than at the other dams and results from having two powerhouses and a relatively low probability of being guided by the bypass screens. If fish passing through turbines at Bonneville Dam are generally smaller and those passing via spill and the corner collector are larger, then the combination of these groups would have a wide range of lengths, which could explain the results for bypass system passage versus the other routes combined.

The second possible mechanism of size selection by bypass systems is the ability of a fish to escape when it senses the change in water velocity created by the bypass screens and gatewells (Zabel et al. 2005; Enders et al. 2012). Larger and more physically fit fish have greater strength and swim speed, allowing them a better chance to escape the bypass screens. This suggests that among fish entering the powerhouse, those that are guided into the bypass system would be smaller and in poorer condition, on average, than those that pass via turbines. However, it provides no information regarding differences in size or condition between fish that enter the powerhouse and those that pass via spill.

It was not possible in our study to distinguish whether the association between length and bypass probability was due to differential passage between the powerhouse and the spillway or whether it was driven by selection between bypass and turbine passage given entry to the powerhouse. This distinction can only be made if the exact route of passage is known for each fish, and we only had information on whether a fish passed through a bypass system or not. Further research using data from dam passage studies that employ radiotelemetry or acoustic tags, which allow accurate determination of each passage route, should focus on associations between length, spatial distribution, and route of passage.

Our second major finding was the strong evidence for an association between fish length and return probability for both species, with larger fish having a higher probability of returning as adults. Size has been found to be a significant factor in survival during the first ocean year for seven species of Pacific salmon *Oncorhynchus* spp. (Holtby et al. 1990; Koenings et al. 1993; Miyakoshi et al. 2001; Farley et al. 2007; Cross et al. 2009) as well as other related anadromous salmonids, such as Atlantic Salmon *Salmo salar* (Saloniemi et al. 2004), Brown Trout *Salmo trutta*, and Arctic Char *Salvelinus alpinus* (Jensen et al. 2017). A mass review of marine survival studies focused on anadromous salmonids spanning a range of species and tag types found that fish length was one of the most frequent significant predictors of fish survival (Drenner et al. 2012).

Within the Columbia River basin, Tipping (2011) found that size at tagging had a significant effect on adult return probabilities for Chinook Salmon in 7 of 10 release groups. Releases of hatchery fish in the Deschutes River (a tributary that enters the Columbia River upstream of two dams in the hydropower system) also showed length to be a strong predictor of adult return (Beckman et al. 1999). Evans et al. (2014) found that juvenile length and condition were strong predictors of adult survival in steelhead from the Columbia and Snake rivers. In a study of Chinook Salmon from the Willamette River (a tributary of the Columbia River that enters downstream of the hydropower system) based on scale analysis, Claiborne et al. (2011) found a significant effect of ocean entry size on adult survival in 3 of 4 years examined. However, Romer et al. (2013) did not find a significant effect of fish length on adult survival and return in two coastal groups of steelhead tagged in 2009. Zabel and Williams (2002) found that larger yearling Chinook Salmon were more likely to return as adults, and Zabel et al. (2005) and Passolt and Anderson (2013) reported a size-dependent survival pattern in the hydropower system.

Three mechanisms controlling size-selective mortality in teleost fish were suggested by Sogard (1997): differences in vulnerability to predation, susceptibility to starvation, and tolerance of environmental extremes. Currently, the two primary hypotheses explaining observations of higher survival by larger smolts are the critical size hypothesis (Beamish and Mahnken 2001; Farley et al. 2007) and size-related susceptibility to predation (Holtby et al. 1990; Henderson and Cass 1991; Saloniemi et al. 2004; Cross et al. 2009). The critical size hypothesis suggests that juvenile salmonids must reach some minimum critical size to survive their first winter at sea. This may be related to energy reserves or other factors involved in surviving the winter. Smaller smolts grow more slowly (Ruggerone et al. 2009) and thus are less likely to reach this critical size in time, especially during years with poor ocean productivity (Holtby et al. 1990; Saloniemi et al. 2004). This hypothesis also explains the differing strength of size-dependent survival between years. In studies of Atlantic Salmon, Coho Salmon *O. kisutch*, Pink Salmon *O. gorbuscha*, and Sockeye Salmon, size was identified as a good predictor of survival within years but the strength of the relationship varied between years (Holtby et al. 1990; Henderson and Cass 1991; Saloniemi et al. 2004; Cross et al. 2009).

Size-specific consumption by predators can be due to limitations of mouth gape size, behavioral selection, or size-dependent escape ability of the prey. Size-selective predation on juvenile salmonids has been documented in the early phase of ocean residence (Parker 1971; Healy 1982; Hargreaves and LeBrasseur 1986; Holtby et al. 1990). Since predation risk is generally assumed to decrease with increasing size, size-specific survival patterns due to predation seem likely to vary between years for the same reasons as the critical size hypothesis. Regardless of the specific mechanism or combination of mechanisms, at least in some years there are strong indications that larger juvenile salmon survive at higher rates during their first year of ocean residence.

As predators themselves, larger salmon smolts have a wider selection of prey available due to their larger gape sizes and faster swim speeds, allowing faster growth in the ocean and a lower probability of starvation. Larger salmon also mature faster and return at earlier ages (Scheuerell 2005; Tattam et al. 2015), which means that they have a shorter duration of exposure to mortality risks in the ocean.

Our third major finding was the moderate to weak evidence for a negative association between bypass history and return probability when length was not accounted for, whereas evidence for that association weakened or disappeared when length was taken into account. For Chinook Salmon tagged at Lower Granite Dam and steelhead tagged at or upstream of Lower Granite Dam, bypass variables were nonsignificant before accounting for length or they became nonsignificant when length was also included in the model. Only for Chinook Salmon tagged upstream of Lower Granite Dam was the number of bypass events marginally significant after accounting for length.

The negative association between fish length and bypass probability was the most likely explanation for the cases where evidence for a bypass effect on return probability diminished or disappeared after accounting for fish length. Smaller fish were more likely to experience multiple bypasses, so the number of bypasses essentially functioned as a surrogate for length in the model. It is clear from our models of bypass passage that smaller fish have a higher probability of bypass passage at most dams when compared to larger fish, which translates into a higher expected number of bypass events during migration. If length is not explicitly accounted for in a model of adult return, inclusion of a variable for the number of bypass events (or even for the number of spillway passage events) in the model could act as a surrogate for fish length. If the bypass variable does not contain additional explanatory power beyond that offered by the correlation with length, then one would expect the apparent effect of the bypass variable on return probability to disappear when length is included in the same model. We saw this phenomenon occur for all steelhead and for Chinook Salmon tagged at Lower Granite Dam. Our simulations further indicated that a false signal for the number of bypasses could be detected as significant more often than by chance when there is no true association with return probability due to the association between fish length and the probability of entering bypass systems.

When evidence for a negative effect of bypass on return probability remains after accounting for length and other confounding variables, it suggests that there could be delayed or long-term effects of multiple bypass events on fish. Our results for Chinook Salmon tagged upstream of Lower Granite Dam provide some support for this possibility. Passage through bypass systems at multiple dams could be causing an accumulation of trauma and stress that results in impaired condition, reduced energy reserves, and increased susceptibility to predation in the estuary and ocean, as has been suggested by others (e.g., Budy et al. 2002; Schaller et al. 2014). Although this seems like a biologically reasonable assumption, the available direct empirical evidence in support of it is mixed.

Maule et al. (1988) reported that blood measures of stress increased cumulatively as fish passed through points in the bypass system at McNary Dam, and several studies summarized by Ferguson et al. (2005) showed increased indices of stress in bypass systems at other dams, but indices returned to pre-stress levels in a relatively short time. Barton et al. (1986) found that multiple handling events of juvenile Chinook Salmon resulted in cumulative physiological stress. Barton and Schreck (1987) identified a relationship between multiple stress events and increased metabolic rate in juvenile steelhead, suggesting that multiple stress events (e.g., multiple bypasses) could result in decreased energy reserves. Mesa (1994) exposed juvenile Chinook Salmon to multiple stressors and found preferential predation by Northern Pikeminnow *Ptychocheilus oregonensis*, an important predator of salmonids in the hydropower system (Rieman et al. 1991), on the stressed individuals compared to controls in a short period, but there were no differences in predation after 1 h of recovery. Sandford et al. (2012) investigated the delayed effect of bypass passage on post-hydropower-system survival by collecting juvenile Chinook Salmon at Bonneville Dam and holding them in seawater tanks; those authors found no effect of bypass history on survival, but they could not account for predation or factors that only occur in the natural environment.

The proportion of yearling Chinook Salmon and steelhead experiencing some level of descaling due to bypass system passage ranged from 1.5% to 9.6% in studies of bypass passage at individual dams in the hydropower system (Ferguson et al. 2005). Multiple bypass events would certainly increase the probability that a fish experiences some level of descaling or trauma. Evans et al. (2014) found that steelhead with general bodily injuries had higher susceptibility to avian predation but that the level of descaling was not influential. Gadomski et al. (1994) reported that experimentally descaled juvenile Chinook Salmon had short-term physiological stress responses but were not more susceptible to predation than controls. Descaled juvenile salmon can suffer high mortality due to an impaired ability to osmoregulate when exposed to seawater within 1 d of the descaling event, but they can recover and survive at normal levels if allowed to remain in freshwater for a few days (Bouck and Smith 1979; Zydlewski et al. 2010). Juveniles migrating through the hydropower system would have sufficient time to recover before reaching the estuary.

It is difficult to explain why multiple bypass events would affect return probability more for Chinook Salmon tagged upstream than for those tagged at Lower Granite Dam and why they would affect Chinook Salmon but not steelhead, especially when we consider that Chinook Salmon from upstream of Lower Granite Dam had the smallest sample size and the lowest number of returning adults compared to the other groups. We cannot rule out the possibility that the results for Chinook Salmon from upstream of Lower Granite Dam reflected a spurious relationship driven by small sample sizes. The direction of the bypass effect for Chinook Salmon tagged upstream of Lower Granite Dam was not consistent from year to year, based on the direct return probability estimates for each number of bypass events (see Supplemental Materials). We were also unable to account for all of the confounding variables that are associated with both bypass probability and adult return, such as fish condition and disease status, which may have differed among the tagging locations. Given these uncertainties, the evidence for a causal relationship between the number of bypass events and return probability for Chinook Salmon tagged upstream of Lower Granite Dam is still questionable.

Another important point is that the probability of experiencing a particular number of bypass events decreases rapidly for each additional number of events greater than two (Supplemental Table S2). This means that the proportion of the migrating populations of yearling Chinook Salmon and steelhead experiencing more than three bypass events is low. Our results indicated that return probability for fish with zero to two or three bypass events tended to be similar (Supplemental Figures S3–S6). Therefore, the overall return probabilities for these migrating populations would not be affected much by any delayed mortality experienced by fish that undergo multiple bypass events.

We were only able to investigate the effects of passing through bypass systems and were not able to investigate the effects of passing through turbines or other routes due to a lack of PIT tag detection in those routes. Turbine passage can result in rapid pressure changes and strikes with blades and other structures in the turbine housing. Multiple passage events through turbines would be expected to lead to accumulated trauma and stress and increased susceptibility to predation. Ferguson et al. (2007) found that juvenile salmon had significant delayed mortality between 15 and 46 km downstream after passing through turbines at McNary Dam; those authors concluded that the likely cause was impaired sensory systems, leading to increased vulnerability to predation. Studies on the delayed effects of turbine passage or other routes of passage on survival beyond the hydropower system are needed but are lacking, mostly due to limitations in tagging and detection technologies.

Others have attempted to estimate the effect of passage through either bypass systems or turbines on survival to adulthood by creating an index of powerhouse passage for release groups of fish (Petrosky and Schaller 2010; Schaller et al. 2014; McCann et al. 2017). There are different ways of calculating these indices based on various assumptions about passage route probabilities, but the resulting group-level metric is an estimate of the expected number of powerhouse passage events experienced by each fish across the set of dams passed during the migration. These methods do not account for the known bypass events of individual fish, and there is no way to know which fish actually went through turbines. There is also no way of knowing whether the individual fish that actually went through turbines or bypass systems had a lower probability of return. The authors of those studies found negative associations between survival to adulthood and indices of the number of powerhouse passages, but they did not account for fish size or condition in their models. Even if they would have included fish characteristics, modeling approaches that use temporal or spatial aggregations of fish as observational units can only account for individual fish characteristics as group-level summary statistics, which results in the loss of important information. There is a need to be able to account for individual fish characteristics as well as individual passage route histories in our modeling of survival to adulthood, but doing so directly is not possible given current data limitations.

Ideally, tag detection would be present in every route of passage, and we could then explicitly link the actual route of passage to the fate of individual fish. Monitoring of PIT tags in this way is costly and not a viable option in the near future. Active (radio or acoustic) tags allow for determination of the passage route with fairly high precision, but the current life of those tags is short and they cannot be used to obtain data on adult returns. Application of both PIT tags and active tags to fish could provide a solution, but such tagging efforts are costly and burdensome on the fish, resulting in small sample sizes and results that are potentially not representative of the population at large. A secondary solution could be to develop more sophisticated models that would take advantage of all available tagging data and would account for the unknown passage routes (spill or turbine) of individual fish by using probabilistic relationships that depend on fish length and other covariates, such as in a Bayesian framework. Such models may offer more accurate predictions of the effects of specific passage routes on adult returns than are currently available. This is an area of our current research.

In conclusion, based on our results and those of others, it is imperative that researchers investigating return probability or bypass probability include the length of individual fish in their models. If other data related to measures of individual fish health exist (e.g., condition factor, disease status, etc.), then those data should also be included. Neglecting these important sources of information could lead to spurious modeling results, which could misinform management decisions and lead to misallocation of limited resources.

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SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Nov 10 09:50:55 2020

To: 'David Welch'

Subject: RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Importance: Normal

Hi David,

Kurt Miller of River Partners sent out a statement to regional governors, calling for more focus on climate change effects, and they cited your study.

(b)(5) [redacted]

[redacted]

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Sunday, November 8, 2020 1:43 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Just wondered about this final comment of yours: “and we are currently trying to figure out how we would sample the adult species”.

Is this based on PIT tags in the returns, or something else? Remember that unless/until the harvest is monitored for PIT tags the use of those tags for measuring survival is deeply compromised. We did not even hint at this in the published paper because of its sensitivity, but if you take survival back to LGR then you really need to get PIT tag monitoring of the Indian catch between Bonneville Dam & LGR in place—our reported harvest rates did not include those impacts. But if the proportion of the return that is harvested is at all variable in the upstream fisheries then it directly impacts the SAR estimates at LGR.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 6, 2020 1:33 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

(b)(6) [redacted]

FPC just put out a memo which probably will appear on their site. They want to reduce effort at the Smolt monitoring project sites (which they oversee, but PSMFC staff carry out the work), and reallocate it for more CSS tagging effort and locations. The rationale is that then BPA wouldn't be able to say it costs too much because it would be a net neutral budget between these two projects. They are saying that Rock Island dam and John Day are not very useful for smolt monitoring. (b)(5) [redacted]

(b)(5) [redacted]

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Friday, November 6, 2020 10:34 AM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

(b)(6) [redacted]

All this talk of "non-representative samples" by the FPC is (forgive me) a red herring. Most areas of science don't pick data to fit a belief pattern—and they certainly don't base important conclusions on a correlation, as the Columbia is doing by basing operations on a projection of how spill will increase adult SARs. I would argue that in most areas of science where an important question needs to be resolved the correct way to do so should be to set up treatment and control groups using a randomized double blind study.

(b)(5) [redacted]

[redacted]

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 4, 2020 3:51 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

This is actually a great point, that the criticisms of the size limits of Vemco tags shouldn't should be reversed or dropped when there is now a focus on differential behavior by size. I should mention that to our hydro group. UW and PNNL were really put on the defensive for not being able to tag smolts below a certain size with JSATs Ryan Harnish's group at PNNL did a type of synthesis of the existing JSATs survival studies at all the dams, and I might be able to share this with you.

I was able to talk to Jody this afternoon. There has been some communication from the Corps and probably [redacted]

Jody thinks that maybe the end of next week would work out for setting up a call? I will definitely remind her on Friday or Monday and then reach out to you to see what time might work.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, November 4, 2020 2:17 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: [EXTERNAL] RE: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Thanks—interesting reading.

I have only gotten part way through the exchange, but I am struck by—yet again—the FPC group arguing for "non-representative" fish as a big issue. ("*…salmon and steelhead tagged at Lower*

Granite Dam are unrepresentative of the overall population, and thus analyses based on these fish are likely misleading or spurious").

This is very common in how the group deals with analyses (Kintama's or others) that doesn't come up with their expectations… something must be wrong with the groups of fish used because they don't have the mortality pattern we predict.

Oddly, no one in the region seems to say…OK, let's go and see if the differences the FPC claim ***likely*** are be distorting up the results ***really are*** distorting the results. It seems that it is sufficient to claim that "maybe" it is a problem is good enough… no one goes to the effort of seeing whether it really does make a difference. The FPC used that same argument with our study of delayed mortality (Rechisky et al 2013); they argued that our use of smolts in the upper half of the size spectrum was unrepresentative because even though both the Yakima & Snake River smolt groups had equal survival migrating out over the array, the smaller half of the size spectrum ***might*** have given a different result. But they ignored the point that if the upper half of the size class had no difference in survival but by the time the adults came back there was a three-fold difference in adult survival, then if the smaller 50% of the fish had delayed mortality because of the Snake River dams their survival now had to be ***1/6th*** that of the Yakima fish, not 1/3rd!

Oddly, they didn't seem to be in favour of us re-doing the experiment using the smaller tags now available. Nor, unsurprisingly, did they ever cite the Rechisky et al (2014) MEPS paper where by shifting tagging to Bonneville & John Day dam we were able to tag a much greater fraction of the size range of smolts and still found no difference in survival relative to prior dam passage.

An awful lot of money gets wasted in the Columbia because people just argue and rationalize why what they believe to be true rather than actually rolling up their sleeves and actually doing the work to test their beliefs.

dw

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 4, 2020 11:53 AM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>; David Welch <David.Welch@Kintama.com>
Subject: FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Hi,

I'm watching at Wisconsin and Michigan pull ahead this morning?

Anyway, I am forwarding the FPC review and Faulkner et al. rebuttal to their paper at TAFS. Sort of interesting how involved this was getting. SARs and delayed mortality are at the center of it. I have been interested in the phenomenon of CSS study hatchery fish having higher mean SAR than the NOAA LGR tagged study smolts. They assert that this has to be due to a tremendous effect of going through a single bypass at Lower Granite, however the difference between CO and C1 (no detections at Lower Granite, Goose or Monumental vs one or more) is only 10% for Chinook and steelhead, (and no difference for subyearlings), so that just doesn't add up.

I will hopefully reach Jody later this afternoon

Christine

From: Sullivan,Leah S (BPA) - EWP-4 <lssullivan@bpa.gov>
Sent: Tuesday, October 27, 2020 1:46 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

Christine, Scott – Have you heard much about this "dance?" See attachments. I'm going to try to review and digest as time permits tomorrow.

Leah

From: Studebaker, Cynthia A CIV (USA) <Cynthia.A.Studebaker@usace.army.mil>
Sent: Tuesday, October 27, 2020 10:26 AM
To: Sullivan,Leah S (BPA) - EWP-4 <lssullivan@bpa.gov>
Subject: [EXTERNAL] FW: Faulkner Rebuttal [by Oregon] & Response to Rebuttal [by Faulkner]

From: Petersen,Christine H (BPA) - EWP-4

Sent: Tue Nov 10 15:23:25 2020

To: 'David Welch'; Erin Rechisky

Subject: FW: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

Importance: Normal

Attachments: 2020-11-10 Regional Leaders Call for Guiding Principles for Four-State Process_Final.pdf

FYI – this letter was widely distributed. A number of people in our hydrology/power generation group here at BPA heard about your paper in Clearing Up and have been inquiring about it. I will ask for feedback next week when Jason Sweet discusses it in his weekly meeting.

Christine

From: Ball,Crystal A (BPA) - EW-4 <caball@bpa.gov>
Sent: Tuesday, November 10, 2020 1:35 PM
To: ADL_EW_ALL <ADL_EW_ALL@BPASite1.bpa.gov>
Cc: Welch,Dorothy W (BPA) - E-4 <dwwelch@bpa.gov>; Armentrout,Scott G (BPA) - E-4 <sgarmentrout@bpa.gov>; Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>; Kennedy,David K (BPA) - EC-4 <dkkennedy@bpa.gov>
Subject: FW: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

BPA-2021-00513-F 6556

I'm forwarding the attached letter to the four state governors and a press statement from Northwest RiverPartners.

The letter calls for specific guiding principles to effectively guide the four-state process, including a holistic approach, social cost of carbon and scientific rigor.

The state-led effort is still in the early design phase. Intergovernmental Affairs has participated in some informal conversations with the states around this process but there is a lot we need to understand and consider before we know what Bonneville's role in this process might be.

Thanks,

Crystal

Crystal Ball

Executive Manager | Fish & Wildlife Program EW-4

Bonneville Power Administration
bpa.gov | P 503-230-3991 | C (b)(6) [redacted] | E caball@bpa.gov

From: Kurt Miller <kurt@nwriverpartners.org>
Sent: Tuesday, November 10, 2020 8:38 AM

To: Kurt Miller <kurt@nwriverpartners.org>
Subject: [EXTERNAL] NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

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PRESS STATEMENT

November 10, 2020

In Joint Letter to Governors, Dozens of Northwest Leaders Urge Holistic Approach to Four-State Salmon Recovery Process

Contents of the letter below and attached:

=============

Dear Governors Brown, Bullock, Inslee, Little and Governor-Elect Gianforte:

On behalf of over three million of the region's community-owned utility customers and thousands of small businesses, farms, and manufacturers which depend on clean, affordable hydropower, recreation, irrigation, and navigation, we thank you for coming together to actively work on salmon recovery in the Pacific Northwest.

We collectively embrace the critical importance of healthy salmon populations for the Pacific Northwest and its Tribal Nations. The communities and organizations we represent live here and care greatly for the region's natural environment. It is part of our shared Northwest ethic and heritage.

As Northwest states move towards bold clean energy goals, we point out that several of the nation's most respected environmental advocacy groups recently acknowledged hydropower's importance in the nation's fight against climate change.

Regionally, hydropower plays an even bigger role, providing close to half of all our electricity and 90% of our renewable electricity.

As a result, our region has the least carbon-intensive electric service and the most-affordable renewable power in the nation. It is crucial that we retain this leadership position in clean and affordable energy to meet the region's equity, environmental health, and economic recovery objectives.

Our respective organizations have never believed there is any inherent conflict between the region's hydropower, irrigation, recreation, and navigation systems and healthy salmon populations. The data reflect this perspective.

Viewed on a decade-by-decade basis, the numbers of adult salmon returning to the Columbia River Basin have seen significant improvements since the lower Columbia River dams and lower Snake River dams were built, bolstered by successful hatchery programs and significant fish passage improvements.

There is no denying, however, that compared to the number of juvenile smolts produced, the overall percentage of returning adults is on the decline. That trend is not unique to the Columbia River Basin.

A new peer-reviewed study published in *Fish & Fisheries* shows there have been near-uniform declines in Chinook salmon survival across the West Coast of North America over the past 50 years.

This finding includes rivers with dams and those without dams; from pristine rivers in Alaska to more urbanized rivers in the Puget Sound. The study shows these declines have averaged approximately 65% over the 50-year period. Research indicates this general trend applies to steelhead and southern coho populations, as well.

Two other studies released this summer also point to the strong relationship between climate change, warming oceans, and declining salmonid health.

In its recently released Biological Opinion (p 276), NOAA Fisheries showed that climate change appears to have a much larger effect on Chinook salmon survival in the oceans than in rivers. Alarmingly, NOAA indicates Chinook salmon populations may face extinction in 20 to 30 years if the observed relationships between warming ocean temperatures and salmon survival continue.

Pointing to a more hostile ocean environment, due to ocean-warming and competition from pink salmon, scientists at the University of Alaska found the size of Chinook and sockeye salmon in Alaska's rivers has declined significantly since 1960, as salmon are spending fewer years at sea. The researchers purposely chose a region of North America without dams to isolate this oceanic effect.

It is often implied that breaching the lower Snake River dams will solve the problem of salmon recovery because we are told its habitat is pristine. However, decades of development have taken a toll on many areas of the river. Additionally, the *Fish and Fisheries* study demonstrates that even truly pristine rivers have experienced equivalent steep declines in adult salmon survival.

In conclusion, the referenced studies show salmon struggles are not isolated to the Columbia River Basin. Instead, we have an ocean-wide problem, which requires a holistic approach and perspective.

Accordingly, we, the signatories of this letter, call for the following guiding principles to effectively guide the four-state process:

- **Trans-Oceanic Acknowledgement:** Solutions must be grounded in the fact there is strong scientific research demonstrating the declines in key salmon populations are due to warming, acidifying oceans that are shifting the balance between salmon predators and prey. If these trends continue, salmon survival may decline even further. If this reality is not understood as the baseline, then the solutions that come out of the four-state process will inevitably be unsuccessful.

- **Holistic Approach**: Solutions must be holistic in nature, addressing the broad nature of salmon survival declines. As a result, favored solutions should prioritize efforts to address challenges in the shared ocean environment.

- **Social Cost of Carbon:** Solutions must be evaluated for their effect on the social cost of carbon. The recently adopted Record of Decision for Columbia River System Operations includes data-driven estimates for carbon production increases if hydropower generation is diminished.

- **Diversity, Equity, and Inclusion:** Solutions must be examined for their likely socioeconomic and health impacts for under-represented and vulnerable communities that need access to affordable energy, clean air, and agricultural jobs. The recently adopted Record of Decision for Columbia River System Operations includes relevant scenarios for increased customer costs if hydropower generation is diminished.

· **Wildfires & Climate-Driven Disasters:** Solutions must not add to the risk of wildfires and other climate-driven disasters that can affect both salmon and people.

· **Balanced:** Solutions must be balanced in nature when evaluating the hydropower system, recognizing the Congressionally-authorized multiple purposes of the Federal Columbia River Power System. These purposes include flood control, navigation, recreation, irrigation, and electricity production.

· **Scientific Rigor:** Solutions that would diminish significant clean energy resources and/or low carbon transportation infrastructure must undergo non-partisan and rigorous scientific testing before adoption.

Once again, we thank you for your efforts as you plan to bring diverse stakeholder groups together to help the region recover threatened and endangered salmon populations. This goal is incredibly important. We offer our pledge to assist you in the process as regional stakeholders and to provide subject matter expertise.

Respectfully,

November 10, 2020

Dear Governors Brown, Bullock, Inslee, Little and Governor-Elect Gianforte:

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Once again, we thank you for your efforts as you plan to bring diverse stakeholder groups together to help the region recover threatened and endangered salmon populations. This goal is incredibly important. We offer our pledge to assist you in the process as regional stakeholders and to provide subject matter expertise.

Respectfully,

REGIONAL ORGANIZATIONS

Kurt Miller
Northwest RiverPartners

John Francisco
Northwest Requirements Utilities

Kristin Meira
Pacific Northwest Waterways Assn

STATEWIDE ORGANIZATIONS

Will Hart
Idaho Consumer-Owned Utilities Association

Stacey Satterlee
Idaho Grain Producers Association

Joseph Anderson-Genesee
Idaho Wheat Commission

Gary Wiens
Montana Electric Cooperatives' Association

Roger Kline
Oregon People's Utility District Assn

Ted Case
Oregon Rural Electric Cooperative Assn

Clint Carlson
Oregon Wheat Growers League

Ryan Poe
Washington Assn of Wheat Growers

Gary Bailey
Washington Grain Commission

Kent Lopez
Washington Rural Electric Cooperative Assn

Joe Lukas
Western Montana G&T
WESTERN MONTANA ELECTRIC
GENERATING & TRANSMISSION COOPERATIVE, INC.

MEMBER/PARTNER ORGANIZATIONS

Mike Bradshaw
Benton Rural Electric Association

Randy Grove
Central Lincoln People's Utility District

Scott Peters
Columbia Rural Electric Association

Roman Gillen
Consumers Power Inc.

Kevin Nordt
Grant PUD

Kristin Masteller
Mason PUD 1

Alex McGregor
The McGregor Company
McGregor Land & Livestock

Roger Kline
Northern Wasco People's Utility District

David Doernsfeld
Port of Lewiston

Chad Black
Raft River Electric Cooperative

Tony Schacher
Salem Electric Cooperative

From: Erin Rechisky

Sent: Tue Nov 10 17:21:28 2020

To: Petersen,Christine H (BPA) - EWP-4; David Welch

Subject: [EXTERNAL] RE: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

Importance: Normal

Hi Christine,

Thanks. Yes, I/we are on Kurt Miler's distribution list, so I received it earlier today.

Erin

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 10, 2020 3:23 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: FW: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

FYI – this letter was widely distributed. A number of people in our hydrology/power generation group here at BPA heard about your paper in Clearing Up and have been inquiring about it. I will ask for feedback next week when Jason Sweet discusses it in his weekly meeting.

Christine

From: Ball,Crystal A (BPA) - EW-4 <caball@bpa.gov>
Sent: Tuesday, November 10, 2020 1:35 PM
To: ADL_EW_ALL <ADL_EW_ALL@BPASite1.bpa.gov>
Cc: Welch,Dorothy W (BPA) - E-4 <dwwelch@bpa.gov>; Armentrout,Scott G (BPA) - E-4 <sgarmentrout@bpa.gov>; Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>; Kennedy,David K (BPA) - EC-4 <dkkennedy@bpa.gov>
Subject: FW: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

I'm forwarding the attached letter to the four state governors and a press statement from Northwest RiverPartners.

The letter calls for specific guiding principles to effectively guide the four-state process, including a holistic approach, social cost of carbon and scientific rigor.

The state-led effort is still in the early design phase. Intergovernmental Affairs has participated in some informal conversations with the states around this process but there is a lot we need to understand and consider before we know what Bonneville's role in this process might be.

Thanks,

Crystal

Crystal Ball

Executive Manager | Fish & Wildlife Program EW-4

Bonneville Power Administration
bpa.gov | P 503-230-3991 | C [redacted] | E caball@bpa.gov

From: Kurt Miller <kurt@nwriverpartners.org>
Sent: Tuesday, November 10, 2020 8:38 AM
To: Kurt Miller <kurt@nwriverpartners.org>
Subject: [EXTERNAL] NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

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PRESS STATEMENT

November 10, 2020

In Joint Letter to Governors, Dozens of Northwest Leaders Urge Holistic Approach to Four-State Salmon Recovery Process

Contents of the letter below and attached:

=============

Dear Governors Brown, Bullock, Inslee, Little and Governor-Elect Gianforte:

On behalf of over three million of the region's community-owned utility customers and thousands of small businesses, farms, and manufacturers which depend on clean, affordable hydropower, recreation, irrigation, and navigation, we thank you for coming together to actively work on salmon recovery in the Pacific Northwest.

We collectively embrace the critical importance of healthy salmon populations for the Pacific Northwest and its Tribal Nations. The communities and organizations we represent live here and care greatly for the region's natural environment. It is part of our shared Northwest ethic and heritage.

As Northwest states move towards bold clean energy goals, we point out that several of the nation's most respected environmental advocacy groups recently acknowledged hydropower's importance in the nation's fight against climate change.

Regionally, hydropower plays an even bigger role, providing close to half of all our electricity and 90% of our renewable electricity.

As a result, our region has the least carbon-intensive electric service and the most-affordable renewable power in the nation. It is crucial that we retain this leadership position in clean and affordable energy to meet the region's equity, environmental health, and economic recovery objectives.

Our respective organizations have never believed there is any inherent conflict between the region's hydropower, irrigation, recreation, and navigation systems and healthy salmon populations. The data reflect this perspective.

Viewed on a decade-by-decade basis, the numbers of adult salmon returning to the Columbia River Basin have seen significant improvements since the lower Columbia River dams and lower Snake River dams were built, bolstered by successful hatchery programs and significant fish passage improvements.

There is no denying, however, that compared to the number of juvenile smolts produced, the overall percentage of returning adults is on the decline. That trend is not unique to the Columbia River Basin.

A new peer-reviewed study published in *Fish & Fisheries* shows there have been near-uniform declines in Chinook salmon survival across the West Coast of North America over the past 50 years.

This finding includes rivers with dams and those without dams; from pristine rivers in Alaska to more urbanized rivers in the Puget Sound. The study shows these declines have averaged approximately 65% over the 50-year period. Research indicates this general trend applies to steelhead and southern coho populations, as well.

Two other studies released this summer also point to the strong relationship between climate change, warming oceans, and declining salmonid health.

In its recently released Biological Opinion (p 276), NOAA Fisheries showed that climate change appears to have a much larger effect on Chinook salmon survival in the oceans than in rivers. Alarmingly, NOAA indicates Chinook salmon populations may face extinction in 20 to 30 years if the observed relationships between warming ocean temperatures and salmon survival continue.

Pointing to a more hostile ocean environment, due to ocean-warming and competition from pink salmon, scientists at the University of Alaska found the size of Chinook and sockeye salmon in Alaska's rivers has declined significantly since 1960, as salmon are spending fewer years at sea. The researchers purposely chose a region of North America without dams to isolate this oceanic effect.

It is often implied that breaching the lower Snake River dams will solve the problem of salmon recovery because we are told its habitat is pristine. However, decades of development have taken a toll on many areas of the river. Additionally, the *Fish and Fisheries* study demonstrates that even truly pristine rivers have experienced equivalent steep declines in adult salmon survival.

In conclusion, the referenced studies show salmon struggles are not isolated to the Columbia River Basin. Instead, we have an ocean-wide problem, which requires a holistic approach and perspective.

Accordingly, we, the signatories of this letter, call for the following guiding principles to effectively guide the four-state process:

- **Trans-Oceanic Acknowledgement:** Solutions must be grounded in the fact there is strong scientific research demonstrating the declines in key salmon populations are due to warming, acidifying oceans that are shifting the balance between salmon predators and prey. If these trends continue, salmon survival may decline even further. If this reality is not understood as the baseline, then the solutions that come out of the four-state process will inevitably be unsuccessful.
- **Holistic Approach**: Solutions must be holistic in nature, addressing the broad nature of salmon survival declines. As a result, favored solutions should prioritize efforts to address challenges in the shared ocean environment.
- **Social Cost of Carbon:** Solutions must be evaluated for their effect on the social cost of carbon. The recently adopted Record of Decision for Columbia River System Operations includes data-driven estimates for carbon production increases if hydropower generation is diminished.
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- **Balanced:** Solutions must be balanced in nature when evaluating the hydropower system, recognizing the Congressionally-authorized multiple purposes of the Federal Columbia River Power System. These purposes include flood control, navigation, recreation, irrigation, and electricity production.
- **Scientific Rigor:** Solutions that would diminish significant clean energy resources and/or low carbon transportation infrastructure must undergo non-partisan and rigorous scientific testing before adoption.

Once again, we thank you for your efforts as you plan to bring diverse stakeholder groups together to help the region recover threatened and endangered salmon populations. This goal is incredibly important. We offer our pledge to assist you in the process as regional stakeholders and to provide subject matter expertise.

Respectfully,

From: David Welch

Sent: Tue Nov 10 18:44:13 2020

To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Subject: [EXTERNAL] RE: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

Importance: Normal

Yes, thanks Christine—

I will definitely be interested to hear what the comments are from Jason—I hadn't thought that K.C. Mehaffey would actually lead off her piece with my rather critical responses to her questions (I thought they should wrap the article up with them), but I think the issues do need to be addressed. I am outlining them here in some greater detail for your internal discussions:

(b)(5)

[redacted]

(b)(5)

[redacted]

So my comments quoted in KC Mehaffey's piece are blunt, but the issues are a good deal more serious than we outlined in the journal paper. Feel free to pas this on to Jason and others as you see fit.

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

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Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>

Sent: November 10, 2020 3:23 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: FW: NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

FYI – this letter was widely distributed. A number of people in our hydrology/power generation group here at BPA heard about your paper in Clearing Up and have been inquiring about it. I will ask for feedback next week when Jason Sweet discusses it in his weekly meeting.

Christine

From: Ball,Crystal A (BPA) - EW-4 <caball@bpa.gov>
Sent: Tuesday, November 10, 2020 1:35 PM
To: ADL_EW_ALL <ADL_EW_ALL@BPASite1.bpa.gov>
Cc: Welch,Dorothy W (BPA) - E-4 <dwwelch@bpa.gov>; Armentrout,Scott G (BPA) - E-4 <sgarmentrout@bpa.gov>; Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>; Kennedy,David K (BPA) - EC-4 <dkkennedy@bpa.gov>
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Crystal

Crystal Ball

Executive Manager | Fish & Wildlife Program EW-4

Bonneville Power Administration
bpa.gov | P 503-230-3991 | C (b)(6) [redacted] E caball@bpa.gov

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Sent: Tuesday, November 10, 2020 8:38 AM
To: Kurt Miller <kurt@nwriverpartners.org>
Subject: [EXTERNAL] NWRP Press Statement: Dozens of Regional Leaders Call for Holistic Approach to Four-State Process

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Once again, we thank you for your efforts as you plan to bring diverse stakeholder groups together to help the region recover threatened and endangered salmon populations. This goal is incredibly important. We offer our pledge to assist you in the process as regional stakeholders and to provide subject matter expertise.

Respectfully,

From: David Welch

Sent: Tue Nov 17 15:51:29 2020

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky

Subject: [EXTERNAL] Any FPC response??

Importance: Normal

Hi Christine—

By now I was expecting to be reading a blistering memo reviewing our work that the FPC had put on their website, but all seems strangely quiet. Have you heard anything about whether a response is being planned? (I am assuming there will be one, but am not going to put time into trying to pen a response because (a) I need to see what counterclaims they may make and (b) I'm not sure where/how I can best disseminate my response if they do).

David

P.S. So far the only negative response I am aware of is this scathing (and incorrect) characterization of our paper in response to a press release put out by NW River Partners in the San Juan Islander newspaper. It doesn't seem that the two authors of the critique have actually read our paper. Given that this really is a minor dust-up between NWRP and the folks advocating to save the orcas by taking out the dams and is in a very limited circulation newspaper, I am saving my response for more substantive (& higher profile) criticisms.

https://sanjuanislander.com/news-articles/environment-science-whales/environment/31892/guest-column-northwest-riverpartners-peddles-its-snake-river-dam-disinformation-in-the-san-juan-islands

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

From: David Welch

Sent: Tue Nov 17 16:14:29 2020

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] New micro tag

Importance: Normal

Hi Christine—

I thought you might find this announcement of interest. Vemco (now a subsidiary of InnovaSea) is formally announcing the release of a new small tag. It is about the size of the smallest JSATs tag (and uses the PNNL-developed battery under license to achieve roughly the same form factor as the JSATs tag). However, I am hopeful that the high rate of false positive detections that the JSATs system records will be substantially reduced using the Vemco coding scheme, which is less aggressive. We anticipate testing the V3 later this winter or early next spring in some formal field trials in the ocean here in BC, COVID willing.

Regards, David

https://www.innovasea.com/news/innovasea-introduces-tiny-v3-acoustic-tags/

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

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From: David Welch

Sent: Thu Nov 19 17:10:44 2020

To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky

Cc: Aswea Porter

Subject: [EXTERNAL] RE: Dams and Salmon Study Pt 1

Importance: Normal

Haven't heard anything from Jody as yet, Christine. I would be keen to have that initial discussion because I think the timing is good to do the studies I outlined previously.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: November 19, 2020 5:08 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Aswea Porter <Aswea.Porter@Kintama.com>
Subject: RE: Dams and Salmon Study Pt 1

Hey – that is a good placement on the radio. I thought your soundbite was very clear.

Has Jody Lando been able to contact you? Coworkers have said that they've heard from people at outside agencies about your study. I think Jody wanted to try to set up something after the American thanksgiving week to set up a call – she will be talking to upper management here.

Thanks

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, November 19, 2020 12:31 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: [EXTERNAL] RE: Dams and Salmon Study Pt 1

Thanks, Erin (c.c. Christine)—

Just realized that there was a second part broadcast today to the link you had sent me on the first part… more tomorrow, apparently! I'm pleased—I think it gets the message across in a pretty clear way.

https://www.aginfo.net/report/47807/Washington-State-Farm-Bureau-Report/Dams-and-Salmon-Study-Pt-1 https://www.aginfo.net/report/47808/Washington-State-Farm-Bureau-Report/Dams-and-Salmon-Study-Pt-2

David

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: November 19, 2020 12:05 PM
To: David Welch <David.Welch@Kintama.com>; Aswea Porter <Aswea.Porter@Kintama.com>
Subject: Dams and Salmon Study Pt 1

https://www.aginfo.net/report/47807/Washington-State-Farm-Bureau-Report/Dams-and-Salmon-Study-Pt-1

From: David Welch

Sent: Thu Nov 26 16:12:20 2020

To: Ben Zelinsky

Subject: [EXTERNAL] HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Importance: High

Attachments: It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Ben-

After mulling over how best to respond to a commentary on our recent paper by Steve Hawley, I ultimately concluded that it is time to call out the region on its whole approach to salmon conservation. Earlier today I submitted the attached response to Bill Rudolph at the Columbia Basin Bulletin and I expect that it will be published there tomorrow, although I have not heard back from him yet.

My response is self-explanatory. My hope here is to lay out the evidence that most of the regions' biologists have had blinders on for decades and that this is why BPA spends so much and gets so little in return in terms of actual progress.

I hope you & BPA can use this to try to push for a more thoughtful regional dialogue rather than just the perpetual call for ever more extreme restrictions on power production.

You can start doing so by requiring that regional groups show what is factually wrong with my response.

Regards, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

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The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: David Welch <David.Welch@Kintama.com>
Sent: November 26, 2020 10:07 AM
To: Bill Rudolph (billr@newsdata.com) <billr@newsdata.com>
Cc: David Welch <David.Welch@Kintama.com>
Subject: It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Hi Bill-

As promised—no head butting or eye gouging. However, I did call out essentially the whole current approach as bogus, so it may be classified as rude and unkind. □

With luck this may prompt some more serious soul searching about whether the region really is doing as well as people assume.

Please confirm receipt and of course let me know if you have any concerns with publishing this. Otherwise I will assume that it will be published as written…. I would like to give a few people a heads up so that they don't feel that they have been blind-sided

Best, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

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RESPONSE: IT SHOULDN'T TAKE A DEGREE IN MARINE BIOLOGY TO SEE THE OBVIOUS

By David Welch *(703 words)*

Mr Hawley misconstrues my shock—I am shocked because biologists monitoring survival thought it unimportant to ask why salmon survival reported elsewhere was no better than Snake River populations. Decades ago someone should have asked what was wrong with the accumulating data (and fixed it) or asked why current Columbia Basin policy laser-focussed on the dams can really restore salmon populations if survival is the same elsewhere. The answer reported in our paper is that the data really are consistent with a coastwide decline but that the Columbia also has a big problem with what was thought to be the gold standard in survival monitoring—PIT tag data. This too is shocking.

Mr Hawley notes that "*...the best available science ...draw[s] the same conclusion*". For decades, "the best available" science ignored the similarity in survival reported coastwide and the obvious implications for regional rebuilding targets. Similarly, its failure to recognize that PIT tag survival estimates are horribly compromised by large, unaccounted for changes in salmon harvest should be equally concerning. That elementary error may hopelessly compromise the past quarter-century of survival analyses used in multiple Biological Opinions. Although we did not dwell on this in our paper, biologists also did not recognize that the renegotiated US-Canada Pacific Salmon Treaty created a negative feedback system that mandated harvest rules obscuring any effect of the dams on adult survival, which also went unrecognized. Thus, as used for the past quarter-century, the PIT tag system only estimated escapement to the river, not survival. (An animation is here). Each of these failures is evidence of massive groupthink. What else is being missed?

Out of the ashes of scientific failure emerges new science and major advance. The belated recognition of hand washing, continental drift, the Bretz Floods, and especially that stomach ulcers are treatable with antibiotics are all examples where large groups of scientists vehemently opposed today's orthodoxies and delayed real progress for decades. I believe that current management of Columbia River salmon populations will be added to this list.

No one is questioning that Columbia River dams at one time reduced smolt survival. However, that problem has been fixed, although few want to accept this. The remaining problem does not require a university degree to understand—middle school math suffices. Both the Fish Passage Center (FPC) and NOAA report average survival of about 52% for Snake River smolts migrating through the 8-dam FCRPS, so over half survive. By the time adults return the SAR averages 1%, so only 1/52nd of smolts passing Bonneville return as adults. The Columbia does not have a smolt survival problem—rather, it has insufficient adults returning from the ocean to satisfy demand.

The only way dams can have a big effect on the SAR is if delayed mortality plays a major role in determining ocean survival. Mr Hawley is silent on why we could demonstrate—using the FPC's own data—that most comparisons that should show the claimed reduction in survival with increased dam passage do not.

Many biologists still assume that poor ocean survival is substantially influenced by delayed mortality, essentially driving the region to set policy based on an untested correlation. However, the same mind-set that ignored the direct role of the ocean set the region up to be blind-sided by failing to monitor salmon harvest...something well within our ability to manage.

If hundreds of biologists cannot recognize these various issues, then surely the possibility exists that the current approach to salmon conservation is fundamentally flawed in other ways as yet unrecognized. Severe climate change is already upon us, and will get far worse. "*A fix for a warming ocean*" is not in the cards. What happens when marine survival declines from 1 in 52 to 1 in 520? Are current policies stress-tested for such possibilities? What legal obligations will be triggered in consequence? Ignoring the ocean's role may have severe unintended consequences—the recent initiative to raise dissolved gas caps to levels known to be harmful to fish in the hope it improves adult survival is a good example. Even with the best of intentions, simplistic solutions to complex situations may potentially do more harm than good—to the detriment of both salmon conservation and greenhouse gas-free power production.

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Thu Nov 26 16:12:33 2020

To: David Welch

Subject: Automatic reply: HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Importance: Normal

I will be out of the office until 11/27/20. If you need assistance while I am out, please contact Marcella Renner at (503) 230-5136.

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Mon Nov 30 10:11:43 2020

To: David Welch

Subject: RE: HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Importance: Normal

Hello David,

Thanks for keeping me in the loop on this. Want to try again to check in this week? Sorry about the last time – I [redacted] I tried to text you but never heard back so not sure I used the right number. Long way of saying my apologies and let's try again.

Tomorrow 10-12 and 2-4 are pretty open for me if that happens to work for you.

All the best.

Ben

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, November 26, 2020 4:12 PM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx
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(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: David Welch <David.Welch@Kintama.com>
Sent: November 26, 2020 10:07 AM
To: Bill Rudolph (billr@newsdata.com) <billr@newsdata.com>
Cc: David Welch <David.Welch@Kintama.com>
Subject: It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Hi Bill-

As promised—no head butting or eye gouging. However, I did call out essentially the whole current approach as bogus, so it may be classified as rude and unkind.

With luck this may prompt some more serious soul searching about whether the region really is doing as well as people assume.

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Best, David

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From: David Welch

Sent: Mon Nov 30 10:44:24 2020

To: Zelinsky,Benjamin D (BPA) - E-4

Subject: [EXTERNAL] RE: HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Importance: Normal

Hi Ben—

Tomorrow is fine from my side from 10-12, so you pick the time and platform. Zoom, Teams, etcetera are all fine.

I never got a text, so perhaps check what number you have for my cell? I will attach the two numbers I use below.

David

David Welch

(m) +[redacted] (b)(6)

(house) +[redacted] (b)(6)

From: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
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All the best.

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Sent: Thursday, November 26, 2020 4:12 PM
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Importance: High

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I hope you & BPA can use this to try to push for a more thoughtful regional dialogue rather than just the perpetual call for ever more extreme restrictions on power production.

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Sent: Mon Nov 30 12:16:13 2020

To: David Welch

Subject: RE: HEADSUP--It Shouldn't Take a Degree in Marine Biology to See the Obvious-FINAL (25 Nov 2020).docx

Importance: Normal

Let's do tomorrow at 10 then. Messenger worked well for us last time if that still works for you.

Looking forward to it.

Ben

From: David Welch <David.Welch@Kintama.com>
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To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
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The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: David Welch

Sent: Tue Dec 01 09:31:23 2020

To: Ben Zelinsky

Subject: [EXTERNAL] Nguyen et al (Overcoming barriers to transfer of scientific knowledge-integrating biotelemetry into fisheries management-2020).pdf

Importance: Normal

Attachments: Nguyen et al (Overcoming barriers to transfer of scientific knowledge-integrating biotelemetry into fisheries management-2020).pdf

Morning, Ben-

If you have a couple of minutes to spare before we speak at 10 am, I suggest you read the first two pages of this document—It just came out.

Although it is focused on the Great Lakes, the message of what is needed to get new scientific understanding accepted also applies to the Columbia (other than the science politics being more extreme out here).

Cheers, David

Socio-Ecological Practice Research
https://doi.org/10.1007/s42532-020-00069-w

RESEARCH ARTICLE

Overcoming barriers to transfer of scientific knowledge: integrating biotelemetry into fisheries management in the Laurentian Great Lakes

Vivian M. Nguyen[1,2] · Caleigh Delle Palme[2] · Brian Pentz[3] · Christopher S. Vandergoot[4] · Charles C. Krueger[4] · Nathan Young[5] · Steven J. Cooke[1,2]

Received: 28 June 2020 / Accepted: 9 October 2020

Abstract
The science–practice divide is a stubborn problem in environmental management. Existing research tells us that a range of factors affects the uptake of new science into practice and policy, including socio-organizational, individual, and evaluative variables. Here, we seek to understand the variables influencing the uptake of biotelemetry-derived information in the Laurentian Great Lakes fishery management system. To do so, we used semi-structured telephone interviews ($n=50$) to capture the views of managers, researchers, and assessment biologists affiliated with the Great Lakes Fishery Commission (GLFC). Our results suggest that biotelemetry offers epistemological value (generating new and important information), but faces barriers tied to perceptions concerning practicalities of the technology, such as its cost. The practical limitations facing the use of biotelemetry evidence were more specific and potentially more easily resolved than the entrenched individual and socio-organizational challenges of using types of knowledge other than biotelemetry. The persistence of the science–practice divide was evident in our findings. Formal entities and boundary organizations such as the GLFC and inter-sectoral networks that promote interactions, meetings, and connections among researchers and practitioners can help overcome this gap. The Great Lakes Acoustic Telemetry Observation System (GLATOS) network can play a boundary role in facilitating biotelemetry science transfer by focusing on overcoming its evaluative limitations (e.g., costs, technological limitations). Further, the GLFC and GLATOS are well positioned to play a greater role in science transfer by facilitating interactions among scientists and practitioners to help reconcile differences in perceptions.

Keywords Knowledge transfer · Knowledge exchange · Fishery management · Technology diffusion · Great Lakes · Science–practice divide

1 Introduction

Timely, up-to-date, and relevant scientific information is widely seen as an essential input for effective environmental policy and decision-making processes (Pullin and Knight 2003; Sutherland et al. 2004; Young et al. 2013; Nguyen

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s42532-020-00069-w) contains supplementary material, which is available to authorized users.

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5 School of Sociological and Anthropological Studies, University of Ottawa, 120 University Private, Ottawa, ON K1N 6N5, Canada

Published online: 23 November 2020

et al. 2016). Ideally, decisions based on the best-available scientific evidence can promote sustainable outcomes for resources, ecosystems, and the individuals, communities, and industries reliant on resource access (i.e., an evidence-based approach; Sutherland et al. 2004; Rousseau 2006; Pfeffer and Sutton 2006). However, research suggests that management decisions are often based on non-scientific types of evidence, such as personal observation and experiences, anecdotal evidence, organizational traditions, or collectively held 'conventional wisdom' (Pullin and Knight 2003; Pfeffer and Sutton 2006; Young et al. 2016a; Nguyen et al. 2017a; Cooke et al. 2017). Consequently, it is not sufficient for researchers to simply publish in academic peer-reviewed papers and expect evidence to be 'transferred' and taken up by decision-makers. A growing body of literature suggests that to enhance the role of scientific evidence in environmental decision-making, greater effort needs to be invested in understanding the human dimensions of knowledge use, including the views, motives, and preferences of knowledge users (Nguyen et al. 2017a; Young et al. 2018).

1.1 Theoretical framework: challenges in narrowing science–practice gap

The challenges involved in integrating new knowledge into policy and decision-making contribute to the disconnect between the state of scientific evidence and its use in practice. This disconnect is called the 'science–practice gap' and exists among other disconnects in environmental policy and decision-making, including research–implementation and knowledge–action gaps (Nguyen et al. 2017a; Bertuol-Garcia et al. 2018). The obstacles to bridging the science–practice gap can be broadly categorized into three major categories: social–organizational challenges, individual-level challenges, and evaluative challenges (see Young et al. 2018, p. 52).This framework presents the theoretical basis of our study and analyses.

Social-organizational challenges relate to how structures and practices within organizations may influence a user's receptiveness to new information and data. These include bureaucratic practices and norms, incentive structures, and capacities of key personnel to understand and apply information, political considerations, and communicative limitations. For example, Rose et al. (2018) conducted a global survey capturing perceptions of different stakeholders about the relative importance of barriers to considering evidence in conservation decisions. Social–organizational barriers emerged as being highly significant, specifically in organizational cultures that downplayed conservation as a political priority, resulting in mismatches in timescales, lack of funding, and attention to other priorities (Rose et al. 2018, p. 4).

Individual-level challenges refer to capacities and preferences held by key individuals in the context of dealing with evidence or data. Examples of individual-level challenges include a person's skills, educational background, level of familiarity with new knowledge, prior experiences, and/or preferences that may encourage or discourage engagement with new forms of evidence. Interviews conducted with government employees and stakeholders responsible for co-management of the Fraser River salmon fishery in Western Canada highlighted individual-level challenges that included motivations of individuals such as: 'lack of political will,' being unable to 'teach old dogs new tricks' or decisions that are found to be constrained by previous decisions and incentive structures (Nguyen et al. 2018b, p. 468).

Lastly, *evaluative challenges* refer to perceived strengths and weaknesses of the evidence or data. Knowledge claims are evaluated by potential users based on a range of criteria. These include its *epistemological value* (the degree to which the information or knowledge is deemed accurate and credible); its *practical value* (the degree to which it is applicable to known problems, with minimal costs, trade-offs, or limitations); and lastly, its *perceived fit or departure from current practices* (the degree to which adoption of the knowledge or information would disrupt existing views and/or processes) (Young et al. 2018, p. 52). Nguyen et al. (2018b, p. 469) and Rose et al. 2018 (p. 4) also found evidence that evaluative challenges are significant for the uptake of scientific evidence, particularly if uncertainty exists about the reliability or credibility of new knowledge, the lack of policy relevance and applicability of scientific findings to knowledge users, or complexity and uncertainties related to the knowledge or problem.

1.2 The science–practice gap: biotelemetry research and fisheries management

Given that fisheries are closely tied to culture, livelihoods, economics, and politics, the use of new evidence or knowledge in fishery management can present unique challenges. Fish are highly accessible relative to other natural resources and make important contributions to food security and livelihoods (Holmlund and Hammer 1999; Lynch et al. 2016). A variety of socioeconomic and political challenges surround the management of fisheries resources, including the needs and rights of Indigenous fishers, as well as the interests of recreational and commercial fishers (Lackey 1998; Hardin 2009; Nguyen et al. 2016). Additionally, a major scientific challenge complicating management is the vastness and complexity of aquatic environments, which has represented a major barrier to acquiring information about fish population dynamics required for effective management (Hussey et al. 2015).

Recent advances in biotelemetry (i.e., remote monitoring devices; reviewed in Hussey et al. 2015) have opened new avenues to observe and understand aquatic organisms.

Electronic tags are smaller and can be attached to free-ranging animals, passively providing information about their movements in space and time to listening receivers. With this technique, animals must be caught, handled, and physically tagged, but unlike traditional tagging methods, the animals do not have to be recaptured to provide information on their movement and locations. As such, many research and management questions can only be answered through this approach (Hussey et al. 2015; Cooke et al. 2016; Lennox et al. 2017). The growing repertoire of global telemetry-derived data recorded in the oceans and inland waters has led to novel information about the ecology of many species and their response to changing environments. These telemetry tools and data have made important contributions to fishery management, including improved understanding of habitats, invasive species control monitoring, and stock assessment, and have informed the design of marine protected areas (Crossin et al. 2017; Brooks et al. 2019). Still, examples of improved policy and management measures are rare considering the relatively large investment of resources into telemetry research (McGowan et al. 2016; Young et al. 2018). Biotelemetry array networks (networks of listening receivers) have been established worldwide, including in Australia, the USA, Germany, South Africa, and Norway. They have also been deployed in binational contexts, including in the Laurentian Great Lakes. Given the resources allocated to biotelemetry and the wide geographic range where the technology has been installed, it is important to understand how telemetry research informs fishery management decisions, and what barriers the technology faces. Understanding what barriers exist and how they might be resolved is a crucial part of understanding how return-on-investments can be maximized.

Hesitation in applying telemetry-derived data to fishery management often relates to technological and procedural limitations, the study design and analysis, and capacity and interpretation challenges. For example, uncertainties-associated limitations of the technology have included limited size and number of animals' tagged, false detections, limited detection ranges, and potential effects of tags on animal behavior (reviewed in Brownscombe et al. 2019b). Other reported barriers to incorporating biotelemetry into fishery management include: skepticism and distrust of biotelemetry, competing priorities, inflexible institutional structures, challenges in interpreting complex data; lack of awareness and access to new findings; or lack of management relevance in study design (Young et al. 2013, 2018; Mcgowan et al. 2016; Krueger et al. 2018; Nguyen et al. 2018a, b; Brownscombe et al. 2019a, b). Of course, many of these challenges are not unique to biotelemetry and have been commonly documented in various other contexts (Rose et al. 2018, 2019). However, rapid technological improvements have resulted in an accelerated use of biotelemetry, allowing the generation of novel information that traditional approaches cannot offer (Lennox et al. 2017).

Biotelemetry research has found success in influencing fishery management most often when researchers and practitioners worked together (Brooks et al. 2019, Browscombe et al. 2019a; Nguyen et al. 2019). Brooks et al. (2019) described three case studies in North America where biotelemetry data were successfully used to inform fisheries and habitat management, highlighting that in each of the cases, biotelemetry was coupled with other evidence and research techniques such as genetics, physiology, and traditional knowledge, demonstrating that multiple lines of evidence presented a stronger case for policy reform (Cooke et al. 2013). Further, researchers in these cases were actively engaged with managers and stakeholders, which was identified as an enabler to successful integration of findings in decision-making (Nguyen et al. 2018a; Brooks et al. 2019).

To date, few studies have sought to examine and resolve the relationship between biotelemetry's unrealized potential and the growing consensus that knowledge uptake is a function of the knowledge users' perspectives and experiences. Previous work in this area investigated perspectives of knowledge users in the Pacific Salmon fisheries in the Fraser River, British Columbia (Young et al. 2016a, b, 2018, Nguyen et al. 2018b), but case studies remain rare.

1.3 Case study: Laurentian Great Lakes fisheries management and biotelemetry

The management of fisheries in the Laurentian Great Lakes (herein referred to as the Great Lakes) is coordinated across jurisdictions by the Great Lakes Fishery Commission[1] (GLFC), established by Canada and the USA through the Convention of Great Lakes Fisheries (1954). The GLFC's core duties include developing, funding, and coordinating binational research programs, providing recommendations to governments, implementing a control program for the invasive sea lamprey, and disseminating information critical to sustain the fishery (Gaden et al. 2012, p. 312). The GLFC also serves as a forum for communication among fishery managers, assessment biologists, and researchers and also fosters the sharing of stakeholder views and feedback (Gaden et al. 2008, p. 56). The GLFC's geographic scope includes the eight US states and the Canadian province of Ontario (Fig. 1).

The GLFC employs a Joint Strategic Plan[2] as a framework to facilitate the management of transboundary fish stocks by federal, provincial, state, and tribal jurisdictions (Gaden and Krueger 2018). The execution of the Joint Strategic Plan

[1] www.glfc.org.

[2] http://www.glfc.org/pubs/misc/jsp97.pdf.

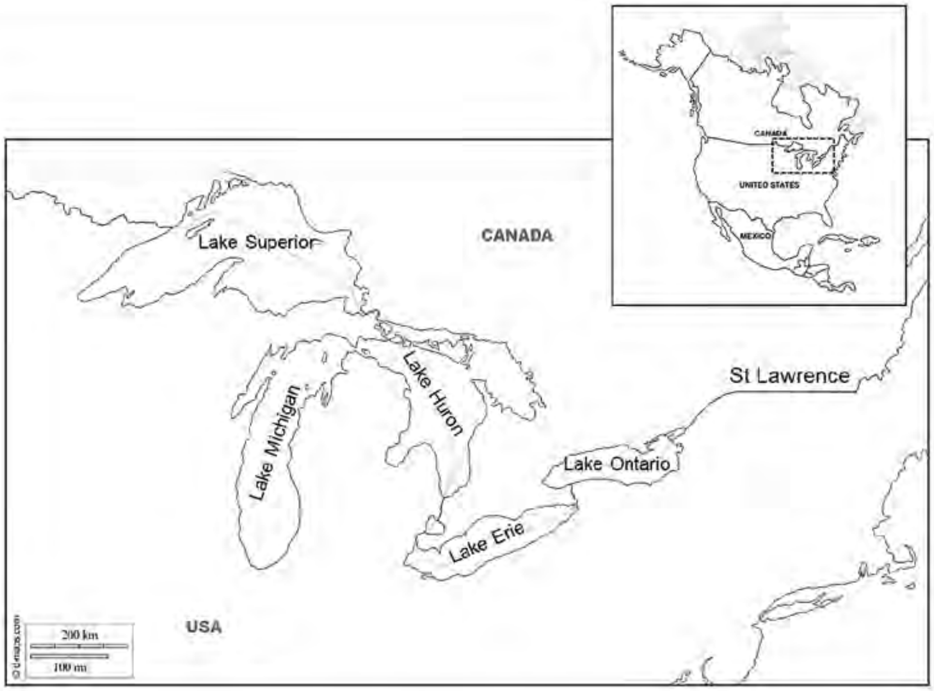

Fig. 1 Map of the Laurentian Great Lakes relative to North America (adapted from d-maps.com)

has produced a non-binding inter-jurisdictional governance structure that is highly cooperative, where fishery management decisions are made by consensus among jurisdictions who strive to produce decisions informed by science (Gaden et al. 2008, p. 56). This structure includes Lake Committees and Lake Technical Committees,[3] which consist of representatives from the provincial, state, and tribal agencies with fishery management authority (Fig. 2). The Lake Committees are comprised of high-ranking managers with decision-making authority from each lake's fishery agency who meet to address shared needs (Gaden et al. 2012, p. 57). Fishery researchers and assessment biologists contribute to the Lake Technical Committees, which also include individuals with relevant expertise from universities and federal agencies. The technical committees advise the Lake Committee managers of information important for resource-related decision-making. Given that the responsibilities of fishery managers, researchers, and assessment biologists on these committees cover the provision of scientific advice, policy advice, and include decision-making authority (described in Fig. 2), these fisheries professionals constitute an important population to investigate and understand the science–practice gap.

The GLFC has actively promoted and supported the use of acoustic telemetry within the Great Lakes through sponsorship of the Great Lakes Acoustic Telemetry Observation System[4] (GLATOS; Krueger et al. 2018). GLATOS was founded in 2010 and funded by the GLFC via funds provided by the US Great Lakes Restoration Initiative as administered by the US Environmental Protection Agency. GLATOS's purpose is 'to advance and improve conservation and management of Great Lakes fishes by providing information on fish behavior, habitat use, and population dynamics' (Krueger et al. 2018, p. 1760). To support this goal, GLATOS supports a network of more than 200 investigators using telemetry in the basin representing over 45 agencies and universities via coordination meetings; workshops; the Web site and a database; consultation services; data archiving and management; lending of acoustic telemetry equipment; and promotes science transfer (Krueger et al. 2018, p. 1760). Results of ongoing and completed telemetry studies associated with GLATOS have been presented annually within the GLFC's committee structure of Lake Committees and Lake Technical Committees as part of GLATOS's science transfer efforts.

The Great Lakes Basin is a crucially important case to examine, as it is one of the only basin-wide systems with an established biotelemetry network, and this network has been associated with more than ten years of biotelemetry research. We seek to explore and capture perspectives of knowledge users on the integration of biotelemetry into fishery management in the Great Lakes. To do so, we pursue two central objectives: First, we seek to understand how knowledge users view the role, potential, strengths, and limitations of biotelemetry as applied in the Great Lakes. Specifically, we sought out the viewpoints of three types of vocations—resource managers, researchers, and assessment

[3] http://www.glfc.org/joint-strategic-plan-committees.php.

[4] https://glatos.glos.us/.

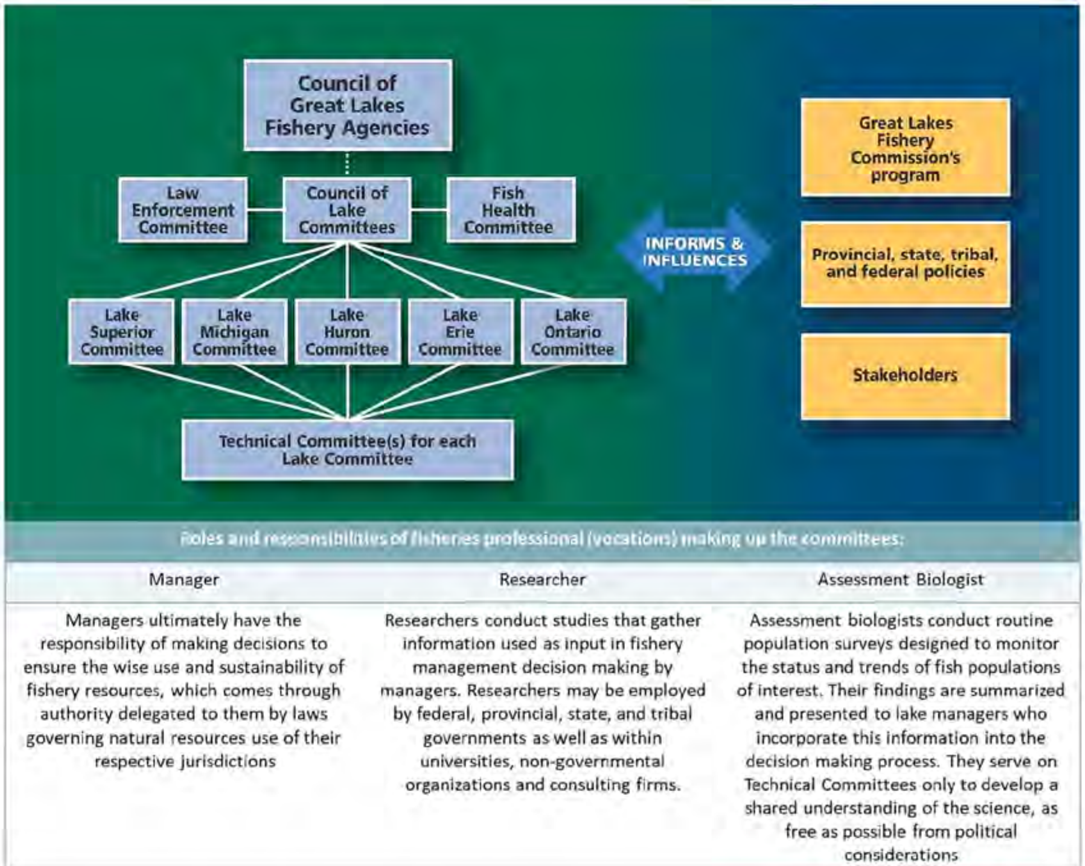

Fig. 2 Organizational structure of committees that inform and influence the GLFC's programs; provincial, state, tribal, and federal policies as well as stakeholders (adapted from Gaden et al. 2008 and http://www.glfc.org/joint-strategic-plan-committees.php). Committees are made up of fisheries professionals that broadly fit into three vocation types: managers, researchers, and assessment biologists. The roles and responsibilities of each vocation are described

biologists—held by members of science-based management organizations within the Great Lakes. Second, we seek to understand what barriers face the uptake of biotelemetry data in the research and management community. In doing so, we hope the study offers practical information concerned with improving the uptake and mobilization of evidence produced by biotelemetry. Our study contains two sources of novelty for this literature. First, our research provides basin-wide perspective with multiple jurisdictions. Second, reported successes associated with biotelemetry have often come from the perspective of researchers (e.g., Nguyen et al. 2018a, 2019; Brooks et al. 2019; Brownscombe et al. 2019a, 2019b), and here we broaden the vocational scope to include fishery managers and assessment biologists.

2 Methods

This research is part of a larger study on knowledge mobilization supported by the GLFC's Science Transfer Program.[5] Our research design was exploratory and used semi-structured telephone interviews to elicit views of fisheries professionals (managers, assessment biologists, and researchers) associated with the GLFC Lake Committee structure. The study received ethics approval from the Carleton University Ethics Board (#106530).

2.1 Interview development

The interview instrument contained 25 questions developed using the knowledge–action framework by Nguyen et al. (2017a) as well as advice from collaborators and key

[5] http://www.glfc.org/science-transfer.php.

Table 1 Summary of interview questions analyzed in this study

Question	Type	Results summarized in:
Have you used biotelemetry in your own work?	Open-ended	Table 3
What are the strengths of biotelemetry?	Open-ended	Tables 5, 7
What are the limitations of biotelemetry?	Open-ended	Tables 6, 7
Likert-type questions concerned with biotelemetry research	Likert type	Table 4, Fig. 3
In your experience, what do you think are barriers to using new scientific knowledge in fisheries management?	Open-ended	Table 8

informants from the GLFC and GLATOS (see Supplementary Information for full interview instrument). Interviews consisted of a series of open-ended questions as well as a set of closed-ended Likert-type opinion questions. Open-ended questions (Table 1) sought to elicit information about participant backgrounds, their views about the role of biotelemetry in the Great Lakes Basin, the benefits and limitations of biotelemetry, and barriers to mobilizing new scientific evidence into policy and decision-making. The closed-ended Likert-type questions covered a variety of topics regarding production, use, value, and sharing of biotelemetry science (Fig. 3). We asked participants to indicate their level of agreement on a five-point scale with a sixth option of 'I don't know' also available. To assess our interview instrument, we conducted two test interviews with individuals possessing expertise in biotelemetry techniques and research but who were not from the Great Lakes arena. No adjustments to the interview question guidelines or procedures were made after these tests.

2.2 Data collection and analysis

We identified interviewees from a list provided by the GLFC which contained contact information for members of the Commission's Lake Committees and Lake Technical Committees ($n=94$). In addition, we identified several other key informants, including GLFC staff ($n=12$). Interview invitations were sent by email on June 6, 2017, and three reminders were sent. Interviewee affiliations were self-reported (by committee and vocation, see Table 2).

We conducted a total of 49 semi-structured interviews by telephone and conducted one interview by e-mail for a total of 50 interviewees (out of 106 contacted individuals). The remainder of the population (56) did not respond to the invitation after several reminders. During the semi-structured telephone interviews, the interviewer followed a predetermined set of questions but allowed respondents to diverge from the script (Axinn and Pearce 2006). The interviews took place between June 2017 and October 2017 and lasted between 35 and 70 min. All interviews were audio-recorded with the consent of participants.

We transcribed audio-recorded interviews with Transcribe[6] an online transcription service. We reviewed interview transcripts to ensure accuracy and to increase our familiarity with the transcripts to prepare (i.e., to identify potential emerging themes) for the coding step. To analyze the data obtained from open-ended questioning, we used NVivo 12 (NVivo qualitative data analysis Software; QSR International Pty Ltd. Version 12, 2018) and inductively coded the data following a three-step qualitative analysis procedure (Thomas 2006, Sutton and Austin 2015). Specifically, we assigned codes to responses, then merged similar codes, and finally assigned codes into relevant thematic categories. We reviewed all categories to ensure they were mutually exclusive. These thematic categories were then classified into evaluative, socio-organizational, and individual-level strengths, the core themes of Young et al. (2018)'s framework used as the basis of our qualitative analysis. For open-ended questions, the percentage of respondents citing a particular theme was calculated rather than the total number of times interviewees cited a theme. For closed-ended, Likert-type questions, the percentage of respondents selecting a particular Likert-type option was used. Percentages were calculated out of 50 total respondents, except (1) where explicitly noted or (2) where results are summarized by vocation type (Table 2). Our qualitative inductive analysis allowed for themes to emerge. The qualitative analysis was used to understand patterns or recurrences in experience and thinking of individuals in order to map the landscape of participant's thoughts on topics of interest (Maxwell 2004).

3 Results

We organize the results into three sections. In the first section, we summarize the broad contours of the interviewees' viewpoints regarding their previous involvement with biotelemetry and their views on whether its role should be expanded in the Great Lakes. In the second section, percentages of interviewees who cited various benefits and limitations of biotelemetry are presented. While the first two sections of the results report both open-ended and closed-ended

[6] https://transcribe.wreally.com/.

interview questions specific to the use of biotelemetry in the Great Lakes Basin, the final section reports solely open-ended data to illustrate perceived barriers to the adoption of new scientific evidence by the respondents, providing context for understanding the barriers to science transfer in this system.

3.1 Understanding interviewee background experiences and perceptions on the role of biotelemetry

Most interviewees (84% of 50) had direct experience with biotelemetry through current or previous involvement in research (not necessarily as the one conducting the research, but as a collaborator, funder, or user). Only 16% of interviewees indicated they had not been directly or indirectly involved with biotelemetry research, suggesting that most of the sample population provided a good cross section of experiences with, and exposures to, biotelemetry (Table 3). The majority of interviewees (> 50%) thought that the role of biotelemetry in the Great Lakes fishery management should be expanded (Table 4). Only two out of 27 managers and one out of 11 assessment biologists disagreed with the statement.

3.2 What science transfer benefits and limitations does biotelemetry generate?

In analyzing the interviewee responses, we identified 16 types of strengths of biotelemetry data (Table 5) and 18 types of limitations (Table 6) through our coding of open-ended questions. The majority of strengths (14 of 16) and weaknesses (16 of 18) fell into the *evaluative* category, with *individual*-level strengths and weaknesses of biotelemetry cited by the fewest interviewees.

3.2.1 Evaluative strengths and limitations: epistemological

Within the *evaluative* category, interviewees cited *epistemological* benefits most often (Table 5). Respondents frequently cited biotelemetry's ability to generate evidence useful for understanding several questions related to species biology, including species movement (mentioned by 78% of interviewees), life history and ecology (32%), habitat data (30%), and behavior (28%). Epistemological-type strengths of biotelemetry data also cited were for understanding environmental stressors (22%) and population ecology (24%). Examples of positive responses demonstrating evaluative value of biotelemetry information are illustrated below:

> "*It gives you an absolute understanding of where the fish go and when, and the route that they took to get there much more so than the traditional tagging method*" (Interview #5, Manager).

> "*They* [biotelemetry researchers] *are doing migration* [studies], *spawning fidelity, doing a mix stock analysis, life history events, temperature preferences. There's a lot to be learned by it.*" (Interview #37, Manager).

Aside from the types of questions biotelemetry can help answer, several interviewees (34%) noted that biotelemetry yields high-quality data. For example, we illustrate a positive comment on data quality here:

> "*You get a more continuous data set you can't get in other ways. For instance, you can get the temperature of where the fish is at every 15 s. That is way more continuous than the point you get with a gill net at a spot at a certain time. You get a better dataset with much more continuous data.*" (Interview #47, Manager).

The *epistemological* limitations cited most were that biotelemetry data often rely on a small sample size, potentially limiting confidence in results (26%), and that it produces data more relevant for understanding individual fish behavior rather than population-level behavior (14%) (Table 6). A smaller proportion of interviewees expressed concern that biotelemetry can produce skewed evidence with respect to age distribution (6%) and abundance (4%). We illustrate the more negative sentiments about the limitations on sample size and population-level assessments below:

> "*The sample sizes can be low and that's also another statistical problem. Fifty fish may not actually tell you everything you need to know about a whole population. I see those as very strong limitations.*" (Interview #5, Manager).

> "*When you are thinking about management at a population scale as large as the Great Lakes, if you have a population of 50 million walleye and you got 400 tags out there, what do you really know about the population? Extrapolating from your frame of reference is a pretty big leap that I think both researchers and managers just really need to be cognizant about as they talk about what insights they're making coming from various research projects.*" (Interview #8, Manager).

Five of the nine Likert-type opinion questions (Fig. 3) investigated *epistemological* perceptions of biotelemetry data. Two of these Likert items generated agreement among vocations in support of the reliability of knowledge generated by biotelemetry: Interviewees noted that knowledge generated about fish behavior was reliable and that the fish handling process (i.e., catching and tagging the fish) did not impair data reliability (Fig. 3). The other three epistemologically focused Likert-type questions revealed disagreement both within and across vocation types. Although most interviewees agreed that biotelemetry contributes reliable information on fish behavior, we found variability in the opinions of its reliability in generating ecosystem-level knowledge

Table 2 Affiliation of participants by committee membership and vocation

Great Lakes Fishery Commission Committee	Vocation			Total ($n=50$)
	Manager ($n=27$)	Researcher ($n=12$)	Assessment Biologist ($n=11$)	
Lake Ontario	2	0	0	2
Lake Ontario Technical	2	1	5	8
Lake Erie	4	0	0	4
Lake Erie Technical	1	1	0	2
Lake Huron	0	0	0	0
Lake Huron Technical	3	3	1	7
Lake Michigan	3	0	0	3
Lake Michigan Technical	5	3	0	8
Lake Superior	4	0	0	4
Lake Superior Technical	2	2	5	9
Council of Great Lakes Agencies	1	0	0	1
Not on a committee	0	2	0	2

Table 3 Responses (in percentage) to the question 'Have you used biotelemetry in your own work?'

Experience with biotelemetry	Percentage of respondents ($n=50$)
Direct involvement	
Currently working on several projects involving biotelemetry	24
Currently involved in some projects	28
Have used biotelemetry in the past but does not currently use	26
Indirect involvement	
Via funding oversight	6
No previous involvement	
Have not been involved in projects involving telemetry	16

Table 4 Expanding the role of biotelemetry in the Great Lakes Basin (in percentage)

Biotelemetry should play a more standard role in fishery management than it currently does	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Manager ($n=27$)	4	52	33	7	0
Researcher ($n=12$)	0	67	33	0	0
Assessment biologist ($n=11$)	9	45	27	9	0

(Fig. 3). The perspective of managers was the best example of this contrast: While 100% of managers agreed that biotelemetry was useful for fish behavior, 52% indicated they were not convinced that biotelemetry was a reliable source of ecosystem data. Researchers and assessment biologists were much more positive on the ability of biotelemetry to help understand ecological factors. On whether 'biotelemetry information should be taken with a grain of salt' (Fig. 3), assessment biologists demonstrated more skepticism relative to the other vocation types. Despite some disagreements among researchers and assessment biologists about using biotelemetry data only after peer review, overall, these vocation types considered this approach acceptable. Managers, however, noted the strongest disagreement, indicating that using non-peer reviewed biotelemetry data in some circumstances was acceptable (48% of 27 managers disagreed or strongly disagreed with this statement (Fig. 3).

Managers and researchers offered more positive comments about the *epistemic value* of biotelemetry than other vocation types, with 56% of managers and 42% of researchers offering positive-only comments (Table 7), while only 36% of assessment biologist provided positive-only comments. None of the vocation types cited negative-only epistemological attributes of biotelemetry, but each vocation

Table 5 Positive or supportive comments (and percentage of respondents) about biotelemetry cited in open-ended questioning

Young et al. 2018 framework classification		Code	Percentage of respondents ($n=50$)
Positive or supportive comments about biotelemetry			
Socio-organizational strengths	Communicative strengths	Fosters collaboration	2
Evaluative strengths	Epistemological value	Movement (distance, migration)	78
		Produces high-quality data	34
		Life history and ecology	32
		Habitat data	30
		Behavior	28
		Population ecology	24
		Environmental stressors	22
		Mortality and survival	18
		Individual-level data	14
		Invasive species management	14
		Novel information	10
		Animal physiology	6
	Practical value	Low human resource demands	12
		High volumes of data	10
	Perceived fit or departure from current practices	Fosters scientific inquiry	6
Don't know			2

Table 6 Negative or less supportive comments (and percentage of respondents) about biotelemetry cited in open-ended questioning

Young et al. 2018 framework classification		Code	Percentage ($n=50$)
Limitations of biotelemetry			
Socio-organizational challenges	Communicative limitations	Coordination and communication	4
Individual-level challenges	Skills, communication, familiarity	Lack of necessary expertise or capacity	6
Evaluative limitations	Epistemological limitations	Small sample sizes	26
		Produces information at individual level not population level	14
		Receiver accuracy	10
		Study design flaws	6
		Lacks mortality data	6
		Can produce skewed/unrepresentative age data	6
		Can produce skewed/unrepresentative abundance data	4
		Data robustness	4
		Lacks physiological data	2
	Practical limitations	Cost is too high	38
		Collecting and processing data	28
		Limited receiver availability	20
		Recovering receivers	6
		Depth limitations of receivers	6
		Battery life	4
		High human resource demands	2
	Perceived fit or departure from current practices	Doesn't replace current practices, tools, or approaches	4
Not aware of any limitations			6

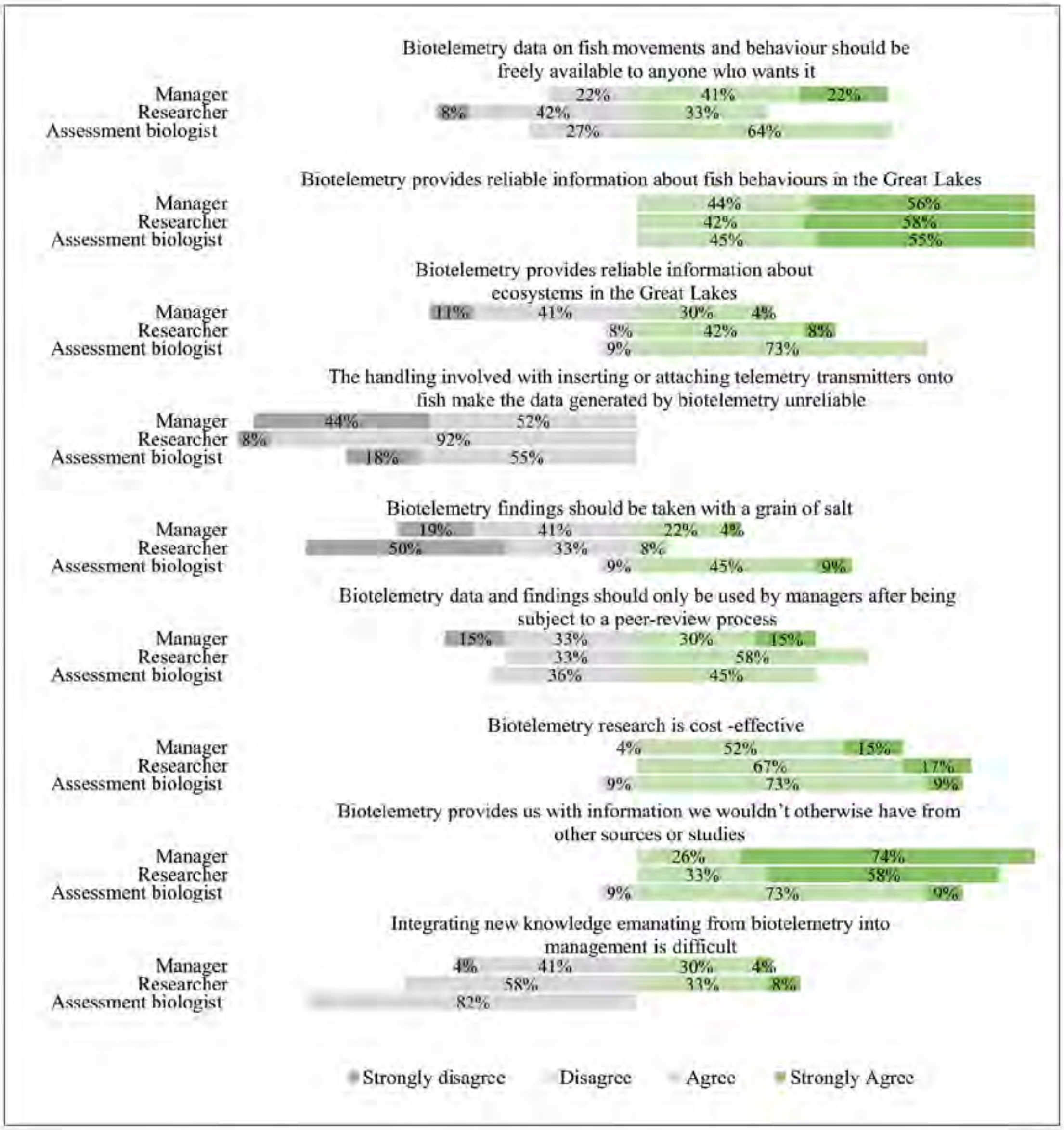

Fig. 3 Responses to Likert-type opinion statements by vocation type. We only include answers provided that contain a degree of polarity (i.e., agree or disagree) and omit neutral answers (including 'neither agree nor disagree' and 'I don't know')

type provided mixed positive and negative comments about biotelemetry, including 44% of managers ($n=27$), 50% of researchers ($n=12$), and 6% ($n=11$) of assessment biologists.

3.2.2 Evaluative strengths and limitations: practical

Overall, all vocations held negative views of the *practical* attributes of biotelemetry with 51% of managers ($n=27$), 67% of researchers ($n=12$), and 92% of assessment biologists ($n=11$) citing at least one practical drawback of biotelemetry without citing any practical benefits (Table 7).

Interviewees cited *practical limitations* of biotelemetry most often but named fewer types of practical limitations relative to epistemological concerns, which may suggest common thoughts about biotelemetry's practical limitations. Thirty-eight percent of all interviewees noted that the cost to conduct biotelemetry research was a barrier to use and uptake of biotelemetry data (i.e., science transfer), while 28% of interviewees noted that collecting and processing the volume of data yielded by biotelemetry created significant practical challenges. Twenty percent identified that receiver

Table 7 Perceptions of the evaluative strengths and limitations (by percentage) of biotelemetry by polarity of answer and across vocation types

Vocation	Positive only	Mixed	Negative only	Not mentioned
Manager ($n=27$)				
Epistemic value	56	44	0	0
Practical value	4	26	51	19
Fit	7	0	4	89
Researcher ($n=12$)				
Epistemic value	42	50	0	8
Practical value	0	0	67	25
Fit	8	0	0	92
Assessment biologist ($n=11$)				
Epistemic value	36	64	0	0
Practical value	0	0	92	9
Fit	9	0	0	91

Epistemic value refers to the perceived as either flawed, irrelevant, and limited value, or novel, credible, and reliable with high value. *Practical value* refers to ease of use of information (e.g., cost, time lags, access, spatial coverage), and *Fit* refers to perceived fit or departure from current practices. These definitions follow the Young et al. (2018) framework

availability was limited. An example of a comment related to cost as a barrier is shown below:

> "*[Biotelemetry research] is very expensive, and in a large lake, I think a smaller barebones study required 150 receivers, which is a lot of money. And then it takes a lot of resources to get those set.*" (Interview #34, Manager).

Not many *practical benefits* of biotelemetry were noted compared to practical limitations, with 12% of interviewees noting that biotelemetry requires low human resource demands and 10% of interviewees citing the high volume of data produced by biotelemetry as an important benefit (Table 5).

Among the Likert-type question examining the practicality of biotelemetry, we found positive consensus among all vocation types on the statement 'biotelemetry research is cost-effective.' Interestingly, this differs from the practical issue that biotelemetry cost is too high in the open-ended questioning. Further, high agreement occurred among respondents that biotelemetry produces data that cannot be produced through other methods (Fig. 3).

3.2.3 Evaluative strengths and limitations: perceived fit with existing structures and practices

The third type of evaluative strength/limitation from Young et al. (2018)'s framework is the *perceived fit* of new knowledge into existing management structures and practices, which was not mentioned often among interviewees (Table 8). Results did not produce a clear signal around this characteristic: Though 6% of interviewees suggested that biotelemetry worked within existing structures to promote scientific inquiry, 4% noted that biotelemetry does not replace current practices, tools, or approaches (Table 6). We asked interviewees to indicate whether they agreed or disagreed with the statement 'Integrating new knowledge emanating from biotelemetry into management is difficult' (Fig. 3), and found assessment biologists unanimously felt integrating biotelemetry data was not difficult, while researchers and managers differed, with mixed agreement and disagreement on this statement.

3.2.4 Socio-organizational strengths and limitations

Interviewees cited *socio-organizational* strengths and weaknesses related to biotelemetry far less frequently than *evaluative* characteristics. One interviewee noted that biotelemetry research fostered collaboration, while two interviewees suggested that the usefulness of biotelemetry was limited by complications arising from collaboration. We included one Likert-type question aimed at understanding socio-organizational characteristics, which was 'Biotelemetry data on fish movements and behavior should be freely available to anyone who wants it' (Fig. 3), to understand perspectives about data sharing. The majority of managers (63%, $n=27$) and assessment biologists (64%, $n=11$) 'agreed' or 'strongly agreed' with the statement, while a minority of researchers (33%, $n=12$) agreed with this statement (Fig. 3).

3.2.5 Individual-level strengths and limitations

No *individual-level* benefits were cited by interviewees, while 6% of interviewees noted only one type of individual-level barriers, a lack of expertise, as complicating the use and uptake of information generated by biotelemetry.

Table 8 Perceived barriers (by percentage) to using new scientific knowledge in fishery management

Young et al. (2018) framework		Code	Mngrs (n=26)	Res (n=11)	Biol (n=10)	Overall percentage (n=47)
Barriers to mobilizing new evidence into policy						
Socio-organizational challenges	Organizational inflexibility	Institutional inertia	15	18	0	13
		Legal context	4	0	0	2
		Management metrics	0	9	0	2
		Timeliness of evidence	4	0	0	2
	Absorptive capacity	Integration challenges	4	9	0	4
	Political considerations	Acceptance by stakeholders	22		10	14
	Communicative limitations	Communication between researcher and manager	19	27	10	19
		Communication with the general public	12	0	0	6
		Communication of complexity	0	9	0	2
Individual-level challenges	Skills, education, familiarity	Finding out about new evidence	12	9	20	13
		Access to journals	4	0	0	2
		Access to unpublished data	4	0	0	2
		Inability to process complex data	0	0	10	0
		Personal constraints	1	0	0	0
	Experiences and preferences	Prior experiences of key individuals	8	36	30	19
Evaluative limitations	Epistemological limitations	Confidence in evidence	12	0	10	9
		Relevance of evidence	4	9	0	4
		Limitations of evidence	4	0	0	2
		Knowledge complexity	4	0	0	2
	Practical limitations	Cost (unspecified)	15	36	10	19
		Time constraints (unspecified)	12	0	20	11
		Labor availability	0	9	10	4
		Gear and supplies	0	9	10	2
		Travel restrictions	4	0	0	2
	Perceived fit or departure from current practices	Fit with historical norms	4	9	0	4
Not aware of any limitations			4	0	0	2

Results are shown as a proportion of respondents citing the relevant barrier by vocation type and by proportion of complete interview set. Conceptual framework employed is based on that designed by Young et al. (2018). *Mngrs* managers, *Res* researchers, *Biol* assessment biologists

3.3 Barriers to the adoption of new scientific knowledge into management and policy

The final section of our results addresses how interviewees perceived barriers limiting the adoption, or uptake, of scientific data (generally) into use by managers and resource management institutions. While the data presented in Sect. 3.2 focused on strengths and benefits of the data produced by biotelemetry, here we provide an examination of barriers that can complicate or preclude uptake of new knowledge more generally.

3.3.1 Evaluative barriers

Ten types of evaluative limitations were cited, and as aforementioned, interviewees most commonly identified *practical limitations* as barriers to the mobilization of knowledge produced by biotelemetry (Table 6). Similarly, the interviewees also perceived practical limitations to be core barriers to the uptake and implementation of new evidence into policy (Table 8). The perceived cost to integrating new evidence was cited by 19% of all interviewees (n=47), with researchers citing it most often (36% of 11; Table 8). Time constraints were the second most cited practical limitation, noted by 11% of interviewees ($n=47$). Interviewees did not specify cost and time constraints and spoke about these concepts more generally.

Similar to results from biotelemetry uptake, *epistemological* factors were not predominantly cited as barriers to the uptake of new knowledge and evidence. The most commonly noted *epistemological* barrier was 'confidence in evidence,' with only 9% of all interviewees ($n=47$) citing this barrier. The results of this category are perhaps most interesting when viewed as a function of vocation type—0% of researchers ($n=11$) noted this *evaluative* limitation, while 12% of managers ($n=26$) cited confidence as a barrier.

3.3.2 Socio-organizational barriers

Eight types of *socio-organizational* barriers to the uptake of new knowledge were cited by interviewees. Communicative limitations were the most often cited *socio-organizational* barrier, with 19% of interviewees ($n=47$) noting that communication between researchers and managers was a key limitation. This limitation was cited more frequently by researchers (27%, $n=11$) than managers (19%, $n=26$). Other *socio-organizational* barriers cited by interviewees included institutional inertia (13%, $n=47$) and the acceptance of new evidence by stakeholders (11% of all respondents ($n=47$) cited this barrier, and 15% of managers ($n=26$)). Interestingly, *socio-organizational* challenges associated with the public and stakeholders were most frequently cited by managers and rarely or never by researchers and assessment biologists (Table 7).

3.3.3 Individual-level barriers

Individual-level barriers featured more prominently in respondents' answers about mobilizing new evidence than individual-level benefits/limitations with biotelemetry (no individual-level strengths cited and 6% cited as a challenge; Table 6). Within this category, finding out about new evidence was cited most frequently (13% overall vocations, $n=47$; Table 8), of which 20% (of 47) assessment biologists made up the respondents in this category. Second, prior experiences of key individuals (often termed as path dependence in the literature) were cited as a barrier by 19% of respondents consisting primarily of researchers and assessment biologists citing this barrier. Other individual-level barriers (only cited by about 2% of respondents) included access to journals, access to unpublished data, inability to process complex data, and (unspecified) personal constraints (Table 8).

4 Discussion

Overall, our results shed light on the challenges of integrating biotelemetry findings into Great Lakes fishery management by revealing how individuals possessing three vocation types perceived benefits and limitations of biotelemetry of three vocation types. First, we discuss biotelemetry-specific perceptions within the Young et al. (2018) framework. Second, we discuss the role of vocations and the continued science–practice divide, and lastly, we compare the barriers facing the uptake of biotelemetry evidence relative to the mobilization of new knowledge more generally.

We interviewed nearly 50% of our total target population, which consisted of fisheries professionals associated with the GLFC. Given this level of coverage, it is unlikely that any major thematic codes were missed at the population level (Guest et al. 2006, Francis et al., 2010). The fact that the GLFC established and sponsors GLATOS could mean that our sample population may be biased toward individuals already familiar and supportive of biotelemetry research and its application. Their familiarity with the information that biotelemetry provides may explain the more positive perceptions of biotelemetry's epistemological value than expressed by individuals or groups outside of the Great Lakes as documented in the Fraser River case (Young et al. 2013, 2018) where skepticism was recorded. In the Great Lakes Basin, the GLATOS network has played a crucial role in promoting knowledge sharing and exchange among fisheries professionals and in demonstrating the value and impacts of biotelemetry research (see e.g., Krueger et al. 2018, Fielder et al. 2020 for management impacts). Given that most of our sample population were generally positive, aware and supportive of biotelemetry research may signal that science transfer activities (i.e., annual meetings, committee presentations, relationship development, developing research-practitioner network) within the Great Lakes Basin are working. Other cases around North America examining the science transfer of biotelemetry have noted similar activities promoted the translation of findings into fishery management action, including integrating managers and stakeholders into the research, having applied research funding and objectives, having established relationships among researchers and practitioners, and presenting preliminary data in a timely manner (e.g., Brownscombe et al. 2019, Brooks et al. 2019).

4.1 Evaluative challenges: biotelemetry is perceived to offer high epistemological value but with practical limitations

We found that information and knowledge derived from biotelemetry research is highly regarded for its *epistemological* value, as noted in other Great Lakes-based GLATOS research (e.g., Hayden et al. 2014, Fielder et al. 2020) and elsewhere, particularly for understanding fish movement (distance, migration) and applying this information to management. The fact that interviewees also mentioned the value of biotelemetry in generating environmental and ecological information suggested that they felt biotelemetry data were useful for pursuing and answering a range of scientific questions (not only on fish) and for informing management. Young et al. (2018) conducted similar research on Pacific salmon fishery management in Fraser River, British Columbia, and interviewed government employees including fishery managers, assessment biologists, and researchers (from Department of Fisheries and Oceans Canada) as well as stakeholders affiliated with the co-management of the salmon fishery (e.g., industry, First Nation organizations, consultants, and environmental non-governmental organizations). As with study participants in the Great Lakes, government employees involved in the management of the Fraser River demonstrated general support for expanding the role of biotelemetry in salmon management (72% of 16 respondents). Despite the more heterogeneous interviewees in the Fraser River salmon case study, we found similar areas of agreement and disagreement on the Likert-type opinion statements of biotelemetry. For example, both studies showed strong agreement that biotelemetry provides reliable information on fish behavior as well as offering information that was unattainable from other methods or sources (Young et al. 2018). Although high agreement occurred on reliability of information on *fish behavior*, mixed opinions existed about reliability of biotelemetry research on *ecosystem-level information* by both studies. Similar sentiments were found in the open-ended questioning of strengths of biotelemetry for both Great Lakes and Fraser River studies. Participants identified information on movement (timing, distance, and migration), fish behavior, and high-quality or original data among the epistemological strengths of biotelemetry. Overall, a fairly strong endorsement of the scientific knowledge output of biotelemetry technology occurred. However, our findings highlight the remaining question of whether individuals feel that the epistemological value of biotelemetry is worth the cost and other practical limitations that were cited.

4.2 Cost-effective and cost-prohibitive: a paradox of new technology

The finding that cost remained the most notable to greater deployment and uptake of biotelemetry in the Great Lakes contrasts with the results of other studies. Globally, a survey of just over 200 international fish telemetry researchers found that researchers perceived the challenges facing the uptake of biotelemetry findings to be limitations of the technology itself and its resulting data (Nguyen et al. 2018a) more so than cost. As with Fraser River managers (Young et al. 2018), GLFC fisheries professionals noted that the cost (of transmitters) and resource burden (labor capacity requirements for field work and data processing) associated with biotelemetry complicates the use of the technology. Interestingly, though interviewees cited cost as a major limitation to its integration in fishery management, the results of open-ended questioning showed that all vocation types nonetheless consider the technology to be cost-effective for research (especially once capital costs are amortized over time). Perhaps, this result was because of the perceived reliability of the data, the volume of the data produced, and perceptions about the variety of scientific questions the data can help answer.

In the Great Lakes, acoustic telemetry is often conducted by attaching a transmitter to the fish (either via surgery or externally) which transmits acoustic signals to a receiver that can be tens of meters away, or a few kilometers away. The signals are recognized as a code unique to each fish and recorded with date and time stamp by receivers (reviewed in Thorstad et al. 2013; p. 884). Acoustic receivers can be positioned as in lines or grid patterns and continuously listen for the movements of tagged fish. The initial investment for acoustic equipment (receivers, tags, and field work) can be large, but the equipment can function for several years, which lowers the cost of this method when amortized over the device's life span. Given that acoustic telemetry arrays are still relatively new to the Great Lakes (~10 years or less), some lingering sentiments of large initial costs and maintenance may exist. Thus, while biotelemetry can produce large volumes of trustworthy data capable of answering important scientific and management questions, funding this work remained a major challenge in the minds of the respondents. The fact that biotelemetry was viewed as both cost-effective and cost-prohibitive may reflect static research budgets within agencies and research funding organizations.

For the technology to be implemented more expansively under the scenario of static research budgets, biotelemetry would have to displace other research and assessment methods to free-up funds. As such, those looking for their biotelemetry research to be used and supported must demonstrate its impact. McGowan et al. (2016) discusses conservation return-on-investments from animal tracking (biotelemetry) data and offers a framework using the value of information for decision-making to help improve decisions on investing in more data collection or conservation action or other activities requiring resource trade-offs. They argue that new tools to weigh costs and benefits are needed to improve the return-on-investments of biotelemetry research for conservation decision-making (McGowan et al. 2016; p. 428). So far, little work has been done investigating the cost–benefits of biotelemetry (e.g., investigating cost relative to conventional or alternative methods), which may be a useful route for further investigation, especially considering our findings that biotelemetry was viewed as being both cost-effective and cost-prohibitive.

4.3 Socio-organizational challenge: Mixed views on data sharing and indication of reluctance from the research community

Fifty percent of researchers in our study disagreed that biotelemetry on fish movements and behavior should be freely available to anyone, which contrasted to the relatively positive views on data sharing held by managers and assessment biologists. This result was somewhat consistent with other findings concerned with the sharing of biotelemetry data. Previous work by Nguyen et al. (2017b) found about 39% of surveyed fish telemetry researchers, globally, were less agreeable to sharing biotelemetry data. Many concerns were related to loss of opportunity/ownership over data or misuse of data (i.e., misinterpretation or inappropriately exploiting animal information). Nguyen et al. (2017b) reported that individuals who are part of telemetry networks were 2.8 times more likely to share their data. Relevant to our study, GLATOS data policy reflects these concerns and is as follows:

> GLATOS is a collaborative network for the exchange of data owned by individual members. Each principal investigator (member) determines who can access their project's detailed biological tagging data and subsequent detections of those tagged fish, consistent with their own agency or funding source policy. To facilitate collaboration and planning, receiver locations and dates of operation are available to all members. (https://glatos.glos.us/faq; accessed June 16, 2020).

In practice, the GLATOS basin-wide database is used by a researcher to search across all existing receivers (receivers they deployed as well as receivers deployed by others) for tag detections within the scope of the researcher's project. Thus, finding detections of telemetry tags on other researchers' receivers is promoted and considered a form of data sharing. However, a researcher cannot search for tag detections that are not a part of their project; thus, data sharing via the GLATOS database has some restrictions. Given that GLATOS is a network embedded within the GLFC, we expected greater support for data sharing/collaboration among researchers. Although we did not explore the reasons for the concerns over data sharing, sociopolitical reasons may exist that explain hesitancies around data sharing. Further, our questioning did not specify sharing data with the public vs those within the network, which leaves some knowledge gaps. For example, telemetry data could be used to influence harvest or quota regulations among jurisdictions such as within the Lake Erie walleye sport and commercial fisheries (Vandergoot et al. 2019). Further, sharing data used to identify critical habitat of a species at risk may create the potential for data misuse (as noted in Nguyen et al. 2017b), as sharing this information could result in potential unintended consequences such as overexploitation of species at risk (Cooke et al. 2017).

4.4 Individual-level challenges: not a major barrier in the Great Lakes Basin

Few individual-level challenges were identified, with the exception of three interviewees describing lack of expertise and capacity with biotelemetry. This sentiment resembled those reported by a survey of fish telemetry researchers around the world noting that large and complex datasets generated by biotelemetry were a major barrier to integrating biotelemetry findings into management because of the lack of expertise to interpret them (Nguyen et al. 2018a). Nonetheless, as alluded to, the presence of GLATOS and its science transfer efforts may have played an important role in overcoming individual-level challenges such as skills, education, and familiarity with the technology.

4.5 The science–practice culture divide persists—how can it be overcome?

Participants in this study came from three vocation groups (fishery managers, researchers, and assessment biologists) within the GLFC's Lake Committees and Technical Committees. Interestingly, differences in sentiments were expressed across vocations on the evaluative strengths and limitations of biotelemetry. The answers provided by assessment biologists, who were Technical Committee members, were more negative across all themes than other vocation types, while managers held the most positive views about biotelemetry. For example, assessment biologists, unlike researchers and managers, were more positive about the ease of integrating biotelemetry-derived knowledge into management. These differences may be influenced by the nature of the role and responsibilities of different vocations, as assessment biologists are often on-the-ground and implementing strategies or integrating different sources of scientific information into assessment models, and thus may have greater direct exposure to, and experience with, the (im)practicalities associated with biotelemetry. Although the potential role of biotelemetry in stock assessment has been considered (Cooke et al. 2016), still relatively few examples exist of where this integration has occurred in practice within the Great Lakes (Landsman et al. 2011).

Our result was similar to the findings from the Fraser River salmon case study, where Young et al. (2018) found polarized sentiments relating to the epistemic value, practical value, and fit of biotelemetry and management between government employees and stakeholders. Stakeholders in that study were more critical than government employees about biotelemetry informing fishery management. Further, qualitative information from Young et al. (2018) illustrated that some managers view biotelemetry as a good tool for research, but not as useful for management purposes. Indeed, these inconsistent sentiments among Great Lakes user groups (i.e., useful for research, not management) of the value of biotelemetry may lead to disagreement over the potential role of biotelemetry research in fishery management as it did in Fraser River management (Young et al. 2018).

Our findings, when analyzed by vocation, were consistent with patterns of the cultural divide between researchers and managers previously identified in the literature (e.g., Olsson et al. 2004, Sunderland et al. 2009). In our study, practitioners or managers demonstrated greater political concerns relating to acceptance of evidence by the public and stakeholders than researchers, whereas no researcher listed these concerns as potential reasons for barriers to mobilizing telemetry evidence. Furthermore, managers reported a greater diversity of socio-organizational challenges than the other vocations. On the other hand, those in science-oriented vocations (researchers and assessment biologists) cited the prior or past experiences of key individuals as a key barrier to the uptake of scientific evidence; almost no manager acknowledged this issue. These findings were evidence of the persistence of the science–practice divide.

We speculate that our findings were an indication that fishery management and policy arenas and outcomes are still something of a 'black box' for researchers to understand. Thus, researchers need to better understand knowledge users and integrate manager perspectives into their research. To meet this need to integrate managers with research studies, the first four major telemetry studies conducted through the GLATOS network had fishery managers from agencies with jurisdictional authority as co-principal investigators (Krueger et al. 2018). Managers helped to ensure that Great Lakes telemetry research was relevant to their decision-making needs. A study funded by the GLFC in 2014 concerning climate change information identified the gap between research and practice where many opportunities to reconcile data and information demands of decision-makers with available future research were missed (Mulvaney et al. 2014). In that study, the authors identified preferred information channels that resource managers and policy decision-makers at the GLFC used to obtain information. E-mail was the most frequently cited medium used, while the preferred medium of receiving climate information was found to be presentations at meetings and conferences. This information is consistent with anecdotal evidence suggesting that GLFC meetings are a key activity for science transfer. The GLFC has an established form of knowledge exchange through their committee meetings that consists of an overnight stay with organized events to facilitate informal interactions and relationship building among the meeting participants. The emphasis on the importance of these meetings is a unique feature of the GLFC and GLATOS and has been identified for its success in promoting social ties and establishing relationships. These meetings are thought to increase the effectiveness of management coordination in the multi-jurisdictional Great Lakes (Leonard et al. 2011). Although the Joint Strategic Plan and coordination efforts from the GLFC have been viewed as an important and successful initiative for improving coordination and communication among management jurisdictions and researchers, room for improvement still exists to bridge across differences in culture and norms of science and practice.

Literature outside of fisheries on the science–practice or science–policy gap has highlighted the use of boundary organizations as a promising pathway to promoting the integration of science into practice/policy (Carr and Wilkinson 2005; O'Mahony and Bechky 2008). At present, boundary organizations are not yet well defined and are not formalized in agencies or other governing bodies. The GLFC and GLATOS are potential examples of how a boundary organization associated with multi-jurisdictional fishery management agencies can help with science transfer through facilitating and promoting awareness of biotelemetry research and studies, fostering collaboration and communication, and developing relationships and trust among researchers and practitioners (Krueger et al. 2018). Our findings highlight areas that may require reconciling among vocations including perceptions of challenges to narrowing the science–practice gap such as importance of stakeholder acceptance, awareness of new evidence, and prior experiences of key individuals (Table 8). Specific to telemetry, areas that GLATOS, as a potential boundary organization, could help address include perceptions of data use before or after peer-review, data sharing concerns, and reliability of biotelemetry information (Fig. 3).

4.6 How do the perceived barriers facing mobilization of biotelemetry data differ from the mobilization of knowledge more broadly?

We identified 25 unique barriers for mobilizing general scientific knowledge and found they were distributed evenly among the limitation category types: We identified nine unique socio-organizational barriers, six individual-level barriers, and 10 evaluative barriers (Table 8). Together, these results indicated that perceived barriers facing uptake and mobilization of findings from biotelemetry were fewer and more specific than barriers that face knowledge mobilization of new evidence. This finding is relevant because some types of barriers, including those falling into *socio-organizational and individual-level* barriers, are more easily resolved than others. For example, socio-organizational barriers (due to organizational inertia, path dependencies, and related established interests) are perhaps the type of barrier category most difficult to circumvent or resolve (Yang and Maxwell 2011, Nguyen et al. 2018b). Solving these types of barriers may require normative changes or legal changes in institutional approaches—fundamental changes that can be difficult if not impossible to engineer. Similarly, some individual-level barriers can also be thought of in terms of path dependency (i.e., past decisions or actions persisting through time leading to resistance to change). Although some individual-level barriers (such as access to evidence and research) can be resolved through minor and incremental shifts in behavior and policy, this approach is not true of all individual-level barriers. Specifically, the 'prior experiences of key individuals,' the most cited individual-level barrier, is characterized by a dynamic similar to socio-organizational barriers. Key individuals can understand problems and solutions in entrenched ways that can overlap with institutional contexts and prevailing incentive structures. Key individuals may rise to prominent positions precisely because of their subscription to a set of ideas and approaches commonly understood to be within institutional norms. Their perspectives can thus be difficult to change in ways that are profound or fundamental—types of change which are required to realize the promise of new technologies.

Resolving *evaluative* limitations, by comparison, is likely easier than addressing the *socio-organizational* barriers and *individual-level* barriers listed above. Evaluative barriers can (ideally) be addressed and resolved through continual refinement of new technology and corresponding increases in confidence in the accuracy of results. For example, limited sample size was the most cited evaluative barrier facing biotelemetry evidence. Resolving this barrier (i.e., by increasing sample size or demonstrating the sufficiency of existing sample sizes) would be an incremental change perhaps complicated by funding availability but is one that can be resolved if prioritized or enabled by cost decreases. Thus, evaluative barriers are fundamentally different from those emanating from legal structures or ideological positions and should be easier to resolve. Because socio-organizational and individual-level barriers are perhaps more intractable and more difficult to overcome than evaluative barriers, our results suggest that resolving barriers and improving uptake is likely more achievable for biotelemetry than for general types of new knowledge. This interpretation also suggests that the GLFC and GLATOS are well positioned to promote acceptance of biotelemetry evidence and that barriers to wider adoption of the technology and the evidence it produces were within our study more related to resource availability than organizational design.

5 Conclusions

Our study reinforces the epistemological value that biotelemetry brings to fishery management as highlighted by several key studies in this field around the world (e.g., Cooke et al. 2013, Thorstad et al. 2013, Mcgowan et al. 2016, Crossin et al. 2017, Lennox et al. 2017, Brownscombe et al. 2019). Biotelemetry possesses significant potential to answer questions relevant to both management and scientific enterprises and their intersection. The major challenge for biotelemetry to reach its fullest potential in informing fishery management lies within its practical limitations such as technological limitations, and most of all cost, which, from our findings, may be relatively more easy to overcome than challenges in using other types of scientific knowledge. As with other studies, our results suggested that the cultural divide between managers and scientists may be partly responsible for challenges to knowledge mobilization. Managers, researchers, and assessment biologists simultaneously considered the technology as both cost-effective and cost-prohibitive. This dual perspective can be considered as both confirmation of the significant potential of biotelemetry to resolve uncertainties and also a call for additional resources to collect, process, and disseminate knowledge generated by this method. Follow-up research to understand the evolving perceptions of knowledge users of biotelemetry would be worthwhile to understand the role of time (and implementation of recommendations to overcoming current barriers) in mobilizing scientific findings into practice.

The fact that socio-organizational and individual-level barriers to mobilizing biotelemetry knowledge were not commonly thought by interviewees as meaningful barriers was a noteworthy result of our study and was perhaps a function of an effective governance structure as well as shared norms and common goals. The mandates and activities, such as promoting trust, communication, relationship building, and networking that the GLFC and GLATOS prioritize, are in line with success stories and recommendations in the literature on overcoming the science–practice gap. Both organizations act as boundary organizations. To promote greater uptake of biotelemetry findings, GLATOS, in particular, should consider prioritizing activities that mitigate evaluative limitations highlighted in our study. Further, focusing on reconciling the science–practice divide by addressing misalignment in perceptions or understanding of fisheries prioritize, and shedding light on the policy or management 'black box' via continued meetings and platforms of networking may facilitate greater science transfer. To overcome the barrier of cost, GLATOS and GLFC could offer financial aid for start-up and maintenance cost of projects and continue to promote the epistemological value of biotelemetry in fishery management through continuous effective briefings and communication of research.

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Authors' contributions All authors contributed to the study conception and design. Data collection was performed by Delle Palme. Material preparation and data analysis were performed by Pentz and Delle Palme with input from Nguyen, Cooke, and Young. The first draft of the manuscript was written by Delle Palme, Nguyen, and Pentz, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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From: David Welch

Sent: Tue Dec 01 13:48:16 2020

To: Ben Zelinsky

Subject: [EXTERNAL] New (really small) tag

Importance: Normal

Attachments: Vemco Tags (V3 to V16).png; Rechisky, Welch et al (Performance of a high-frequency (180 kHz) acoustic array-Anim. Biotelem. 2020).pdf

Here is a photo of the tags that I said I would send.

#3 & #4 from the left are the tags we used back in the BPA-funded work (69 kHz).

#2 is a 180 kHz tag which we have extensively evaluated and characterized its performance in the ocean (see the attached paper just out—the abstract is all that you need to read to get the gist of what we achieved).

#1 is the new tag and is approximately the same size at the JSATs “injectable” tag (307 kHz). It is still in the pre-commercial stage but we have a formal agreement with the company to do a full-on “Kintama” performance evaluation in the February-March in the coastal ocean off the west coast of Vancouver Island, pandemic permitting. This is very promising because it will probably cover the entire size range of Fall & Spring Chinook, coho, sockeye, and steelhead. Acoustic tags will never work for outmigrating pink or chum fry—just too small.

Nice talking to you again.

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**


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Animal Biotelemetry

TELEMETRY CASE REPORT

Open Access

Performance of a high-frequency (180 kHz) acoustic array for tracking juvenile Pacific salmon in the coastal ocean

Erin L. Rechisky*, Aswea D. Porter, Paul M. Winchell and David W. Welch

Abstract

Background: Acoustic telemetry is now a key research tool used to quantify juvenile salmon survival, but transmitter size has limited past studies to larger smolts (> 130 mm fork length). New, smaller, higher-frequency transmitters ("tags") allow studies on a larger fraction of the smolt size spectrum (> 95 mm); however, detection range and study duration are also reduced, introducing new challenges. The potential cost implications are not trivial. With these new transmitters in mind, we designed, deployed, and tested the performance of a dual-frequency receiver array design in the Discovery Islands region of British Columbia, Canada. We double tagged 50 juvenile steelhead (*Oncorhynchus mykiss*) with large 69-kHz tags (VEMCO model V9-1H) and small 180-kHz tags (model V4-1H). The more powerful 69-kHz tags were used to determine fish presence in order to estimate the detection efficiency (DE) of the 180-kHz tags. We then compared the standard error of the survival estimate produced from the tracking data using the two tag types which has important implications for array performance and hypothesis testing in the sea.

Results: Perfect detection of the 69-kHz tags allowed us to determine the DE of the 180-kHz tags. Although the 180-kHz tags began to expire during the study, the estimated DE was acceptable at 76% (SE = 9%) when we include single detections. However, 95% confidence intervals on steelhead survival (64%) were 1.5 × larger for the 180-kHz tags (47–85% vs. 51–77% for 69 kHz) because of the reduced DE.

Conclusions: The array design performed well; however, single detections of the 180-kHz tags indicates that under slightly different circumstances the DE could have been compromised, emphasizing the need to carefully consider the interaction of animal migration characteristics, study design, and tag programming when designing telemetry arrays. To increase DE and improve the precision of 180 kHz-based survival estimates presented here requires either an increase in receiver density, an increase in tag sample size (and modified transmitter programming), or both. The optimal solution depends on transmitter costs, array infrastructure costs, annual maintenance costs, and array use (i.e., contributors). Importantly, the use of smaller tags reduces potential tag burden effects and allows early marine migration studies to be extended to Pacific salmon populations that have been previously impossible to study.

Keywords: Pacific salmon, Array design, Acoustic telemetry, Detection efficiency, Tagging, Survival, Precision, Optimization

Background

Acoustic telemetry is now a key research tool used to study where, and in some cases how, juvenile salmon die during the early phases of their migration and to estimate survival, but transmitter size has limited past studies to larger smolts [1]. Smaller transmitters have been

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recently developed (Fig. 1a), but their size results in both more limited battery payloads and higher transmission frequencies. The smaller battery constrains how often and how "loud" (i.e., how much acoustic power) the tag can transmit, reducing the chance of detecting the emitted signals. Perhaps of greatest consequence, the natural resonant frequency at which a transducer most efficiently converts an electric field into a pressure wave (sound) shifts to higher frequencies as transducer size shrinks, due to the material properties of the piezoelectric ceramic used to form the transducer [2, 3]. Adopting the use of higher frequencies that is implicit in choosing the smallest available tags has important practical implications. The rate of sound absorption in water increases by almost an order of magnitude between 69 and 300 kHz [4]; as a result, the transmitted sound from even very loud high-frequency tags rapidly becomes attenuated with distance from the source. As a consequence of the use of smaller tags, transmitter life, signal detection range, and (often) acoustic power output are reduced, limiting study duration and reducing the probability that a tag will be detected in the vicinity of a receiver. This trade-off has major cost implications for research programs that target juvenile salmon or other small, highly migratory fishes.

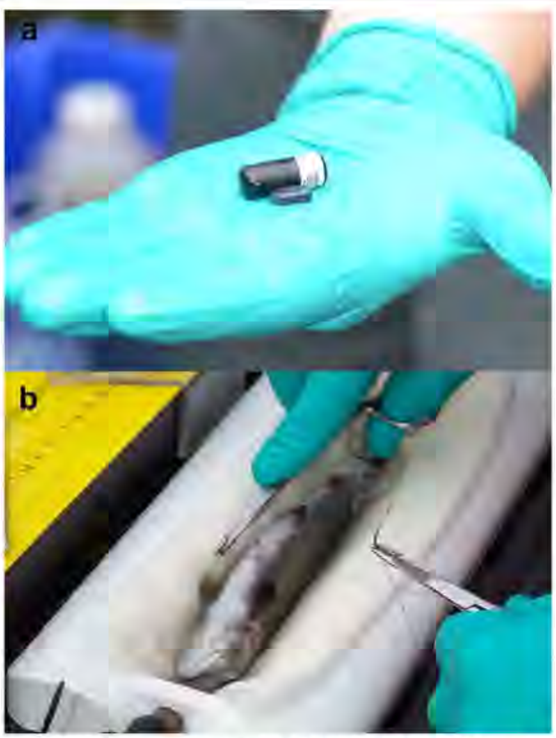

Fig. 1 Double tagging steelhead. **a** VEMCO V9-1H (69 kHz; larger tag) and V4-1H (180 kHz) acoustic transmitters being **b** implanted interperitoneally into a summer steelhead (*Oncorhynchus mykiss*) smolt. One of each tag type was surgically implanted into each of 50 smolts

An acoustic telemetry array known as the POST array (Pacific Ocean Shelf Tracking array; [5]) has been in place since 2004 to monitor the movements of tagged animals in and out of the Salish Sea, the marine waters lying between Vancouver Island and mainland British Columbia, Canada, and within the US state of Washington [6, 7]. This array was designed using VEMCO (Bedford, Nova Scotia, Canada) acoustic receivers capable of detecting 69-kHz VEMCO transmitters. Knowledge of the early marine life history of salmonids has been greatly enhanced by the continuous successful operation of this array (e.g., [8–16]).

The POST array design was originally developed for use with low-powered V9 acoustic transmitters (69 kHz,145 dB re 1 μPa @ 1 m), which were the only salmon-smolt-sized tag that was available at the time the original array design was developed [5]. This tag had a roughly 400 m detection range in the ocean ([17]; see Additional file 1: Figure S1) and approximately four month life span after activation, and in practice was detected with ~ 85–90% efficiency on the individual receiver arrays forming the overall POST array (also variously referred to as curtains, lines, or gates elsewhere in the literature) when the average tag transmission interval was approximately every 60 s [14]. Multiple surgical trials indicated that this tag could be reasonably implanted in large smolts ≥ 140 mm in fork length (FL) [18–20].

In 2007, VEMCO introduced the V7 acoustic tag (69 kHz; 136 dB re 1 μPa @ 1 m) which are physically smaller than V9s and can be implanted into smolts ≥ 125–130 mm fork length [19, 21–23]. The trade-off is that this smaller tag has a weaker acoustic signal at source resulting in both a reduced range (reduced from ~ 400 to ~ 300 m in our experiments; see Additional file 1: Figure S1) relative to the low-powered V9 tags and a shorter lifespan when using the same programming. With all other factors remaining equal, this drop in range means that only about three-quarters as many tagged fish will be detected on a given telemetry array and only for a reduced maximum time period, restricting the detection efficiency (DE, the proportion of tagged fish present that are detected), and the maximum potential tracking distances and study duration. Despite this loss of information, the accuracy of the results using V7 tags has generally been deemed satisfactory when using release groups of a few hundred smolts per year to achieve baseline survival estimates in British Columbia [9, 10, 14] and in other salmon-bearing rivers systems [24–26]. Nevertheless, the minimum smolt size limits of approximately 130 mm (V7) or 140 mm FL (V9) excludes a substantial proportion of the overall size spectrum of migrating

Pacific salmon smolts. This raises important questions concerning the applicability of past results, given the lack of data from the population demographic that is contained within the lower end of its size spectrum.

Over the past decade, smaller tags operating at correspondingly higher frequencies have been developed, e.g., the Juvenile Salmon Acoustic Telemetry System (JSATS) tags, which transmit at 416.7 kHz [27, 28] and have been used primarily in fresh water, and VEMCO's family of 180-kHz [29] tags which are used in fresh water and marine environments. The first of the 180-kHz tags to be marketed was the V6 (V6-4H, 6 mm diameter, 16.5 mm length, 1.0 g in air, 143 dB re 1 μPa @1 m) followed by the V5 (e.g., V5-1H: 4.3 mm diameter, 12.7 mm length, 0.65 g in air, 143 dB) and more recently, the V4 (V4-1H: 3.6 mm diameter, 11 mm length, 0.42 g in air, 134 dB), with the latter capable of being implanted into salmon smolts smaller than 100 mm FL [30]. Despite their small size, these high-frequency VEMCO tags have roughly the same acoustic power output as some of the 69-kHz tags; however, the achieved detection range is much reduced because the higher-frequency signals attenuate more quickly in water. We found that the now-discontinued V6 tag had a detection range of ~ 80–100 m in the marine waters of the Strait of Georgia (see Additional file 1: Figure S1). We have not formally range tested the smaller V5 and V4 tags, but given their acoustic power relative to the V6, we expect ranges to be of roughly similar magnitude.

Use of a smaller tag has the biologically desirable feature of allowing a greater fraction of the migrating smolts to be included in a study; however, the trade-off is that with equivalent programming these smaller tags are more infrequently detected and for shorter maximum time periods. To improve performance, it is necessary to increase receiver density, tag numbers, and/or the transmission rate of the tag, which have profound implications for developing cost-effective, efficient arrays. For example, in the simplest possible case, the area monitored around a receiver is πr^2, where r is the detection range, so using a V4 instead of a V9 tag means that an array of receivers would theoretically need 16–25 times as many receivers to achieve the same areal coverage (and detections per tag) given the expectation that the tag-detection range will be reduced to 80–100 m from 400 m. Increasing the tag sample size can also compensate for the lower DE; however, if the DE is low (or survival is low), the sample size becomes cost prohibitive to achieve the same confidence intervals as for V9 tags, and when DE is very low, survival is often not estimable in practice in mark–recapture models. Increasing the transmission rate of the tag allows more opportunities for detection, but also decreases transmitter battery life which will in turn, limit study duration. Thus, finding the right balance is important for successfully estimating fish survival using 180 kHz tags.

To facilitate the transition to studies using smaller tags and smaller smolts, we tested the performance a new array design at detecting 180 kHz V4 tags. We deployed dual-frequency receiver arrays (VEMCO model VR4) in the Discovery Islands and Johnstone Strait region of British Columbia, a region bounded by the British Columbia mainland and Vancouver Island, and lying within the original POST array (Fig. 2). These two arrays were deployed as paired lines of receivers (each line is referred to as a subarray), with the subarrays separated by a reasonable distance that is large relative to the internode (receiver) spacing but sufficiently short so that few tagged animals were expected to die during the migration between the first and second subarrays. This resulted in a doubling of the number of receivers forming each of the new arrays, but with internode spacing close to that of the original POST array design so that an objective comparison of performance would be possible. Although we only doubled the number of receivers (rather than increasing it by 16–25 fold), we also decreased the tags' mean transmission intervals (from 60 to 20 s) to increase the probability that tags would be detected when within range of a receiver. We then double-tagged large, hatchery-reared steelhead (*Oncorhynchus mykiss*) smolts with high-power V9 (69 kHz; 151 dB re 1 μPa @ 1 m) and V4 (180 kHz; 134 dB re 1 μPa @ 1 m) tags (Fig. 1), tracked them through the array, and calculated the DE of both tag types (see "Methods"). Based on past performance, the high acoustic power V9 tags were expected to have near-perfect detection, which could then be used as a baseline to calculate the detection efficiency of the smaller 180-kHz tags as well as estimate smolt survival. That is, if the 69-kHz tag was detected and the 180-kHz tag was not, then we knew that the fish was near the receiver but not close enough for the 180 kHz receiver to detect the 180 kHz transmission. We then used a Cormack–Jolly–Seber (CJS) model to explore how the confidence intervals on estimated survival increase with decreased DE and how this may affect future 180 kHz-tag-based studies, where the actual detection probability is uncertain.

Results

Of the 50 double-tagged steelhead smolts released, 42 were detected on the Northern Strait of Georgia (NSOG) acoustic array 19 km north of the release site; eight were never detected (Table 1). One of the 42 detected fish turned south after being detected on NSOG and exited the Strait of Georgia via the Strait of Juan de Fuca. Thirty-two fish were subsequently detected on the Discovery Islands array (DI). Of those, four fish milled back and forth between NSOG and DI, with two of these four

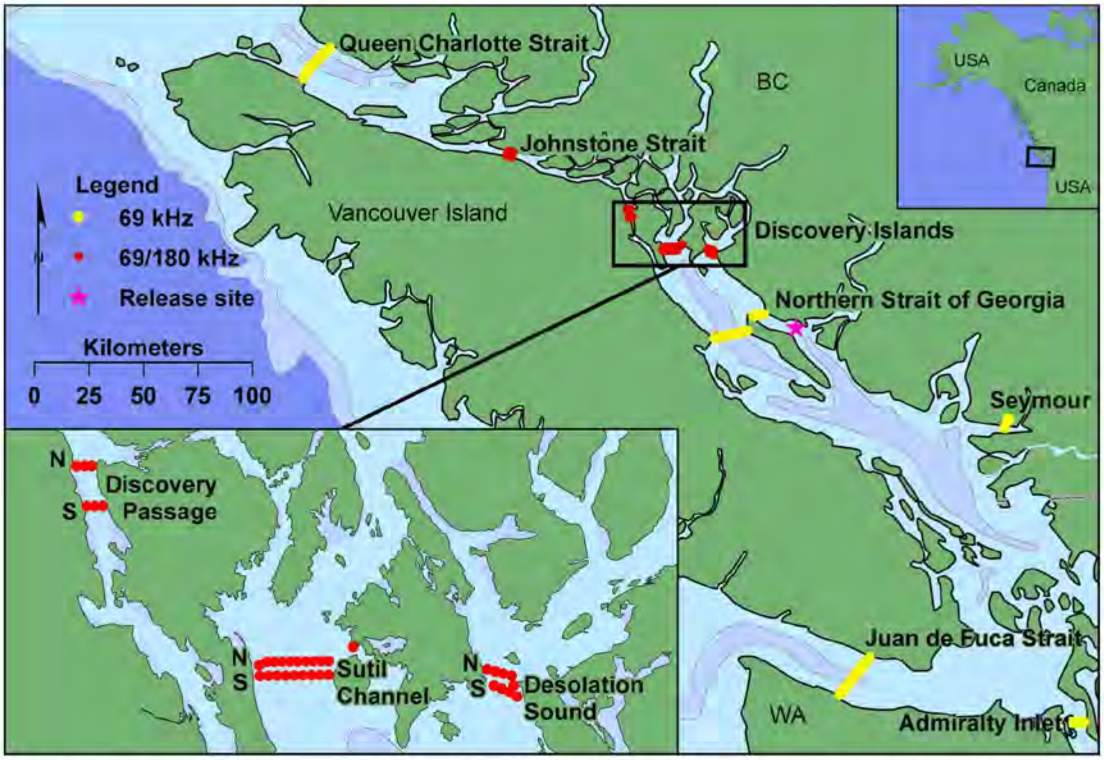

Fig. 2 Map of the acoustic array in 2015. The release location of double-tagged steelhead (*Oncorhynchus mykiss*) in Malaspina Strait is indicated by a star. The Johnstone Strait array is composed of two subarrays. The Discovery Islands array (inset) is composed of three sections: Discovery Passage, Sutil Channel, and Desolation Sound. Each section was composed of two receiver subarrays (north and south). The three northern subarrays were combined to form DI north and the southern subarrays were combined to form DI south

Table 1 Count of steelhead (*Oncorhynchus mykiss*) smolts by tag type detected migrating over the acoustic array

Array	69 kHz	180 kHz
Northern Strait of Georgia (NSOG)[a]	42	7
Discovery Islands (DI)	32[b]	20[b]
Desolation Sound (DS)	3	2
Sutil Channel (SC)	16	12
Discovery Passage (DP)	20	9
Johnstone Strait (JS)	23	4
Queen Charlotte Strait (QCS)[c]	14	NA
Strait of Juan de Fuca (JDF)[c]	1	NA

Fifty double-tagged fish were released

[a] Limited capability of detecting 180-kHz tags. (Few receivers were dual-frequency.)

[b] Several of the fish detected on DI were detected on more than one section

[c] Receivers incapable of detecting 180-kHz tags

last detected at NSOG (i.e., travelling south). There was also milling across the three waterways spanned by the DI array (see "Methods") with seven fish detected at more than one waterway.

A dynamic animation of the movements of the double-tagged Seymour River steelhead smolts is available [31] which can be panned and zoomed and used to obtain summary statistics as well as full detection histories. Movie versions of the animations are available on request.

Detection efficiency (DE)

The 69-kHz transmitters had 100% DE on the NSOG, DI, and Johnstone Strait (JS) arrays (i.e., all fish detected at subsequent locations on the migration path were first detected on the prior arrays (Table 2; Fig. 3). Detection efficiency of 69-kHz tags was also high (91–100%) for each of the individual subarrays forming the DI (south and north) and JS (east and west) arrays.

The DE of the 180-kHz transmitters on DI was 61%. This, however, was a lower bound on the estimate because the tags began to expire before all fish had passed DI (Fig. 4) because we postponed the fish release date (see "Methods"). Most tagged fish (79%) arrived at DI before the median projected day of battery expiry, 42 days post activation, suggesting that some 180-kHz

Table 2 Detection efficiency (DE) of 69-kHz (V9-1H) tags implanted in steelhead (*Oncorhynchus mykiss*) smolts

Array	*N* present	*N* detected	69 kHz DE (SE)
Northern Strait of Georgia	42	42	1.00 (0)
Discovery Islands	32	32	1.00 (0)
Discovery Islands south	32	31	0.97 (0.03)
Discovery Islands north	32	32	1.00 (0)
Johnstone Strait	23	23	1.00 (0)
Johnstone Strait east	23	23	1.00 (0)
Johnstone Strait west	23	21	0.91 (0.06)

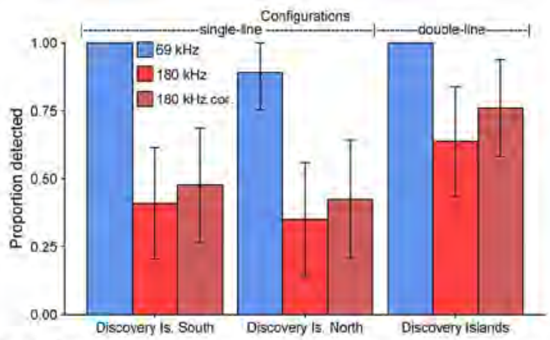

Fig. 3 Detection efficiency estimates and associated 95% confidence intervals for 180-kHz tags relative to 69-kHz tags implanted into steelhead (*Oncorhynchus mykiss*) smolts. Estimates for the 69-kHz tags were made using all detections. Estimates for the 180-kHz tags were made using all tagged fish that had arrived at the array before day 42 post tag activation (when 50% of 180-kHz tags were predicted to have expired). Corrected estimates (cor.) account for premature tag expiry (see "Methods"). Note that the single-line configurations (subarrays) were designed to function together rather than as independent replicates

tags likely stopped transmitting before being detected. If we limit the time period under consideration to 42 days, the calculated DE was slightly higher: 64%. If we assume that all tag batteries had been actively transmitting up to day 42, the DE of the 180-kHz transmitters on DI increases to 76% (referred to as "corrected"; Table 3; Fig. 3).

The DE of the 180-kHz tags on the individual DI lines was 41% on DI south and 39% on DI north using the full dataset, and 41% and 35%, respectively, when limiting the time period to the median date of projected 180-kHz tag expiry, and 48% and 42%, respectively, when corrected for expected tag expiry (Table 3).

Detections per tag

Although the resulting DE values suggest promising performance of the modified array design at detecting higher-frequency tags, a median of only four detections per 180-kHz tag was obtained compared to 73 detections for 69 kHz tags (Fig. 5a). Of the 22 double-tagged fish detected on DI up to day 42 using the 69-kHz tag, five 180-kHz tags were never detected (23%) and four (18%) were detected only once (Fig. 5b). Single detections are often questionable in telemetry studies, but in this case fish presence was confirmed by the paired 69-kHz tag.

Precision of survival estimates

Survival from release in Malaspina Strait to DI based on the 69-kHz data was 64% (32/50) with an SE of 7% and 95% confidence interval of 51–77%. The SE on the survival estimate for the simulated 180-kHz dataset with the same survival (see "Methods") was 9% and the 95% CI was 47 to 85%. Thus, the CIs widen for the 180-kHz tags because of the reduced DE (Fig. 6). See Healy et al. [8] for complete early-marine survival estimates of 69-kHz tagged steelhead from the Seymour River released in or near the Seymour River and tracked to Queen Charlotte Strait (QCS) in the same year as this study.

Discussion

Array performance

High acoustic power 69-kHz transmitters had excellent (100%) DE on the Discovery Islands array, allowing us to evaluate the performance of the new array at detecting harder-to-detect 180-kHz transmitters. The estimated DE was 76% (SE = 9%) for 180-kHz tags (Fig. 3; Table 3). This is comparable to the DE of VEMCO model V7 69-kHz tags that have been used to estimate early marine survival of sockeye (*Oncorhynchus nerka*), steelhead, and Chinook (*Oncorhynchus tsawytscha*) salmon migrating through the original POST array configuration [9, 10, 14]. In a separate concurrent steelhead tracking study, we found that the new array also greatly improved the DE of V7 transmitters (94%, SE = 3.5%, 95% CI 82–98%; [8]). Our results suggest that with appropriately redesigned array geometry it is now possible to track smolts ≥ 95 mm FL in the Salish Sea and other coastal marine ecosystems with acceptable statistical precision, and to track larger fish with lower tag burden with exceptional precision, at approximately a doubling of capital costs over the original POST array design.

Two important additional considerations for future survival studies, however, are that the number of detections recorded per fish was substantially reduced with the 180-kHz tag, as was the operational lifespan of the tags. Eighteen percent of the count of 180-kHz tags deemed present were based on a single recorded detection, despite the more frequent transmission interval (20 s on average vs. 60 s for the 69-kHz tags). Because some tags had expired or were nearing expiry, the frequency of single and zero detections may be biased high in this study

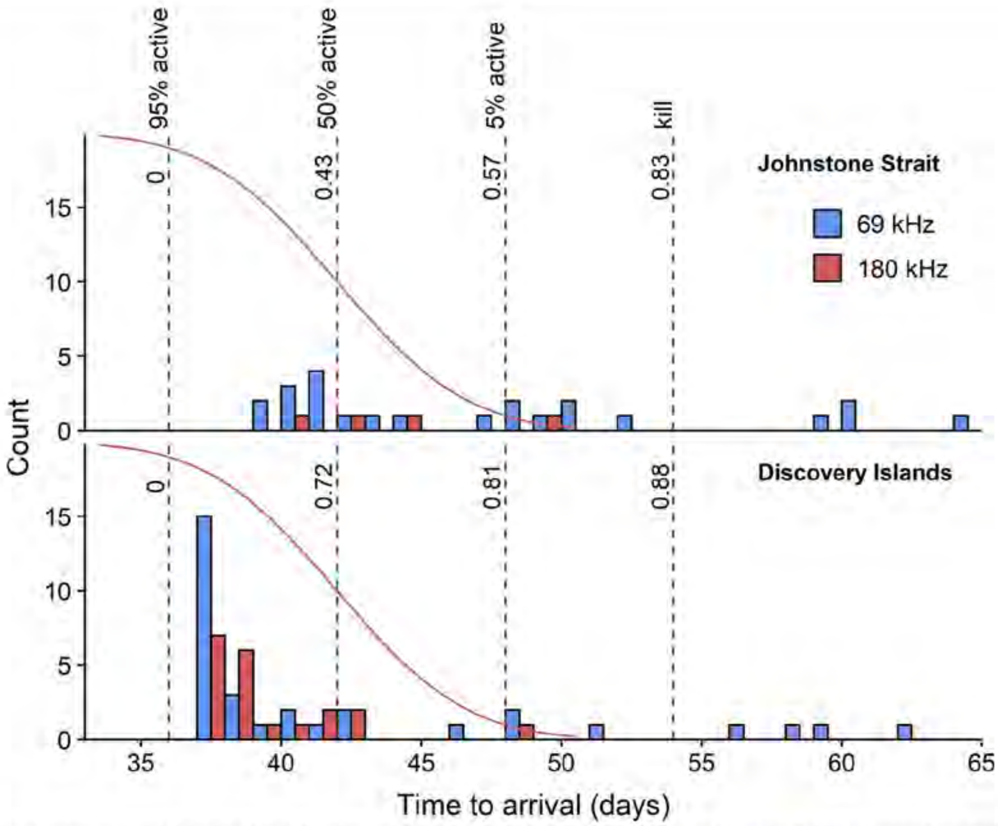

Fig. 4 Tag expiry time and time of arrival of double-tagged steelhead (*Oncorhynchus mykiss*). The red line predicts the proportion of 180-kHz tags that were still transmitting as the fish migrated north, based on the tag failure time distribution (see "Methods"). The dotted lines show the estimated dates at which 95%, 50%, and 5% of the 180-kHz tags were estimated to have remained active, and the kill date (day 54). The numbers on each dotted line are the percentiles of fish arriving at each array by these expiry dates, based on the 69-kHz tag detections. For example, 72% of the fish had arrived at the Discovery Islands array and 43% arrived at the Johnstone Strait array by the median time of 180-kHz tag expiry (day 42)

Table 3 Estimated detection efficiency (DE) of the 180-kHz (V4-1H) tags implanted in steelhead (*Oncorhynchus mykiss*) smolts

Array	Time period	*N* present	*N* detected	*N* corrected	DE (SE)	Corrected DE (SE)
Discovery Islands	< 50% expired	22	14	16.7	0.64 (0.10)	0.76 (0.09)
	100% off	28	17		0.61 (0.09)	
Discovery Is. south	< 50% expired	22	9	10.5	0.41 (0.10)	0.48 (0.11)
	100% off	27	11		0.41 (0.09)	
Discovery Is. north	< 50% expired	20	7	8.5	0.35 (0.11)	0.42 (0.11)
	100% off	28	11		0.39 (0.09)	

DE estimates are for two time periods: for detections recorded before day 42 following tag activation when 50% of 180-kHz tags were predicted to have expired; and for all detections until the tags were programmed to turn off (day 54). Numbers detected in both time periods exclude counts of 180-kHz tags only detected > 24 h after their paired 69-kHz tag ($N = 3$ at Discovery Islands, $N = 5$ at Discovery Islands south, and $N = 3$ at Discovery Islands north). N Present is known from the detection of the 69-kHz tag. The corrected DE is up to day 42

if the weakening battery reduces the acoustic power output (and thus range) near the time of battery expiry. In telemetry studies, single detections are often treated as potentially false and simply discarded, but they can be accepted as real if they meet other screening criteria [32]. In our experience, VEMCO technology as applied in past POST array studies has been very robust to false detections so the presence of a tagged fish can be reasonably inferred from a single detection, particularly when coupled with additional evidence such as travel time

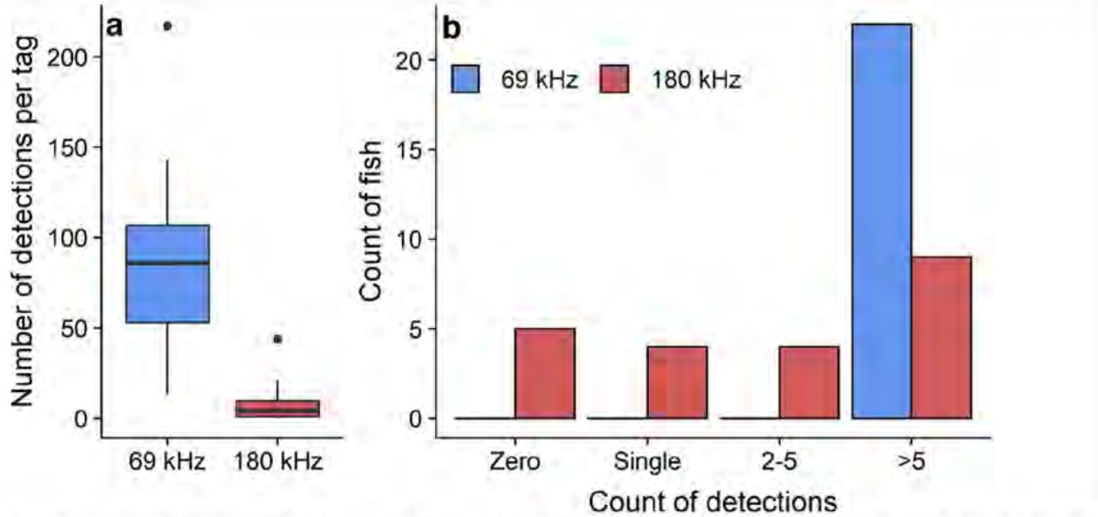

Fig. 5 Detections per tag type. **a** Median number of detections for 22 individual double-tagged steelhead (*Oncorhynchus mykiss*) on the Discovery Islands array that arrived before day 42 post tag activation (when 50% of 180-kHz tags were predicted to have expired). The central lines show medians, boxes show the inter-quartile range (central 50% of data points), whiskers bracket 1.5 times the interquartile range, and closed circles identify outliers. **b** The same data subdivided into count categories. Zero and single detections of 180-kHz tags are known because of the presence of the 69-kHz tag. Single detections are often excluded in telemetry studies and would increase the fraction of undetected 180-kHz tags

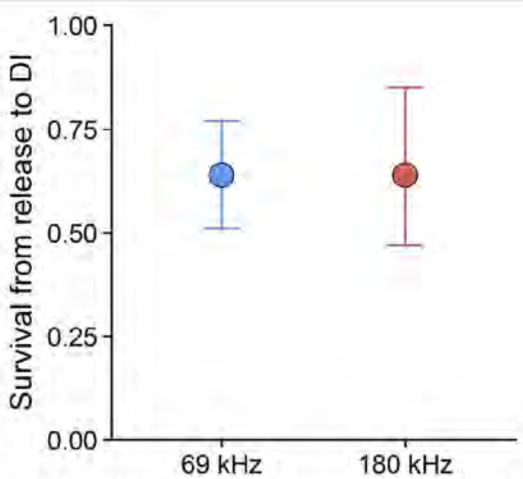

Fig. 6 Comparison of the statistical precision on survival estimates using two tag types. With identical survival estimates, the 95% confidence interval was 1.5x larger for the 180-kHz estimate relative to the 69-kHz estimate as a result of the reduced detection efficiency of the 180-kHz tags (76%) relative to the perfectly detected 69-kHz tags

and migration sequence over preceding and subsequent arrays. It is, however, preferable to have a few detections closely spaced in time to rule out the possibility of false positive detections bearing in mind that a very high number of recorded detections may not be cost-effective [33]. In this study, which was optimized for the 180-kHz tags, we were confident of fish presence or absence because multiple detections were recorded with the paired 69 kHz tag. If we had not had the benefit of the 69-kHz data and single 180 kHz detections had been excluded from the dataset, the efficiency of the Discovery Islands array at detecting 180 kHz tags would have dropped from 76% to ~ 55%. Likewise, if the array performance were to decrease due to stochastic variation, e.g., due to environmental conditions such as increased wind [34] causing potential single detections to be missed, the DE would decrease further.

Whether this further degradation in array performance is acceptable depends on the study design and objectives. A decrease in DE occurred in a subsequent study that was conducted using this array, in which tags were programmed to transmit at a slower rate. Stevenson et al. [30] tracked juvenile sockeye through this array in 2016 using 180-kHz tags transmitting every 45 s on average (to prolong transmitter life) and the resulting detection probability was 50%. It is still possible to estimate survival using CJS models with this reduced DE; however, the uncertainty in the survival estimate becomes larger as a result.

In general, the optimal design of telemetry arrays and the tagging studies that use those arrays involves complex trade-offs that must balance economic constraints (costs) and physical constraints (detection range, tag life) on scientific results. The probability of detection relies not only on the array design and tag programming, but also on the physical environment and the behavior of the tagged animal (e.g., migration speed). For example, performance might be reduced for a species that migrates along outer-coastal routes that could be subjected to higher and more-variable wind and wave states. In our study, the Discovery Islands array was deployed in an area of strong tidal currents (daily maxima > 5 knots) which can potentially degrade detection both because of higher background noise levels (reducing the range that signals can be detected) and the time that tags remain within that detection range; however, alternating tidal currents may also sweep fish back and forth past the receivers with the cycling of the tides, increasing the possibility of repeat opportunities for detection. Some steelhead used in this study also exhibited milling behavior in the area of the Discovery Islands, with individuals moving between Sutil Channel and Discovery Passage, and others moving back south to the NSOG array after being detected on the DI array. The interplay between array geometry, oceanographic features, and animal behavior will all play a role in the achieved performance of future studies.

Precision of survival estimates and trade-offs

To explore how precise CJS survival estimates were for 50 double-tagged fish using only the 180-kHz tag data, we compared the 180-kHz result to the exactly known survival calculated using the 69 kHz tag data, where precision (uncertainty) in the proportion surviving follows a simple binomial probability density function. The 95% confidence interval associated with the 180-kHz survival estimates was nearly 1.5 times larger (Fig. 6) because of the lower detection probability of the 180-kHz tags (76% compared to 100% for 69 kHz tags), increasing the uncertainty in the survival estimate. Whether the resulting confidence intervals are acceptable depends on the study goals. In our study, the 95% confidence interval on estimated survival was 47–85%. This level of precision is likely acceptable for exploratory (or "curiosity driven") research but may well be insufficient for hypothesis testing where smaller survival differences between two experimental groups need to be resolved to address management questions.

Trade-offs are necessary in telemetry studies. To reduce the 180-kHz tag SE on survival, either the number of receivers would have to be increased so that detection rates improve, the number of tags increased, the transmission rate of the tag increased, or some combination of all approaches. For example, a further 50% increase in receivers (and operational costs over time, which scale with array size) may increase the 180-kHz tag detection rate to that of the current 69 kHz rate; however, tighter confidence intervals on the survival estimates can always be obtained for a given array design because the statistical precision on the survival estimates scales proportionally to tag sample size, N, following an inverse square-root law, $SE(S) \propto \sqrt{1/N}$ (unpublished analysis).

Given the same array geometry and fish survival as this study, increasing the tag sample size to $N = 75$ would decrease the SE on the survival estimate to 7.2%, similar to the 69-kHz tag data. Further increasing the sample size to $N = 100$, the SE on survival would decrease to 6%. If confidence intervals half the reported width are desired, then tag sample size must be increased fourfold when using the same array; reducing confidence intervals to one-third the current level requires a nine-fold increase in tagging, etc. Diminishing returns rapidly set in from attempts to increase tag numbers and therefore augmenting the array design with additional receivers may thus prove more effective. High-performing, well-maintained, and geographically extensive arrays may provide better results than a simple array with much higher levels of tagging. For very-high-performing array designs where detection efficiency is essentially perfect, precision will then be determined primarily by tag sample size as the SE approaches that of a binomial proportion (e.g., [35]).

Conclusions

Our study demonstrates that 180-kHz tags can be used in the coastal ocean with reasonable increases in array cost relative to 69-kHz tags, given careful attention to array design and tag programming. The array performed well, detecting 76% of 180-kHz tags but with an approximate doubling in the capital costs of the array relative to the earlier POST array that was designed to detect 69-kHz tags. We found that the confidence limits on estimated survival were approximately 1.5 times larger for the 180-kHz data relative to the 69-kHz data because of reduced detection efficiency (DE). Whether the resulting confidence limits on survival estimates are acceptably small depends on both the scientific questions being posed and the potential economic value of the results. To increase the level of precision, one must consider for a given tag programming the economic trade-off between receiver density (cost to increase DE), and transmitters deployed (cost to increase sample size). Importantly, the use of smaller tags reduces potential tag burden effects which reduces biological effects, and allows acoustic telemetry studies to be extended to smaller fish including some populations where individuals were previously too small to tag.

Methods

Acoustic array

The original POST arrays were deployed along the juvenile salmon migration route in the greater Salish Sea area (Northern Strait of Georgia (NSOG), Queen Charlotte

Strait (QCS), Juan de Fuca Strait (JDF); Fig. 2). These arrays have been operating continuously since their deployment in 2004 and are currently maintained by the Ocean Tracking Network (OTN), Dalhousie University, Halifax, Canada. These arrays have been mostly equipped with VEMCO VR3 receivers that can detect 69-kHz tags only and can remain deployed for multiple years with data accessed remotely via an acoustic modem. They are configured as single lines with receiver spacing averaging 750–790 m. This spacing was suitable for low-power 69-kHz VEMCO V9 acoustic tags, the only salmon-smolt-appropriate tag type available at the time [5]. The use of smaller 180 kHz tags is of interest for research on juvenile Pacific salmon, particularly in the ocean, but these tags are incompatible with 69 kHz receivers.

In 2015, we deployed two additional arrays (43 receivers total) in the Discovery Islands (DI) and Johnstone Strait (JS) using VEMCO VR4 dual-frequency receivers capable of detecting both 180 kHz and 69 kHz tags (Fig. 2). Like the VR3 receivers, VR4s can remain continuously deployed for multiple years with data remotely accessed via a modem. The DI array is composed of three separate sections spanning the possible entry routes into the Discovery Islands: Discovery Passage (DP, to the west), Sutil Channel (SC, central), and Desolation Sound (DS, to the east). DP was located farther north than SC and DS to avoid an area of extreme tidal currents present at the mouth of DP. These routes converge to the north such that only one section was required for the JS array.

Although many array geometries are possible in principle, we deployed DI and JS as paired lines (termed subarrays) separated by 1.2–3.5 kms and with ~ 740 m spacing between individual receivers. The use of paired lines can improve detection efficiency (e.g., [36]) and provide some information on the direction of travel [37]. The subarrays were spaced far enough apart that a single detection was unlikely to be recorded on both simultaneously, but close enough that the sampling event can be considered instantaneous (an assumption required in using CJS models) such that tagged animals were unlikely to die between them. Because they are spaced close together, the subarrays are exposed to similar environmental factors that may affect detection probability (e.g., rainstorms) and are thus not independent replicates. However, the subarray spacing can still improve detection by reducing the probability that transient factors (e.g., a boat passing) may interfere with signal reception. Our achieved subarray distances varied because of geographic and oceanographic differences between sites (DP = 3.5 km, SC = 1.2 km, DS = 1.2 km, and JS = 2.2 km).

The receiver spacing on the individual subarrays in DI and JS was consistent with the POST lines. This allowed us to evaluate how well the individual subarrays detected the 180-kHz tags given the tags' reduced power and range, and also allowed us to compare the 69-kHz DE for individual lines in this tidally extreme area with that of single-line 69-kHz POST arrays in other parts of the study area. Maintaining this spacing also prevented overbuilding of the individual subarrays for 69-kHz tags while ensuring that the two subarrays combined resulted in adequate detection of the 180-kHz tags.

All receivers were successfully offloaded from DI and JS arrays between Aug 30th and Sept 3rd, 2015. OTN offloaded data from NSOG, QCS, and JDF in November 2015.

Acoustic tags

Fish were double-tagged with 69-kHz V9-1H and 180-kHz V4-1H transmitters (Fig. 1a). The V9-1H tags (9 mm diameter, 24 mm long, 3.6 g in air, 151 dB; hereafter 69-kHz tags) were programmed to transmit an acoustic signal at random intervals between 30 and 90 s (60 s average) until battery death or until transmissions were programmed to turn off, 107 days after activation. VEMCO estimated that 95% of 69-kHz tags would still be active 102 days after activation (estimated tag lifespan). The V4-1H tags (3.6 mm diameter, 11 mm long, 0.42 g in air, 134 dB; hereafter 180-kHz tags) were programmed to remain silent for the first four days after activation to conserve battery power prior to fish release (although fish were held beyond four days; see below). On day five they began transmitting randomly every 13 to 27 s (20 s average) until battery death or until transmissions were turned off 54 days after activation. VEMCO estimated that 95% of 180-kHz tags would still be active 36 days after activation, and that 50% would be active 42 days after activation.

Tagging

Fifty summer-run, hatchery-origin steelhead from the Seymour River Hatchery, British Columbia, were surgically implanted with one of each tag type on May 13-14th, 2015. Fish were approximately 14 months of age and ranged between 175 and 236 mm fork length at tagging. The combined tag weight in air was 4.0 g and the average tag burden (weight of the transmitters relative to the weight of the fish) was 4.8%. Tag burdens did not exceed 7%. Smolts selected for tagging were reflective of the size frequency of the overall hatchery population. Tags were implanted using Kintama's standard surgical protocols [18]. In brief, fish were anesthetized individually in 75 ppm (mg/L) of MS-222 buffered with 140 ppm $NaHCO_3$. A maintenance dose of 50 ppm anesthetic buffered with 100 ppm $NaHCO_3$ was pumped through the fish's mouth and over the gills while an incision was made at the ventral midline, midway between the pelvic and pectoral fins. Two transmitters (180-kHz and 69-kHz) were inserted through the incision into the peritoneal cavity, and two absorbable sutures were used to close the incision (Fig. 1b). The fish were held for several weeks at the hatchery because the release date was postponed to accommodate another field study we were conducting (not reported here). No mortalities were observed.

Transport and release

Tagged steelhead were transported to a more northern location along their migration route to avoid elevated levels of mortality which have been documented in Burrard Inlet and the lower Strait of Georgia [8, 38] and boost the sample size used to evaluate array performance. Several weeks after tagging, we loaded the tagged smolts into an aerated fish-transportation tank filled with fresh water along with ~ 150 unmarked individuals, moved them by truck for 2.5 h, loaded the tank onto a chartered commercial fishing vessel, then transited north for a further eight hours for release in Malaspina Strait (Fig. 2) on June 16th, 2015. Fish were released on a flooding tide and in darkness (at 1:00 am) to encourage northward migration and to minimize predation. Fish were released directly into the ocean via a large diameter hose connected to the side of the transport tank at a release site located 19 km south of the NSOG array. Tank temperature (11.7–12.8 °C) and dissolved oxygen concentration (7.3–13.7 ppm) were monitored and maintained throughout the transportation process.

Data management

Prior to analysis, we screened all data for false detections [32]. Although false detections are rare, they may occur as a result of environmental conditions creating noise similar to those used for telemetry, or from collisions between acoustic-tag transmissions that reach the receiver from direct or reflected paths (echoes). Fish with two or more detections of either tag within 0.5 h and with more detections spaced with short intervals (< 0.5 h spacing) than with long intervals (> 0.5 h spacing) were passed. Detections that failed this first step were assessed individually and were passed if the migration sequence was reasonable and if the travel time for the segment (i.e., between receiver lines) was within the 10th–90th percentiles of travel times calculated for each treatment using all detections. None of the 9226 detections were classified as false.

We also examined the sequence of detections to identify fish milling between subarrays: we classified 894 detections of four fish as out of sequence relative to the expectation of linear northward migration (all these fish were detected at NSOG after being detected at DI). These detections were excluded from estimates of detection efficiency and survival, but were included in the visualization of the migration [31].

Data analyses

Detection efficiency of 69-kHz tags

The detection efficiency (DE) of 69-kHz tags for NSOG, DI, and JS was calculated as the number of tagged fish detected at each array divided by the number of tagged fish known to have been there (fish detected + fish not detected but detected at any subsequent array in the migration). The uncertainty in measurements of DE was calculated as the standard error of a proportion, $\mathrm{SE}(p) = \sqrt{p(1-p)/N}$, where p is the detection efficiency and N is the sample size. When detection rates are less than perfect, we typically use Cormack–Jolly–Seber (CJS; Cormack 1964, Jolly 1965, Seber 1965) models to estimate detection probabilities and the associated error around these parameters; however, it was not necessary for the 69-kHz tags because the DE was 100% (see "Results"), so the CJS estimates converge on the binomial probability result.

To compare the 69-kHz tag DE of single-line to double-line configurations, we calculated the 69-kHz tag DE for each subarray in the DI and JS arrays using the same procedure described above (the number of tagged fish detected at each array divided by the number of tagged fish known to have been present), but also including any detections from the other line forming the pair in calculating the number of fish known to have been present (i.e., we assumed that mortality was zero in the short [< 4 km] distance between the paired lines). Like the double line configuration of DI, single line configurations combine all three sections (DP, SC and DS) of the DI array but the three northern subarrays were combined to form DI north and the southern subarrays were combined to form DI south.

Detection efficiency of 180-kHz tags (raw and corrected)

Our analyses focus on the performance of the DI array at detecting 180-kHz tags. Our original objective was to assess performance using both the DI and JS array design; however, fish transport and release was inadvertently delayed by several weeks, resulting in many of the 180-kHz tag batteries weakening or expiring by the time smolts reached JS (Fig. 4). Although battery expiry had begun by the time smolts reached DI, we were able to correct the DE estimates. We did not assess the 180-kHz tag DE at NSOG, QCS, or JDF because these arrays were not equipped to detect 180-kHz tags.

The presence or absence of tagged smolts was established using the 69-kHz tag data, making it possible to calculate the raw proportion of the paired 180-kHz tags that were detected on the DI array and its components by counting the number of 180-kHz tag codes detected relative to the 69-kHz count. The uncertainty for measurements of DE for the 180-kHz tag was calculated using the formula for the standard error of a proportion. We excluded fish that milled over the DI array from the proportion because milling behavior could provide additional opportunities for the 180-kHz tag to be detected and the resulting DE estimates would then be biased upwards. We reduced this bias by calculating the difference in the arrival times between each 180-kHz tag and its paired 69-kHz tag and then excluding all 180-kHz tag detections that were recorded > 24 h after their paired 69-kHz tag were recorded (N=3 at DI and DI north; N=5 at DI south).

Detection efficiency as calculated above probably underestimates the true DE of the 180-kHz tags because the 180-kHz (but not the 69-kHz tags) tags began to expire while the smolts were still in the study area (Fig. 4). To account for tag expiry, we weighted the count of 180-kHz tag detections in each 12-h period by the reciprocal of the tag lifespan curve. VEMCO has measured tag lifespan for large numbers of 180-kHz tags and reports that the tag failure time distribution is closely Gaussian, and well fitted by the mean time of failure, $\bar{t}$, and the standard deviation, σ_t (Drs. D. Webber and R. Vallee, VEMCO, pers. comm.). Thus, the cumulative normal function $(N(\bar{t}, \sigma_t))$ describes the percentage of tags expected to have expired before time t. The weighting function $\omega(t) = 1 - N(t|\bar{t}, \sigma_t)$ then describes the predicted proportion of 180-kHz tags expected to still be active at time t, and the reciprocal $\omega^{-1}(t)$ provides a multiplicative weight to inflate the observed 180-kHz tags detected on a given day to compensate for tags that have expired. For example, at the mean time of failure, 50% of the tags are predicted to have expired, so the corrected number of 180-kHz tags detected on that day would be double.

There are a few cautions associated with this correction factor. First, VEMCO notes that there is some variability in the tag lifespan curve across tag production batches and the specific tags that we implanted were not tested. Second, because the detected time of arrival was not exactly the same between the 180 and 69-kHz tags, we used the arrival time of the 69-kHz tags as t. The disparity likely occurs because of the smaller potential detection area around a receiver for the 180-kHz tag, so it takes longer for the tagged fish to enter the region where it can be detected. Finally, the inflation factors lying in the right hand tail of the distribution (i.e., applied to tag detections occurring later in the observational record, when few tags are predicted to be still active), are likely to incur substantial errors due to even slight departures from normality. To establish a cut off in the right tail of the distribution, we calculated the cumulative DE for these tags by progressively including more and more of the detection record until their kill date (day 54). The corrected estimates were stable for a few days beyond the mean date of tag expiry (day 42) and then became increasingly erratic, presumably due to breakdown in the correction. Thus, we included detections up to day 42 in the corrected estimates of DE for 180-kHz tags.

Survival and confidence intervals using 69-kHz tags

Detection efficiency was 100% for the 69-kHz transmitters at the NSOG, DI, and JS arrays; therefore, survival could be calculated simply as the number of fish detected at each array divided by the number of fish released, and the uncertainty calculated as the standard error of a proportion $(S) = \sqrt{S(1-S)/N}$, where S is survival and N is the sample size. The Wald 95% confidence interval is S ± 1.96*SE.

Survival and confidence intervals using 180-kHz tags: CJS method for comparison

Typical survival studies do not have any additional information to confirm fish survival (i.e., fish are not generally double-tagged with a more powerful transmitter, as they were in this study), so we wanted to estimate the error that was obtained using only the 180-kHz tags where DE is uncertain, and where survival and DE (and their variances) are estimated using spatial variants of the CJS model. These models are used for live-recaptured animals where each array of acoustic receivers that the smolts encounter is considered a recapture event. This framework jointly estimates survival and detection probability and their variances within a maximum likelihood framework and is used when the true detection rate is unknown or less than one. Standard CJS model assumptions are: (1) every tagged individual of each group has equal survival probability and equal probability of detection following release, (2) sampling periods are instantaneous, (3) emigration is permanent, and (4) tags are not lost.

Our data from the 180-kHz tags violate CJS model assumption (1), that every tagged individual has equal probability of detection following release, because some tags expired during the study period. Therefore, we simulated a 180-kHz tag detection dataset unaffected by tag expiry. To do so, we used the values in Table 3 (detection probabilities for 180-kHz tags corrected for tag expiry) and 69-kHz survival estimates to generate capture histories using a custom script in R [39]. In this simulated dataset, each fish (N=50 to equal the sample size at release) was designated as 'detected', or 'not detected', at each array in the migration sequence (DI and JS). Because tag expiry prevented us from estimating the detection probability of 180-kHz tags for JS, the final recapture site in our field study, we assumed in our model that the DE at JS would equal the DE at DI. This assumption is reasonable because both arrays were deployed with the same geometry and had zero gear loss; however, unknown site-specific differences in environmental conditions may alter performance. By setting the DE of JS equal to DI, we could generate capture history sequences that would allow us to estimate survival and detection probability at DI. We used the simulated capture histories and Program Mark [40] to construct CJS models using the R [39] package RMark [41]. Standard error was estimated using the profile-likelihood option available in Program Mark.

We then compared CIs calculated using the powerful 69-kHz tags to the CJS estimates produced using the more difficult to detect 180-kHz tags to determine by how much the precision of the survival estimate degrades when detection probability is less than perfect. The standard error of a survival proportion (used for the 69-kHz tag data) takes into account only the sample size because detection is perfect, while the CJS survival estimate accounts for reduced (imperfect) detection performance as well as sample size. In practice, most telemetry array studies have less than perfect detection performance, so the latter methodology is more common for telemetry-based studies of survival.

Detections per fish per tag type

We further assessed the performance of the DI array by summing the number of 69-kHz and 180-kHz tag transmissions recorded for each individual fish arriving at DI before day 42 (when 50% of 180-kHz tags were predicted to have expired; $N=22$). We subdivided the total detections per tag into "zero", "single", "2–5", and ">5" detections per tag. Validity of single and zero detections from the 180-kHz tags were verified by multiple detections of the more powerful 69-kHz transmitter.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s40317-020-00205-z.

Additional file 1: Figure S1. Detection probability of acoustic tag transmissions as a function of tag depth and tag-to-receiver distance.

Abbreviations

CI: Confidence interval; CJS: Cormack–Jolly–Seber model; DE: Detection efficiency; DI: Discovery Islands array; JDF: Juan de Fuca array; JS: Johnstone Strait array; JSATS: Juvenile Salmon Acoustic Telemetry System; NSOG: North Strait of Georgia array; OTN: Ocean Tracking Network; POST: Pacific Ocean Shelf Tracking; SE: Standard error; QCS: Queen Charlotte Strait array.

Acknowledgements

We thank the Seymour Salmonid Society for providing steelhead for tagging and access to the hatchery; Captain Barry Curic and the crew of the Fishing Vessel Denman Isle for array deployment and fish transport; and Dr. Brian Riddell (Pacific Salmon Foundation) for facilitating the long term lease of acoustic receivers from the Ocean Tracking Network used in this study.

Authors' contributions

ER and DW conceived of the study and designed the array. ER and PW tagged and transported the fish. PW deployed the acoustic receivers and offloaded fish detection data. AP and ER performed data analyses. ER and AP wrote the manuscript with input from DW. All authors read and approved the final manuscript.

Funding

This is Publication Number 43 from the Salish Sea Marine Survival Project: an international, collaborative research effort designed to determine the primary factors affecting the survival of juvenile salmon and steelhead survival in the combined waters of Puget Sound and Strait of Georgia (marinesurvivalproject.com). Funding was provided by the Pacific Salmon Foundation. In-kind support (acoustic receivers) was provided by the Ocean Tracking Network and Kintama Research Services Ltd.

Availability of data and materials

The fish tagging metadata, detection data, and R scripts supporting the conclusions of this article are available in the Dryad repository, https://doi.org/10.5061/dryad.8w9ghx3j8. Array metadata and data are available at Ocean Tracking Network https://members.oceantrack.org/project?ccode=NEPKRS.

Ethics approval and consent to participate

All work involving live fish met the standards laid out by the Canadian Council on Animal Care.

Consent for publication

Not applicable.

Competing interests

DWW is president and owner of Kintama Research Services, an environmental consultancy that designed and operates the main elements of the acoustic telemetry array described in this article.

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Publisher's Note

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Tue Dec 01 13:55:51 2020

To: David Welch

Subject: RE: New (really small) tag

Importance: Normal

Thank you David

Glad we could catch up today

From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, December 1, 2020 1:48 PM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] New (really small) tag

Here is a photo of the tags that I said I would send.

#3 & #4 from the left are the tags we used back in the BPA-funded work (69 kHz).

#2 is a 180 kHz tag which we have extensively evaluated and characterized its performance in the ocean (see the attached paper just out—the abstract is all that you need to read to get the gist of what we achieved).

#1 is the new tag and is approximately the same size at the JSATs "injectable" tag (307 kHz). It is still in the pre-commercial stage but we have a formal agreement with the company to do a full-on "Kintama" performance evaluation in the February-March in the coastal ocean off the west coast of Vancouver Island, pandemic permitting. This is very promising because it will probably cover the entire size range of Fall & Spring Chinook, coho, sockeye, and steelhead. Acoustic tags will never work for outmigrating pink or chum fry—just too small.

Nice talking to you again.

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

From: David Welch

Sent: Thu Dec 03 09:43:33 2020

To: Ben Zelinsky; Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Sharp decline in SE Alaska Chinook returns continue

Importance: Normal

https://www.ktoo.org/2020/12/01/state-says-taku-and-stikine-kings-are-not-projected-to-rebound-in-2021/?mc_cid=bef9a490f8&mc_eid=ceb9fb289e

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Mon Jan 11 09:35:03 2021

Subject: FW: Announcement Posted: Fish and Wildlife Administrator, GS-0480-12 - Closes 1/14/21

Importance: Normal

My apologies, it's come to my attention that my original email didn't go through. I am resending once again, please consider applying / forward to individuals that may be interested.

Thank you,

Luisa

From: Monroy Flores,Luisa F (BPA) - EWB-4
Sent: Tuesday, January 5, 2021 12:45 PM
To: Monroy Flores,Luisa F (BPA) - EWB-4 <lfmonroyflores@bpa.gov>; Jule,Kristen R (BPA) - EWP-4 <krjule@bpa.gov>
Subject: FW: Announcement Posted: Fish and Wildlife Administrator, GS-0480-12 - Closes 1/14/21

Hello,

The GS-12 Fish and Wildlife Administrator position just opened in the Policy and Planning (EWP) org. Below are the details for this job announcement.

Announcement #: DOE-BPA-21-14317-MP

Position Title: Fish and Wildlife Administrator, GS-0480-12, (EWP) – Portland, OR

Opening Date: 01/05/2021

Closing Date: 01/14/2021

USAJOBS - Job Announcement

Individuals that are eligible to apply are:

- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Land and Base Management
- Military Spouses

- Peace Corps & AmeriCorps Vista
- Special Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

Bonneville Power Administration
bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

Facebook-Icon_31x31_v3Flickr-Icon_31x31Instagram-Icon_31x31LinkedIn-Icon_31x31Twitter_31x31YouTube_
31x31

From: David Welch

Sent: Tue Jan 19 11:39:23 2021

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] RE: ISAB Assignment to review Welch et al. 2020

Importance: Normal

Attachments: Schaller et al (Senior Scientists Review of Welch et al. 2020 11.23.20-NWPCC 2021).pdf

Hi Christine—

Of course, we would be glad to share our response with you folks. Unfortunately, it is not quite ready for sharing as yet—Aswea is working on my first draft, and Erin has yet to read my draft or Aswea's edits. And (sigh) we now have the 16(!) page single-spaced memo from Schaller et al that we will need to address as well as the 21 page FPC memo, so lots of work.

Erik Merrill sent me the Schaller memo (attached) last Friday as part of an email advising me of the various times that the ISAB are open for a Zoom meeting to discuss the issues. I have asked Erik the provenance of this memo because it doesn't say, but I am guessing that it is something the authors sent to the NWPCC. I don't think that there is an issue with me sharing it with you folks, but I can't be certain as yet, so please be a bit discreet and ask your colleagues not to share it outside BPA until I understand where it came from and if there is any problem in sharing it.

Overall, my sense of the Schaller et al memo is that it is a useful contribution to the debate—they don't flat out lie and distort what we said as the FPC have done, but they do make a strong claim on the superiority of the PIT tag SARs over CWT-based SARs (more precise and accurate) that is just flat out wrong. I was surprised to see that claim made, so it will be good for folks to have us (Kintama) spell out why the world has changed for them—because harvests are significant and unaccounted for, past PIT tag-based SAR analyses in the Columbia River Basin will be forever compromised and probably can't be fixed. (That doesn't mean they can't be fixed going forwards).

I feel sorry for the individuals that have invested a lot of their career into those analyses, but I guess it just isn't clear yet to people just how consequential the failure to correctly incorporate harvest into all the past SAR analyses are—and the PST modifying harvest rates in response to perceived abundance adds another whole layer of unrecognized complexity to the rather naïve approaches people have used in the past.

David

P.S. BTW, I liked the Lewiston Tribune article you mentioned (Josh Murauskas sent me the link on the weekend). I thought it was a very fair and balanced piece of work. However, I also like it because it shows the fallacy in Michelle's thinking. She is quoted as follows: *"If the ocean conditions are really bad and your objective is to get as many adult fish back to the river as possible, your management strategy is to do everything you can to get the highest possible survival in freshwater, to get as many smolts out to the ocean as possible, to get as many adults back as possible," she said.*". That is not actually true for the reason that I have been banging on about for a decade now—if ocean survival dropped to zero, getting *"as many smolts out to the ocean as possible"* would be a failure—equivalent to flushing them down the toilet.

(b)(5) [redacted]

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: January 19, 2021 11:06 AM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi David,

I was just about to write you. I did not see this yet from Schaller. (this morning we were looking at a critique of the sampling for fish condition in John Day that they issued).

We wanted to ask you if your group was able to share your response to the FPC review. Crystal Ball, Kristen Jule, Jody Lando were interested in it, but they were just discussing the Lewis Tribune opinion piece. Salmon science dispute rages | Outdoors | lmtribune.com . This sounds like a handful to think about and deal with, but your paper was well thought out and you have a good background for many topics that were not in your paper that might come up. I will talk to Jody later this afternoon and will bring this up.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, January 18, 2021 2:11 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: ISAB Assignment to review Welch et al. 2020

Hi Christine—

FYI, below. Just keeping you in the loop.

I assume that you have seen the Schaller et al memo that we have to address as well? (If not, I can send you a copy, but it might be more appropriate to get it from Erik Merrill directly; as my email to him below says, I don't really understand where it was submitted to).

I am looking forward to the ISAB review because this will be (finally!) a chance to professionally call out the FPC and demonstrate just how questionable their credibility is—their 21-page critical memo is chock-full of deceptive claims and (in some cases) even deliberate lies. Refuting this in public is going to be a good thing, and the Schaller et al memo demonstrates that those folks still aren't thinking through the key issues.

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) [redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

From: David Welch <David.Welch@Kintama.com>

Sent: January 18, 2021 2:01 PM
To: Erik Merrill <emerrill@nwcouncil.org>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi Erik-

Thanks for your email last Friday. I asked my co-authors to complete the Doodle poll and be prepared to make themselves available for the virtual review meeting with the ISAB.

I do think that the suggested time line of ~ 90 minutes is unreasonably short—our actual initial meeting could actually run closer to at least half a day and possibly a full(!) day. As things currently stand, we have to present our paper and our response to the FPC memo and (now) the Schaller et al memo. (You can tell the ISAB members that, on the bright side, we will be saving them a lot of work—by addressing the FPC & Schaller memos point by point, they get to sit back a bit and adjudicate on whether in their collective opinions the FPC/Schaller criticisms or our rebuttals are more credible, so we get to do the heavy lifting and then they get to assess whether our rebuttals are on point and hold water).

I wonder if you and I could have an initial call to discuss the issues, and get a sense of direction as to what is most important for the NPCC review? My draft rebuttal of the FPC (21 page) memo is now in the hands of my co-authors and was (at last count) now ~48 pages long (that includes the ~19 pages of text pasted in from the FPC memo so that we can't be accused of avoiding something the FPC wrote). To this we now add the 16 page Schaller et al memo that we also need to address. Fortunately, that memo mostly covers similar ground but with a different emphasis, so will be quicker to deal with.

A couple of questions here:

1. The Schaller et al review doesn't say where it was sent to. How should I reference it… as a memo sent by Schaller et al to the Council? (It doesn't say).
2. What is going to be the most effective format for presenting (and defending our work)? This is the main reason for asking to set up a phone call—it is more of a discussion bouncing back and forth the pros and cons of what is going to work best for the Council/ISAB. I am not looking for unfair advantage here, but if time is short I don't want to put much if any, time on presenting our paper if we have the publicly released FPC memo to deal with—there are a mix of downright lies in it and deliberate misrepresentations that we need to address, so from Kintama's perspective if time is very short we have to devote it to demonstrate that the FPC (& now Schaller) memos are clearly off-base and why.

Like the rest of the planet, I am working from home for the duration of the pandemic. My cell doesn't work well at the house, so try my landline first. (Or specify a time and I can call you).

Regards, David

David Welch,

Kintama Research Services

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From: Erik Merrill <emerrill@nwcouncil.org>
Sent: January 15, 2021 7:51 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Gregory, Stanley Vincent <stanley.gregory@oregonstate.edu>; Erik Merrill <emerrill@nwcouncil.org>; Leslie Bach <LBach@NWCouncil.org>
Subject: ISAB Assignment to review Welch et al. 2020

Hi David,

The ISAB assignment to review your and your co-authors' article "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" has been approved, and we are gathering review materials and scheduling briefings for that assignment and three others.

We invite you and your co-authors to brief the ISAB on your study. If you'd like to brief us, please fill out this Doodle poll of ISAB online meeting dates and time blocks: February 5, February 18, March 18, April 8, and February 19 if needed. We generally schedule briefings for an hour, about 30 minutes each for presentation and discussion. Do you think that is adequate time to present and discuss your team's article? The briefing should help us answer our assignment questions, below. A few days before the briefing, the ISAB might share some additional specific questions to help guide the briefing and discussion.

Please see the ISAB's assignment description and references below, and please send any other key documents to ISAB Chair Stan Gregory (copied) and me to share with the ISAB and others. From our previous email discussion, I know you have the FPC's response to your article and plan to develop a rebuttal. The ISAB will also consider a review by Howard Schaller, Charles Petrosky, and Margaret Filardo, which is attached.

Thank you for considering our invitation, and please share the message and Doodle poll with your co-authors.

Stay well,

Erik

Evaluate "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" (Welch et. al 2020) and its interpretation of the implications of smolt-to-adult return values as well as the Fish Passage Center's review of the paper (FPC 2020)

The Independent Scientific Advisory Board is asked to review scientific basis for the analysis of regional declines in Chinook salmon abundances and the conclusions and recommendations of "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" (Welch et. al 2020). A review by the ISAB could provide an important context for interpreting the findings and important questions raised by this recent publication and the Fish Passage Center's review of the paper (FPC 2020).

Welch et al. 2020 examined SAR data for Chinook salmon for the Pacific coast to determine whether there are large-scale patterns of salmon survival based on coded wire tag data. Welch et al. report Chinook salmon survival has declined broadly across the Pacific coast and SAR values of 1% or less are widely observed. They highlight the use of the low SAR values to support management actions in the Columbia River Basin and question the validity of the interpretation of those SAR values. They note that similar declines in SAR values have been observed in west coast rivers without major dams and suggest that "contemporary survival is driven primarily by broader oceanic factors rather than local factors." They identify several methodological issues related to analyzing coded wire tags and PIT tags to calculate SAR values. Based on these interpretations, they indicate that targets for restoring salmon populations in the Columbia River Basin may not be attainable and question whether restoring freshwater habitat or improving dam passage will improve returns of salmon. The authors suggest that salmon recovery efforts should focus on actions in the marine environment rather than freshwater habitats. Welch et al. 2020 called for "a systematic review by funding agencies to assess consistency and comparability of the SAR data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast." These findings and their interpretations raise critical questions that should be examined more closely.

In response to requests from the Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife, the Fish Passage Center conducted a technical review of the Welch et al. paper and raised issues about the paper's methods, results, and interpretations (FPC 2020).

A review by the ISAB would provide information for the Council and regional policy makers for interpreting the findings of the Welch et al. paper about SARs, salmon survival, and appropriate management actions and the Fish Passage Center's criticism of the paper.

Review questions for the ISAB:

1. Was the Welch et al. analysis scientifically sound, and were the data it used appropriate for addressing the question?

2. Were the conclusions drawn by Welch et al. supported by their results?

3. Does the ISAB have recommendations to improve the current analysis and interpretation of SAR values in the future?

4. Are the criticisms raised by the Fish Passage Center supported by the evidence and do any of those criticisms weaken Welch et al.'s results or conclusions?

5. What are the management implications of the ISAB's conclusions and recommendation?

If feasible, we would appreciate a completed review by April 23, 2021.

References

Fish Passage Center (FPC). 2020. Technical review of Welch et al. (2020), titled, *A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae).* Memorandum from Michele DeHart (FPC) to Bill Tweit (WDFW), Tucker Jones (ODFW), and Margaret Filardo (citizen). December 4, 2020. https://www.fpc.org/documents/memos/53-20.pdf

Welch, D.W, A.D. Porter, and E.L. Rechisky. A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha*, Salmonidae). *Fish and Fisheries* 2020; 00: 1– 18. https://doi.org/10.1111/faf.12514

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Review of: Welch DW, Porter AD, Rechisky EL. A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae). Fish Fish. 2020; 00:1–18. https://doi. org/10.1111/faf.12514

Review by: Howard Schaller, Ph.D. Retired Project Leader of the Columbia River Fish and Wildlife Conservation Office, US Fish and Wildlife Service; Charles Petrosky, Ph.D. Retired Fisheries Biologist, Idaho Department of Fish and Game; and Margaret Filardo, Ph.D. Retired Senior Fisheries Biologist, Fish Passage Center

November 23, 2020

<u>Summary points</u>

In Welch et al. (2020), the authors present information on coastwide salmon survival and conclude that there are important and profound policy implications of Chinook salmon SARs falling to about 1/3rd of early levels and converging to similar levels nearly everywhere along the west coast of North America. This leads them to argue that Chinook survival is primarily a function of ocean conditions, and current efforts focusing on habitat improvements are misguided. However, all of these speculative conclusions drawn by the authors are rooted in fundamental problems in the basic Coded Wire Tag (CWT) data they relied upon, the poor documentation of the source of these data, and the inconsistent application of these data in their estimates and surveys for SAR estimates. The numerous serious technical problems with Welch et al. (2020) negate their major conclusions. Specifically, the technical issues associated with this paper include the following:

- Inconsistencies in the basic CWT release and recovery data used. Welch et al. poorly document the source of these data and, inconsistently apply these data in both their SAR estimation process and in the SAR data and estimates they collate from various reports;
- The hatchery mark groups used in the study represent a combination of hatchery production, supplementation, and experimental groups. Using experimental or supplementation groups could yield SAR estimates considerably different from production releases. They fail to identify these categories of groups used and the implications of using experimental groups;
- There is a misuse, or at least mischaracterization of, what Welch et al. refer to as Pacific Salmon Commission (PSC) Chinook Technical Team (CTC) survival data;
- CWT based survival estimates contain large uncertainty around the estimates due to the short comings of CWT methods and sampling efforts. The authors do not recognize or address that uncertainty;
- Welch et al. present a very one-sided perspective in the comparison of CWT versus Passive Integrated Transponder (PIT) tag based SAR estimates. They fail to recognize that given the many ESA listed fish populations, PIT tags are a more conservation-oriented method that, due to the multiple recaptures of fish, produces a survival estimate that does not require fish mortality to recover the tag;
- The calculation of CWT based SARs for Columbia River populations was inconsistent with that used for the rest of the Oregon, Washington, B.C. and Alaska indicator stocks;

- There is no documentation describing how the authors generated consistent estimates for SARs within and across regions, or how they accounted for discrepancies. In fact, the authors conclude that *'we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series'*. These data discrepancies and methodological problems appear to be a fundamental flaw in their coastwide CWT based SAR analysis;
- These problems compound because the authors ignore the uncertainty for these CWT based SAR estimates, then using these inconsistent estimates they attempt to evaluate patterns of survival across regions, and then compare and make judgement about the efficacy of much more precise PIT tag based SARs;
- Welch et al. rely primarily on coastwide subyearling hatchery Chinook survival rates (based on PSC CTC data) to make inferences about Snake River wild yearling Chinook. This approach is not valid due to the large differences in ocean exploitation rates (ER) between the life history types. Subyearling Chinook have high ocean ER while yearling Chinook have very low ER. Consequently, the survival rate. measurements used by the authors are not equivalent life stages for the subyearling versus yearling populations and are incorrectly used;
- Welch et al. mischaracterize the Northwest Power and Conservation Council (NPCC) 2-6% SAR goals. The goals were established for stream-type wild Chinook, and also applied to wild steelhead. It's widely recognized in the Columbia Basin that the specific goal may not apply to subyearling Chinook because of the dramatically different life history strategy, and certainly not a goal to be applied to hatchery populations;
- Welch et al. establish a false dichotomy for their analysis by incorrectly concluding that ocean conditions are the overriding factor influencing Chinook survival with no impact from freshwater conditions; where the evaluation should focus on the combined influence of both the freshwater and marine environments. The authors ignore the regional strategy for Columbia River populations, which strives to understand the influence of marine conditions when evaluating restoration actions in the freshwater environment. This regional strategy provides a framework where restoration actions can be assessed to determine if they provide a high likelihood of sustained survival rates for achieving recovery goals in the face of variable marine conditions;
- The paper does not establish a specific hypothesis(ses) that is (are) being tested;
- Welch et al. appear to hypothesize that if coastwide Chinook populations have declined, then Snake and Columbia population declines are primarily the result of ocean conditions. However, the primary comparison tests implemented use a very short time series (recent 5 years) without taking into consideration the high level of uncertainty for CWT-based SARs. Given this short 5-year time series analysis (that ignores the confidence intervals about SAR estimates) it is impossible to seriously evaluate the influence of ocean conditions on west coast Chinook survival rate patterns. Consequently, Welch et al. draw an unsupportable conclusion that ocean conditions are driving Chinook survival patterns in similar manner coastwide;
- The Welch et al. analysis has an emphasis on distant Southeast Alaska wild stocks (SEAK), but the authors appear to dismiss SAR values from Mid-Columbia populations as outliers, even though these populations share the same estuary and near shore conditions and are genetically similar to Snake River Chinook populations;

- The limited time period (5 years) precludes actually linking SAR patterns to ocean conditions, especially recognizing the various dispersed ocean entry points (literature e.g., Peterman et al. shows strongest correlation of marine survival within about 500 km of ocean entry points);

- Authors ignored relevant Snake and Columbia literature regarding FCRPS influences on life cycle survival, SARs and marine survival (i.e., delayed mortality) (McCann et al. 2019, Schaller and Petrosky 2007, Schaller et al. 2014, Petrosky et al. 2020));
- Authors present no formal evaluation or hypothesis test for delayed mortality. The results and conclusions on delayed mortality are reached by the authors without any rigorous analyses of SAR estimates or synthesis of previous studies The authors conclusion is derived from their visual inspection of Figure 2 and their unsupported assumption that distant Chinook hatchery populations with different life history are a better SAR comparison to Snake River yearling Chinook populations than wild yearling populations in the Columbia River (which migrate through fewer dams) that share the same estuary and early ocean conditions.

In summary, Welch et al.'s conclusion that ocean conditions drive coastwide SAR patterns, and that freshwater conditions may not be drivers of SARs, is questionable given all the methodological flaws described above. These conclusions are reached by the authors visual observation of patterns in their Figure 2. In order to support their conclusion, a rigorous statistical analysis of these survival rate times series is warranted.

The poorly evaluated conclusion that ocean conditions drive these coastwide SAR patterns is contrary to the large body of published literature that concludes Chinook salmon population survival rates are most influenced during estuary and early ocean life stages (Petrosky and Schaller 2010). Recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Nickelson 1986; Pearcy 1992; Mueter et al. 2002, 2005; Pyper et al.2005; Peterson et al. 2006). This early marine stage is a very vulnerable life stage for salmon because they make the transition from freshwater phase to a seawater phase involving numerous physiological changes while encountering marine predators. Therefore, especially recognizing the various dispersed ocean entry points for the salmon populations included in the Welch et al. paper, the influence of estuary and near shore ocean conditions would be highly variable (Peterman et al. 1998 shows strongest correlation of marine survival within about 500 km of ocean entry points), and would not support a common marine influence across such a wide geographic range of populations used in Welch et al. In fact, numerous peer reviewed studies found that both freshwater and oceanic factors best explain the variation in yearling Chinook SARs, and these assessments are based on long time series that encompasses a large degree of variation in both marine and fresh water environmental and management conditions (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020).

Specific comments (by section)

Abstract

The authors state "Given the seemingly congruent decline in SARs to similar levels, the notion that contemporary survival is primarily driven by broader oceanic factors rather than local factors should be considered." In fact, numerous studies have directly considered local and oceanic factors for PIT tag SARs and life cycle survival rates (which the authors don't cite). These studies have shown that both freshwater migration conditions and marine conditions are highly influential to survival (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020).

The authors state: "Ambitious Columbia River rebuilding targets may be unachievable because other regions with nearly pristine freshwater conditions, such as SE Alaska and northern BC, also largely fail to reach these levels." This authors' conclusion was based primarily on hatchery stocks from these regions, which are irrelevant to wild Interior Columbia stream-type Chinook SAR goals.

The authors claim that PIT tag SAR estimates from the Columbia River Basin are generally consistent with CWT findings is a questionable conclusion. Their primary analysis is based on five years of data, with limited environmental contrast. Studies that have found that both freshwater and oceanic factors are influential to salmon survival are based on long time series, encompassing a large degree of variation in environmental and management conditions (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020).

The authors statement that PIT tag-based SARs are not adjusted for harvest which compromises their intended use, is extremely misleading. The authors fail to point out the several advantages that PIT tags have over CWT, which are especially important in systems with dams and allow for detecting tags in ESA listed fish without having to sacrifice fish to recover a CWT. Including harvest in PIT tag SARs is a relatively simple matter for Interior Columbia stream-type Chinook. In addition, many published analyses have incorporated harvest into PIT tag-based SARs (Schaller et al. 2007, Petrosky and Schaller 2010, McCann et al. 2017, McCann 2018, and Petrosky et al. 2020). These studies illustrate different temporal and spatial patterns in survival rates and document a strong influence of both freshwater and marine conditions on SARs and life cycle survival rates.

1. Introduction

Welch et al. sets up a false dichotomy of ocean versus freshwater influences on salmon survival in literature (whereas a wealth of existing literature shows it can be both in altered systems).

Not sure they accurately reflected NPCC 2-6% SAR goals; they do not acknowledge the parallel objective of understanding ocean influence so that actions taken in freshwater can help ensure salmon can survive in face of varying ocean conditions.

The introduction seems to be setting up a means to discredit NPCC SAR goals for wild interior Columbia stream-type Chinook, but they then focus most of the analysis on hatchery ocean-type Chinook. Recent analysis in Petrosky et al. (2020) gives more direct evidence supporting NPCC goal relative to Marmorek et al (1998) and NMFS Interior Col. River rebuilding goals (ICRTRT 2007). This support is for stream-type Chinook and by analogy steelhead. It is well understood that 2-6%SAR goal applies to stream-type Chinook and steelhead given similar life history expressions. One wouldn't expect ocean type fish that emigrate shortly after hatching to have similar goals. This is complicated by their analysis which relies on hatchery ocean type Chinook, which have nothing to do with wild stream-type Chinook.

Welch et al. misleadingly states that harvest is not included in PIT tag-based survival estimates. They further state that the "*previously unrecognized limitation* of PIT tagging methodologies is critical to current conservation efforts in the Columbia River Basin because of changes to the terms of the US-Canada Pacific Salmon Treaty…" This is completely false; users of the PIT tag data are fully aware of the portions of the life cycle incorporated in PIT tag estimates. Note that it is a trivial matter to incorporate harvest effects for Snake/Columbia stream-type Chinook populations, which are not intercepted in ocean fisheries. In fact, harvest has been accounted for in many published analyses using PIT tags (which they neglect to cite).

The authors describe a 3-fold process for calculating CWT based SARs (which they don't apply), then they criticize PIT tag SAR methods that doesn't include animals removed by fisheries. However, this statement is false, because in many instances PIT tag SAR methods do include fishery pacts (Petrosky and Schaller 2010, McCann et al. 2017, McCann et al. 2018, and Petrosky et al. 2020.

At broadest level of stock comparison, they claim most of the population decline is due to the ocean via common processes. Their broadest level comparison of populations ignores the different life-history types for these stocks. They don't do any direct analysis of how ocean conditions influence patterns for SARs (the authors comparison employs a very short time series of SARs). The authors conclude that ocean conditions drive these coastwide SAR patterns and freshwater conditions have limited influence on SARs. The authors ignore numerous published studies that have directly considered local and oceanic factors for PIT tag SARs and life cycle survival rates. These studies have shown that both freshwater migration conditions and marine conditions are highly influential on Chinook survival rates (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020). For these reasons, the broad generalization (by the authors) that most salmon conservation problems are caused by ocean conditions is extremely misleading.

2.1 Methods/Data Sources

The authors analysis heavily relies on hatchery subyearling Chinook groups. The comparison of survival estimates of these subyearling stocks to SARs for Interior Columbia stream-type Chinook is questionable, because of the difference in life history patterns and period of ocean residence. One may expect to see some general relation of patterns of survival due to large scale ocean conditions, but the authors' approach looked at very short time series of SARs, which would preclude looking at temporal SAR patterns in relation to variable ocean conditions (given past decadal scale oscillation of ocean conditions, Mantua et al. 1997) . However, with the very different life histories, tagging locations and ocean entry points, it's a stretch to expect magnitude of SARs to be similar.

Authors claim PIT tags transmit a signal. PIT tags don't transmit – they're passive receptors after being energized thru antennae array to transmit. The large infrastructure of detection arrays in the Columbia River located at dams and instream sites is why they're used here. PIT tags are more accurate and precise for survival estimates. Using PIT tags, one can differentiate migratory pathways thru system. With CWTs you need to kill a fish to recover the coded information, whereas PIT tags allow for multiple mark/recapture methods. Authors never present or use the large uncertainty surrounding CWT based survival estimates. The authors fail to mention any short comings of CWT resulting in a very one-sided presentation. Given the numerous ESA listed fish populations, PIT tags are a more conservation-oriented method since fish don't need to be killed to read a tag code.

Summary of Methods and Data base problems in Welch et al.

Based on the description of Welch et al. in section 2.2, they calculate the SARs based on the equation in section 2.2. This is a very different estimation procedure than the brood year survivals the PSC calculates, which are the Age 2 survival rates. The age 2 cohort size is estimated through the CWT run reconstruction for a stock specific brood year for a PSC indicator stock. This Age 2 survival rate = (age 2 cohort estimate/CWT release numbers) for an indicator stock and brood year. This is in no way equivalent to SARs used in the Snake or Columbia River studies for stream type Chinook (CSS reports, Petrosky and Schaller 2010, or Haeseker et al. 2012). The Age 2 brood year survival rate was a convention used to estimate a survival factor to be used in the PSC projection model.

So, what Welch presents in the paper is an SAR based on his formula in section 2.2. These SAR estimates are not contained in any PSC documents or produced by the PSC Chinook Technical Committee. Welch carefully states in section 2.2 that the *"database was the source of CWT-based Chinook survival estimates for all regions outside of the Columbia River Basin and for a few stocks located in the Columbia River Basin."* He claims; *the PSC database provides several methods of SAR*. However, review of the supplemental material for the Welch paper provided no reference to a PSC document for his SAR approach. However, curiously in the Welch supplemental material (see attachment Table S1. Datasets of smolt-to-adult return (SAR) estimates for Chinook salmon (*Oncorhynchus tshawytscha*) used in this study: faf12514-sup-0002-tables1.docx) there is a reference to a personal communication with Gayle Brown of DFO (see reference below), **which is not a sanctioned PSC database.** Therefore, they appear to be using something produced by Canada DFO, which is not an official PSC document or database. Either way, it is not clear where the documentation for these data sources and SAR methods resides, or, if they do at all.

Independent of Welch's misattribution of the source of SAR data and methods, there is a long list of problems with the data Welch uses and the inconsistency for SAR methods he employs. These problems include:

1- The dependence on comparing hatchery stock CWT based SAR performance with wild populations.

2- The inappropriate summary and comparison of SAR survival performance using yearling and subyearling populations interchangeably.

3 - The inconsistent approach for calculating CWT based SARs for Columbia River populations versus the rest of the Oregon, Washington, B.C. and Alaska indicator stocks. Welch states in the paper under section 2.3 that for Columbia River Chinook stocks *'they collated some annual reports..... to build up a partial inventory of CWT-based SAR estimates for Chinook."* However, by Welch's own description there

are big differences from the PSC method and huge discrepancies from hatchery program to hatchery program within the Columbia River basin. Welch states that these supplemental Columbia River CWT based SAR estimates were not expanded for incidental mortality or interdam loss, a departure for the method he applies for estimating SARs for the other Oregon, Washington, B.C. and Alaska indicator stocks. In addition, the supplemental Columbia River hatchery program CWT based SAR estimates that Welch inventories have inconsistent methods applied across these programs. In particular, Welch states in section 2.3 that; *'Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish.' See Table S1 for details.* Therefore, by Welch's own description, there are very different methodologies applied to estimating CWT-based SARSs across the regions and even within the Columbia River programs. It appears this fact alone would invalidate the conclusions of the range wide comparison on SARs, given that these discrepancies can impact SAR estimates and associated levels of uncertainty.

4 - These previous issues we identify do not touch on the subject of how the CWT-based SARs have a high degree of uncertainty given the problems of high variability in catch and escapement sampling rates that generate extremely wide confidence bounds in the CWT based SAR estimates. Welch does not report any confidence bounds for his CWT based SAR estimates failing to consider the potentially large uncertainty in his methodology. Welch et al. also ignores this uncertainty when comparing SAR estimates across regions and, therefore, draws tenuous conclusions.

2.2 Pacific Salmon Commission (CWT-based estimates)

Hatchery SARs primarily represent subyearling fall Chinook and are generally calculated from hatchery release to return to hatchery or spawning grounds plus harvested fish. An exception, are five Alaska spring Chinook hatcheries that release directly into ocean after seawater acclimation, which is very different from headwater Columbia River Chinook experience. The Wild Alaska stocks are tagged during downstream migration (SARs exclude mortality from upstream natal areas). It would be informative to have the confidence bounds on these stocks (low mark numbers, high uncertainty, no mark/unmark ratio specific to the wild stocks).

2.3 Agency estimates (CWT-based estimates)

Welch et al. used published estimates for fall, fall-winter, winter Chinook from Sacramento River. They collated hatchery reports to estimate SARs for Columbia Basin spring Chinook (SARs exclude upstream passage mortality). Questionable how well these methods align with Welch methods employed for PSC indicator stocks and quality control on CWT recovery methods. Methods and quality control for many of the supplemental groups differ dramatically. Some of the CWT based estimates were for experimental groups, which is inconsistent with PSC indicator stock estimates for production groups.

2.4 Pacific States Marine Fisheries Commission Estimates

The authors used estimates for UCOL Entiat hatchery spring Chinook. It is unclear what data quality control was employed. The PSMFC source is a data base, and the authors don't describe how they calculated SARs. Entiat mark numbers were variable over years, and in recent years CWT marks were significantly reduced (no CWT estimates after brood year 2007). Entiat Hatchery moved to PIT tags to better estimate survival rates for the hatchery. It appears the Entiat CWT expansions done by authors had no explanation of approach, no Confidence Intervals provide for CWT based SARs, and no mark levels reported by authors. Entiat CWT marking ended in 2007 (Table S1), why is this reported then in 5 most recent years (2010-2014)? The authors' approach for estimating Entiat SARs appears to be a big outlier from the approach they employed to estimate the SARs for PSC indicator stocks.

2.5 Raymond (1988) estimates

Used estimates for Snake and upper Columbia stream-type Chinook (1960s-80s). Smolts indexed at uppermost dam, adults as returns to uppermost dam plus harvest loss (excludes upstream passage mortality as well as mortality of juveniles from natal areas to uppermost dam). Note, Raymond's SAR estimates for Snake stream-type Chinook have been re-calculated to also include upstream passage mortality in CSS reports, but these re-calculated estimates were not used by Welch et al. 2020.

They claim they use the Raymond data in conjunction with CWT estimates for a more complete time series. CWT's don't begin until 1979 when comprehensive PSC recovery began.

Note also SARs in upper Columbia and Snake had declined by the early 1970s in response to dam construction and operation, this decline was prior to the 1978 ocean regime shift.

2.6 Comparative Survival Study (PIT tag-based estimates)

Welch cites using SARs for Snake river Chinook estimated from Lower Granite back to Lower Granite. Note that SARs are also available from LGR to BON, which for wild stream-type Chinook represents primarily pre-harvest returns since the 1990s. (Since ESA listing, there is no directed harvest and limited catch and release mortality (about 2%) allowed below Bonneville dam).

Welch et al. cite CSS report language that SARs do not incorporate losses due to harvest because PIT tags not sampled in fisheries. They neglect to mention or cite that several published analyses (and Chapter 5) do incorporate harvest rates (and upstream passage loss) in stream-type Chinook and steelhead SAR estimates (a fairly trivial matter for stream-type Chinook and steelhead).

2.7 Division by life history

Populations were grouped by subyearling/fall and yearling spring Chinook. When Welch et al. draw the conclusion that ocean conditions are primarily responsible for the patterns of Chinook survival coastwide, it is inappropriate to lump their SAR estimates for stream-type and ocean type Chinook stocks. In addition, they ignore the numerous studies that assess the ocean and inriver factors that best explain the variation in SARs and life cycle survival for wild stream type Chinook.

2.8 Comparisons between regions

The authors do not document how they generated consistent estimates for SARs within and across regions. In fact, the authors conclude that 'we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. This appears to be a fundamental flaw in the coastwide CWT based SAR analysis. This problem only compounds when the authors ignore the uncertainty for these CWT based SARs, then they attempt to evaluate patterns of survival across regions, and then compare and make judgement about the efficacy of much more precise PIT based SARs. The authors make no attempt at formally evaluating the similarity or difference in patterns of SAR estimates across populations. In fact, no attempt is made to estimate the CIs for any of the SAR estimates. The authors simply draw the conclusions for their interpretation of a visual inspection of figure 2. The conclusions drawn from similarities and differences from figure 3 do not provide an evaluation of the pattern of SARs. Also, given the differences in life histories, hatchery vs wild, and within hatchery groups experimental versus production groups the SAR comparisons are dubious at best.

The extremely short 5-year time series (employed by the authors) inhibits making robust and rigorous conclusions about ocean factors that influence survival patterns for Chinook populations. Because of different mark levels and recovery rates for different groups, the analysis should have directly considered the CI about the CWT SARs to reflect the highly uncertain nature of these estimates.

The use of normalized ratio relative to Snake isn't clear whether this is for CWT. Analyses should directly incorporate the uncertainty in CWT and PIT SARs, to support rigorous and robust conclusions concerning temporal and spatial survival patterns for Chinook populations.

Note: The authors acknowledged that SARs may not measure the same portion of life cycle for the various stocks employed in their comparison.

2.9 Comparison between CWT and PIT tag-based SARs

It is not clear from Welch et al. how they made adjustments for release to LGR and harvest mortality PIT based SARs.

In the equation for the aggregate correction factor in section 2.9 it is unclear and undocumented where the estimates for the parameters S_{smolt} and S_{adult} originated, which are critical parameters that shape comparison.

The second approach to estimate correction factor was to identify populations with both CWT based and PIT based SARs through regression analysis. The authors tried, but couldn't develop a relationship between PIT and CWT based SARs. They couldn't find much data from the same populations to compare CWT based to PIT based SARs, and all of these comparisons are from hatcheries. Where both SAR estimates were available, regression relationships were strong but biased. Subyearling CWT SARs were higher than subyearling PIT SARs (because harvest was not captured in PIT SARs). Yearling CWT SARs were lower than PIT SARs. A correction factor appears infeasible. All of these comparisons lack rigor, because the authors ignored the confidence intervals for CWT based SARs vs CI for PIT tagged based SARs. Ignoring uncertainty for CWT based SARs (which tends to be relatively high) vs PIT based SARS (relatively low) and the small amount of comparison data, brings the authors slim findings into question.

3 Results

They used SARs from 94 hatchery populations, 26 wild and 3 hatchery-wild mixed populations. All populations outside Columbia are CWT-based. Within Columbia, CWT and PIT SARs were used.

3.1 SARs from coded wire tags

Independent of Welch's misattribution of the source of SAR data and methods, there is a long list of problems with the data Welch uses and the inconsistency for SAR methods he employs. These problems include:

1- The dependence on comparing hatchery stock CWT based SAR performance with wild populations.

2- The inappropriate summary and comparison of SAR survival performance using yearling and subyearling populations interchangeably.

3 - The inconsistent approach for calculating CWT based SARs for Columbia River populations versus the rest of the Oregon, Washington, B.C. and Alaska indicator stocks. Welch states in the paper under section 2.3 that for Columbia River Chinook stocks *'they collated some annual reports..... to build up a partial inventory of CWT-based SAR estimates for Chinook."* However, by Welch's own description there are big differences from the PSC method and huge discrepancies from hatchery program to hatchery program within the Columbia River basin. Welch states that these supplemental Columbia River CWT based SAR estimates were not expanded for incidental mortality or inter-dam loss, a departure for the method he applies for estimating SARs for the other Oregon, Washington, B.C. and Alaska indicator stocks. In addition, the supplemental Columbia River hatchery program CWT based SAR estimates that Welch inventories have inconsistent methods applied across these programs. In particular, Welch states in section 2.3 that; *'Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish.' See Table S1 for details.* Therefore, by Welch's own description, there are very different methodologies applied to estimating CWT-based SARSs across the regions and even within the Columbia River programs. It appears this fact alone would invalidate the conclusions of the range wide comparison on SARs, given that these discrepancies can impact SAR estimates and associated levels of uncertainty.

4 - These previous issues we identify do not touch on the subject of how the CWT-based SARs have a high degree of uncertainty given the problems of high variability in catch and escapement sampling rates that generate extremely wide confidence bounds in the CWT based SAR estimates. Welch does not report any confidence bounds for his CWT based SAR estimates failing to consider the potentially large uncertainty in his methodology. Welch et al. also ignores this uncertainty when comparing SAR estimates across regions and therefore draws tenuous conclusions.

They state that SARs extending back to before 1978 show 3-fold decrease in SARs for hatchery populations. Snake and Upper Columbia rivers stream-type Chinook were in serious decline by early 1970s, well before 1978 regime shift]. Not clear what baseline they actually used for this. Selection of a base line needs to be clear so as to precisely test a posited hypothesis. Methods and results are organized around a vague set of questions without a specific approach to evaluate a well-defined question or hypothesis. For example, the authors describe how they '*collate Chinook SAR time series for the west coast of North America to document broad patterns in survival*'.

Wild populations have higher SARs than hatchery. Limited CWT data for wild and no data from wild versus hatchery SARs from same population. Wild AK SARs lower than hatchery SARs but AK hatcheries release directly into ocean. Only CWT populations in 2-6% recovery range was UW experimental hatchery in Puget Sound & Chilliwack hatchery in Strait of Georgia.

<u>3.2 Comparison between regions</u>

Authors conclusion that ocean conditions drive these coastwide SAR patterns and that freshwater conditions may not be drivers of SARs, is questionable given all the methodological flaws described above; In addition, these conclusions are reached by the authors visual observation of patterns in their Figure 2. In order to support their conclusion a rigorous statistical analysis of these survival rate times series is warranted;

Authors (dubiously supported) conclusion that ocean conditions drive these coastwide SAR patterns, is contrary to the large body of published literature that concludes Chinook salmon population survival rates are most influenced during estuary and early ocean life stages (numerous references from our past pubs; Particularly Petrosky and Schaller 2010). Recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Nickelson 1986; Pearcy 1992; Mueter et al. 2002, 2005; Pyper et al.2005; Peterson et al. 2006).This early marine stage is a very vulnerable life stage for salmon because they make the transition from freshwater phase to a seawater phase involving numerous physiological changes while encountering marine predators. Therefore, especially recognizing the various dispersed ocean entry points for the salmon populations included in the Welch et al. paper, the influence of estuary and near shore ocean conditions would be highly variable (Peterman et al. 1998 shows strongest correlation of marine survival within about 500 km of ocean entry points), and would not support a common marine influence across such a wide geographic range of populations used in the Welch et al. paper.

However, the only comparison tests the authors' implement is using a very short time series (recent 5 years) without taking into consideration the high level of uncertainty for CWT-based SARs. It is difficult to see how from a short 5-year time series analysis (that ignores the confidence intervals about SAR estimates) that one could seriously evaluate the influence of ocean conditions on west coast Chinook survival rate patterns. Finally, the authors claim 'they examined the CWT and PIT tag SAR data sets to evaluate the broader evidence for "delayed mortality," an important theory that argues that the greater dam passage experienced by Snake River stocks predisposes these populations to lower subsequent survival after migration out of the hydropower system than populations not migrating through the Snake River dams'. The authors present no formal evaluation or hypothesis test for delayed mortality and they dismiss the findings of numerous peer reviewed studies that found the operation and configuration of Columbia River hydrosystem impacts SARs and life cycle survival (delayed hydrosystem mortality) for Snake River stream-type Chinook populations. The results and conclusions of the Welch et al. paper are reached by the authors without any rigorous analyses of SAR estimates or synthesis of previous studies.

3.3 SARs from PIT tags

The authors summarize PIT-based SARs in the Columbia River stating that wild fish have generally higher survival and different regions have similar of lower SARs to Snake River. Exceptions are two Mid-Columbia River wild yearling populations (John Day & Yakima), which fall within 2-6% SAR target.

The authors state that both wild and hatchery subyearling SARs from the Mid-Columbia have SARs that fall well below Snake River SAR medians. In addition, the authors state that all other populations (including 3 hatchery Mid-Columbia yearling populaitons) have SARs which rarely or never exceed 2%.

Authors mischaracterize NPCC 2-6% SAR goals. The goals were established for stream-type wild Chinook, and also applied to wild steelhead. It's widely recognized in the Columbia Basin that the specific goal may not apply to subyearling Chinook because of the dramatically different life history strategy and is certainly not a goal to be applied to hatchery populations.

3.4 Comparison of CWT and PIT-based SARs

The authors tried, but couldn't develop a relationship between PIT and CWT based SARs. They couldn't find much data from the same populations to compare CWT based to PIT based SARs, and all of these comparisons are from hatcheries. Where both SAR estimates were available, regression relationships were strong but biased. Subyearling CWT SARs were higher than subyearling PIT SARs (because harvest not captured in PIT SARs). Yearling CWT SARs were lower than PIT SARs. Correction factor appears infeasible. All of these comparisons lack rigor, because the authors ignored the confidence intervals for CWT based SARs vs CI for PIT tagged based SARs. Ignoring uncertainty for CWT based SARs (which tends to be relatively high) vs PIT based SARS (relatively low) and lack the small amount of comparison data, brings the authors slim findings into question.

DISCUSSION

4.1 SAR comparison

3rd paragraph: "North American decreases in survival have occurred despite governments' best attempts through harvest regulation, hatchery enhancement and habitat restoration. A major assumption is that freshwater habitat degradation … make important contributions to the decreasing survival…" Welch et al. ignore the literature in Snake and Columbia that indicate both freshwater and ocean conditions are important drivers. They ignore the NPCC strategy of freshwater actions to ensure salmon can survive in face of variable ocean conditions.

8th paragraph: Delayed mortality paragraph: Welch et al. do cite the CSS chapter on delayed mortality & emphasize that direct tests of the theory have not found evidence to support it (citing their own [flawed] studies. They neglect to cite Haeseker's (2013) review comments and also neglect to mention the weight of evidence that actually does support delayed mortality. They further treat the John Day and Yakima wild yearling Chinook SARs as outliers, by stating that three PIT tagged hatchery mid-Columbia yearling populations and two (wild) upper Columbia populations have similar SARs to the Snake River populations (Figure 5). The flaw with this logic is two-fold: (1) hatchery yearling Chinook SARs are typically lower (sometimes dramatically) than wild due to a number of hatchery operational conditions and genetic differences, which can reduce fitness, and (2) upper Columbia wild yearling Chinook pass through similar number of dams as Snake River populations (the similarity in SARs would be expected due to presence of similar numbers of dams). In addition, mid-Columbia wild steelhead also exhibit higher SARs than counterparts in the Snake and upper Columbia (CSS 2019), mirroring the situation for wild yearling Chinook.

4.2.2 PIT tag-based estimates

Welch et al. statement about exclusion of survival from release to Lower Granite Dam can vary substantially cited (Faulkner et al. 2017). Note that SARs from upper dam to Columbia River mouth (including harvest & dam passage mortality) explained the majority (80%) of variation in life cycle survival rates of Snake River stream-type Chinook over a 70-year period (Petrosky et al. 2020). Whatever survival variation from rearing areas to the uppermost dam occurred in these years was much less influential.

Welch et al. statement that PIT-based SARs do not provide credible measure of SAR (because harvest is not included) is flat-out wrong. SARs can be measured at various locations, as is clearly pointed out in the CSS report which they cite. For wild yearling Chinook, the SAR with returns to Bonneville Dam include virtually all harvest impacts. Since ESA listing, no direct harvest occurs downstream of Bonneville Dam, and incidental catch and release mortality has been capped at about 2% (depending on projected run size). Moreover, incorporating the effects of stream-type Chinook harvest (and upstream passage mortality) into SAR analyses is straightforward and common in CSS Reports (Chapter 5) and peer-reviewed literature (e.g., Schaller et al. 2014; Petrosky et al. 2020).

4.3 Harvest and PIT-based SARs

Welch et al. statement about PIT-based SARs not accounting for stream-type Chinook river harvest is misleading (see previous comments). Harvest accounting for subyearling Chinook PIT-based SARs is more challenging than for yearlings. The authors apparently do not understand how PIT based SARs are used in the Columbia Basin, but uses (or misuses) them anyway.

The authors state that a challenge with using PIT-based SAR estimates to set quantitative recovery targets for Columbia Basin Chinook is that the fishery management strategy is divorced from the goals. This is false for stream-type Chinook. CSS analyses (Chapter 5) and Petrosky et al. (2020) demonstrated that pre-harvest SARs of 4% (the NPCC average SAR goal) for Snake River stream-type Chinook would result in about 70% of historical productivity. In addition, Lower Granite to Lower Granite SARs of less than 1% (after river harvest) have been shown to result in generational declines in abundance of Snake River wild stream-type Chinook and steelhead (CSS Chapter 5).

Conclusions

The authors statement in results section 3.1 '*Most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift..... show an approximate threefold decrease in SARs for hatchery populations (Figure 2).*', is the basis for the major conclusions. They claim '*The policy implications of Chinook salmon SARs falling to about 1/3rd of early levels and converging to similar levels nearly everywhere along the west coast of North America are profound.*' They draw from this statement to make the following conclusions:

1. fisheries community need to re-assess several core conservation assumptions;
2. if survival also falls by roughly the same amount in regions with nearly pristine freshwater habitats (SE Alaska, north-central British Columbia), it is difficult to argue for a major role of regional factors in causing the decline;
3. question the actual effectiveness of freshwater habitat restoration initiatives when northern populations with nearly pristine freshwater conditions have similar SARs;
4. Given the similarity of the decline in survival, the economics of hatchery Chinook production are likely similar in other regions;
5. It is unclear whether the quality of reported harvest rate estimates is good enough for past PIT-based SAR estimates to be reliably converted into useful survival estimates;

All of these speculative conclusions drawn by the authors are rooted in fundamental problems in the basic CWT data they relied upon, the poor documentation of the source of these data, and the inconsistent application of these data in their estimates and surveys for SAR estimates. The authors do not document how they generated consistent estimates for SARs within and across regions. In fact, the authors conclude that 'we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. This appears to be a fundamental flaw in the coastwide CWT based SAR analysis. This problem only compounds when the authors ignore the uncertainty for these CWT based SARs, then they attempt to evaluate patterns of survival across regions, and then compare and make judgement about the efficacy of much more precise PIT based SARs. The authors make no attempt at formally evaluating the similarity or difference in patterns of SAR estimates across populations. In fact, no attempt is made to estimate the CIs for any of the SAR estimates. The authors simply draw the conclusions for their interpretation of a visual inspection of figure 2. The conclusions drawn from similarities and differences from figure 3 do not provide an evaluation of the pattern of SARs. Also, given the differences in life histories, hatchery vs wild, and within hatchery groups experimental versus production groups the SAR comparisons are dubious at best.

The authors conclusion that ocean conditions drive these coastwide SAR patterns and freshwater conditions may not be drivers of SARs, is questionable given all the methodological flaws described above. However, the authors dubiously supported conclusions are dismissive of the large body of published literature that conclude Chinook salmon population survival rates are most influenced during estuary and early ocean life stages (Petrosky and Schaller 2010). Recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Nickelson 1986; Pearcy 1992; Mueter et al. 2002, 2005; Pyper et al.2005; Peterson et al. 2006). This early marine stage is a very vulnerable life stage for salmon because they make the transition from freshwater phase to a seawater phase involving numerous physiological changes while encountering marine predators. Therefore, especially recognizing the various dispersed ocean entry points for the salmon populations included in the Welch et al. paper, the influence of estuary and near shore ocean conditions would be highly variable (literature e.g., Peterman et al. shows strongest correlation of marine survival within about 500 km of ocean entry points), and would not support a similar influence across such a wide geographic range.

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From: David Welch

Sent: Tue Jan 19 12:18:03 2021

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky; Aswea Porter

Subject: [EXTERNAL] FW: ISAB Assignment to review Welch et al. 2020

Importance: Normal

FYI… just in.

From: Erik Merrill <emerrill@nwcouncil.org>
Sent: January 19, 2021 12:15 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Gregory, Stanley Vincent <stanley.gregory@oregonstate.edu>; Erik Merrill <emerrill@nwcouncil.org>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi David,

I will discuss your message with ISAB Chair Stan Gregory (copied here) and get back to you soon.

One clarification, you mention "NPCC review" in your message, which is understandable. However, the review was approved by the ISAB's Administrative Oversight Panel consisting of representatives from the Council, NOAA Fisheries, and CRITFC, rather than just the Council. So this is the ISAB's review to inform the Council, NOAA, Columbia River tribes, and the public.

The Schaller et al. review wasn't to the Council. I'll find out how to cite and let you know. I am using the title of the review and the authors for now.

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, January 18, 2021 2:01 PM
To: Erik Merrill <emerrill@nwcouncil.org>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi Erik–

Thanks for your email last Friday. I asked my co-authors to complete the Doodle poll and be prepared to make themselves available for the virtual review meeting with the ISAB.

I do think that the suggested time line of ~ 90 minutes is unreasonably short—our actual initial meeting could actually run closer to at least half a day and possibly a full(!) day. As things currently stand, we have to present our paper and our response to the FPC memo and (now) the Schaller et al memo. (You can tell the ISAB members that, on the bright side, we will be saving them a lot of work—by addressing the FPC & Schaller memos point by point, they get to sit back a bit and adjudicate on whether in their collective opinions the FPC/Schaller criticisms or our rebuttals are more credible, so we get to do the heavy lifting and then they get to assess whether our rebuttals are on point and hold water).

I wonder if you and I could have an initial call to discuss the issues, and get a sense of direction as to what is most important for the NPCC review? My draft rebuttal of the FPC (21 page) memo is now in the hands of my co-authors and was (at last count) now ~48 pages long (that includes the ~19 pages of text pasted in from the FPC memo so that we can't be accused of avoiding something the FPC wrote). To this we now add the 16 page Schaller et al memo that we also need to address. Fortunately, that memo mostly covers similar ground but with a different emphasis, so will be quicker to deal with.

A couple of questions here:

1. The Schaller et al review doesn't say where it was sent to. How should I reference it… as a memo sent by Schaller et al to the Council? (It doesn't say).
2. What is going to be the most effective format for presenting (and defending our work)? This is the main reason for asking to set up a phone call—it is more of a discussion bouncing back and forth the pros and cons of what is going to work best for the Council/ISAB. I am not looking for unfair advantage here, but if time is short I don't want to put

much if any, time on presenting our paper if we have the publicly released FPC memo to deal with—there are a mix of downright lies in it and deliberate misrepresentations that we need to address, so from Kintama's perspective if time is very short we have to devote it to demonstrate that the FPC (& now Schaller) memos are clearly off-base and why.

Like the rest of the planet, I am working from home for the duration of the pandemic. My cell doesn't work well at the house, so try my landline first. (Or specify a time and I can call you).

Regards, David

David Welch,

Kintama Research Services

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From: Erik Merrill <emerrill@nwcouncil.org>
Sent: January 15, 2021 7:51 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Gregory, Stanley Vincent <stanley.gregory@oregonstate.edu>; Erik Merrill <emerrill@nwcouncil.org>; Leslie Bach <LBach@NWCouncil.org>
Subject: ISAB Assignment to review Welch et al. 2020

Hi David,

The ISAB assignment to review your and your co-authors' article "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" has been approved, and we are gathering review materials and scheduling briefings for that assignment and three others.

We invite you and your co-authors to brief the ISAB on your study. If you'd like to brief us, please fill out this Doodle poll of ISAB online meeting dates and time blocks: February 5, February 18, March 18, April 8, and February 19 if needed. We generally schedule briefings for an hour, about 30 minutes each for presentation and discussion. Do you think that is adequate time to present and discuss your team's article? The briefing should help us answer our assignment questions, below. A few days before the briefing, the ISAB might share some additional specific questions to help guide the briefing and discussion.

Please see the ISAB's assignment description and references below, and please send any other key documents to ISAB Chair Stan Gregory (copied) and me to share with the ISAB and others. From our previous email discussion, I know you have the FPC's response to your article and plan to develop a rebuttal. The ISAB will also consider a review by Howard Schaller, Charles Petrosky, and Margaret Filardo, which is attached.

Thank you for considering our invitation, and please share the message and Doodle poll with your co-authors.

Stay well,

Erik

Evaluate "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" (Welch et. al 2020) and its interpretation of the implications of smolt-to-adult return values as well as the Fish Passage Center's review of the paper (FPC 2020)

The Independent Scientific Advisory Board is asked to review scientific basis for the analysis of regional declines in Chinook salmon abundances and the conclusions and recommendations of "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" (Welch et. al 2020). A review by the ISAB could provide an important context for interpreting the findings and important questions raised by this recent publication and the Fish Passage Center's review of the paper (FPC 2020).

Welch et al. 2020 examined SAR data for Chinook salmon for the Pacific coast to determine whether there are large-scale patterns of salmon survival based on coded wire tag data. Welch et al. report Chinook salmon survival has declined broadly across the Pacific coast and SAR values of 1% or less are widely observed. They highlight the use of the low SAR values to support management actions in the Columbia River Basin and question the validity of the interpretation of those SAR values. They note that similar declines in SAR values have been observed in west coast rivers without major dams and suggest that "contemporary survival is driven primarily by broader oceanic factors rather than local factors." They identify several methodological issues related to analyzing coded wire tags and PIT tags to calculate SAR values. Based on these interpretations, they indicate that targets for restoring salmon populations in the Columbia River Basin may not be attainable and question whether restoring freshwater habitat or improving dam passage will improve returns of salmon. The authors suggest that salmon recovery efforts should focus on actions in the marine environment rather than freshwater habitats. Welch et al. 2020 called for "a systematic review by funding agencies to assess consistency and comparability of the SAR data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast." These findings and their interpretations raise critical questions that should be examined more closely.

In response to requests from the Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife, the Fish Passage Center conducted a technical review of the Welch et al. paper and raised issues about the paper's methods, results, and interpretations (FPC 2020).

A review by the ISAB would provide information for the Council and regional policy makers for interpreting the findings of the Welch et al. paper about SARs, salmon survival, and appropriate management actions and the Fish Passage Center's criticism of the paper.

Review questions for the ISAB:

1. Was the Welch et al. analysis scientifically sound, and were the data it used appropriate for addressing the question?

2. Were the conclusions drawn by Welch et al. supported by their results?

3. Does the ISAB have recommendations to improve the current analysis and interpretation of SAR values in the future?

4. Are the criticisms raised by the Fish Passage Center supported by the evidence and do any of those criticisms weaken Welch et al.'s results or conclusions?

5. What are the management implications of the ISAB's conclusions and recommendation?

If feasible, we would appreciate a completed review by April 23, 2021.

References

Fish Passage Center (FPC). 2020. Technical review of Welch et al. (2020), titled, *A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae).* Memorandum from Michele DeHart (FPC) to Bill Tweit (WDFW), Tucker Jones (ODFW), and Margaret Filardo (citizen). December 4, 2020. https://www.fpc.org/documents/memos/53-20.pdf

Welch, D.W, A.D. Porter, and E.L. Rechisky. A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha,* Salmonidae). *Fish and Fisheries* 2020; 00: 1– 18. https://doi.org/10.1111/faf.12514

Erik Merrill

Independent Science Manager

Northwest Power and Conservation Council

851 SW 6th Avenue, Suite 1100

Portland, Oregon 97204

503-222-5161

800-452-5161 (toll-free)

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Wed Jan 20 11:01:51 2021

To: Monroy Flores,Luisa F (BPA) - EWB-4

Subject: FW: Announcement Posted: Fish and Wildlife Administrator, GS-0480-13 - Closes 1/29/21

Importance: Normal

Hello,

The GS-13 Fish and Wildlife Administrator position just opened in the Oregon Implementation (EWL) org. This position will be the Predation and Harvest lead Below are the details for this job announcement.

Announcement #: DOE-BPA-21-14372-MP

Position Title: Fish and Wildlife Administrator, GS-0480-13, EWL, Portland, OR

Opening Date: 01/20/2021

Closing Date: 01/29/2021

USAJOBS Link: DOE-BPA-21-14372-MP

Individuals that are eligible to apply are:

- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Land and Base Management
- Military Spouses
- Peace Corps & AmeriCorps Vista
- Special Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

Bonneville Power Administration
bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

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From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Fri Jan 22 14:01:38 2021

To: Monroy Flores,Luisa F (BPA) - EWB-4

Subject: Announcement Posted: Archeologist, GS-0193-12 Closes 1/31/2021

Importance: Normal

Hello,

The GS-12 Archeologist position just opened in the Environmental Compliance Cultural Resource (ECC) org. Below are the details for this job announcement.

Announcement #: DOE-BPA-21-14383-MP

DOE-BPA-21-14383-DE

Position Title: Archeologist, GS-0193-12, (ECC) – Portland, OR

Opening Date: 01/22/2021

Closing Date: 01/31/2021

USAJOBS Link: DOE-BPA-21-14383-MP MP Link

DOE-BPA-21-14383-DE DE Link

Individuals that are eligible to apply are:

- Open to all U.S. citizens
- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Land and Base Management
- Military Spouses
- Peace Corps & AmeriCorps Vista
- Special Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

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bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

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31x31

From: Petersen,Christine H (BPA) - EWP-4

Sent: Mon Jan 25 15:52:40 2021

To: Erin Rechisky; David Welch

Subject: Clearing Up, Issue 1988

Importance: Normal

Hi,
A brief reference to your study in one of the articles.

Christine

-----Original Message-----
From: NewsData LLC <dispatch@newsdata.com>
Sent: Friday, January 22, 2021 5:59 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Clearing Up, Issue 1988

You can access this week's issue of Clearing Up on the Web or as a PDF...or both!

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https://www.newsdata.com/clearing_up/

As a subscriber you have full access to digital content allowed by your subscription, once you've completed a simple registration process. Please visit https://www.newsdata.com/tutorial-create-a-login/video_bbd2af52-d02c-11e9-adfe-3fc4ba234b3c.html for information on how to register.

The Clearing Up website also features archives of past issues and links to other NewsData news and information services.

For the PDF version, click this link for this week's issue of Clearing Up:
https://grok.newsdata.com/cgi-bin/viewpdf.cgi?iss=cup1988&cid=IFJrjXxjxeiQ

You can also paste the link into your browser's address box and press Enter (or Return). The issue should appear after a moment.

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From: David Welch

Sent: Mon Jan 25 15:55:31 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Re: Clearing Up, Issue 1988

Importance: Normal

Thx, Christine

Left you a voicemail. Give me a call on my home phone please, when convenient

[redacted]

d

David Welch
M: +[redacted]
Kintama Research Services
Sent from my iPhone

> On Jan 25, 2021, at 3:52 PM, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:
>
> H i,
> A brief reference to your study in one of the articles.
>
> Christine
>
> -----Original Message-----
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> ---
>
> Discover high quality career opportunities:
> http://www.EnergyJobsPortal.com
>
> ---

From: Pisces

Sent: Thu Jan 28 15:32:01 2021

To: Pisces

Subject: Pisces Web Release Tonight - New Dashboard Update!

Importance: Normal

Good afternoon Pisces Users,

A new and improved dashboard is available for your use in Pisces Web. If you would like to begin using the new dashboard, please select the "Use Customizable Dashboard" link on your home page.

The old version of the dashboard will be phased out around March of this year. We encourage you to make the switch and welcome any feedback at support@cbfish.org.

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The following is a list of updates that will be included in the release:

- Add contract hyperlinks and budget categories to BiOp Implementation Plan report
- Capture spending amount and agency for worksites on public land
- Capture that COTR has reviewed/approved a draft Progress (Annual) Report
- Workflow: Display a message to remind everyone that the SOW must first be submitted to COTR to start the process
- Some pages have no progress indicator while being loaded
- Workflow: Always leave the "Notify Contract Manager" feature enabled for the COTR

Important bug fixes include:

- Document author setting: Add document uploader/editor in default list of names
- Transmittal Memo: Allow a Communication document type be selected as proof of authorization for Vehicle Purchase
- CSV download of budget increase requests contains HTML text in "Budget Transfer" column
- Anonymous users could not view Public Tags

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Fri Jan 29 11:41:40 2021

To: Monroy Flores,Luisa F (BPA) - EWB-4

Subject: Announcement Posted: Fish and Wildlife Administrator, GS-0480-11/12 FPL 12, EWU

Importance: Normal

Hello,

The GS-11 / 12 Fish and Wildlife Administrator position just opened in the Washington Implementation (EWU) org. This position will be hatchery focused. Below are the details for this job announcement.

Announcement: DOE-BPA-21-14375-MP

Position Title: Fish and Wildlife Administrator, GS-0480-11/12 FPL 12, (EWU) – Portland, OR

Opening Date: 01/29/2021

Closing Date: 02/07/2021

USA Jobs Link: https://www.usajobs.gov/GetJob/ViewDetails/590810000

Individuals that are eligible to apply are:

- Individuals with disabilities
- Current or former federal employees with competitive service
- Career Transition (CTAP, ICTAP, RPL)
- Land and Base Management
- Military Spouses
- Peace Corps & AmeriCorps Vista
- Special Authorities
- Veterans

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

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From: Petersen,Christine H (BPA) - EWP-4

Sent: Fri Jan 29 18:25:55 2021

To: David Welch

Subject: RE: ISAB Assignment to review Welch et al. 2020

Importance: Normal

I think Merrill said they would present something in February or March.

By the way, there are a couple sections of their report that I'll point out, although I don't know if it is useful.

First – you are aware that there has been a long running discussion over counting returns based on PIT vs window counts at the dams? (it isn't a major major issue though). There are multiple factors that can influence the difference between the two methods (see pg 129)

Next – several years ago they added a chapter (chapter 5) looking at the relationship between SAR and productivity (and trying to identify rate of replacement with R/S). Naturally, there is a positive correlation. In the last 4-5 years they look at a different location for each report. The SAR needed for rate of replacement was different – they needed over 3% for John Day, but 1.5-2% was adequate in parts of the Snake.

[CHAPTER 1 (fpc.org)]

From: David Welch <David.Welch@Kintama.com>
Sent: Friday, January 29, 2021 3:18 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] RE: ISAB Assignment to review Welch et al. 2020

Erik just wrote and asked that the timing for the start of our two hours will get pushed back to a 10:15 start. We have just two hours total, so we have decided to stick to the facts about our paper and not deliberately call the FPC out as deliberate liars (although part of me really wants to… I don't think I have ever dealt with a group that was so willingly dishonest and willing to present deliberately deceptive results. It goes a long way to explaining how the FPC painted themselves into a corner with their past claims).

So, to be clear, when you says that ". Scott said that FPC will be commenting on the size selectivity passage topic but not on their review of your paper", does that mean that the ISAB will not be asking for a separate presentation from them?

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: January 29, 2021 2:07 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi, thanks

Scott Donahue said that Erik Merrill says that they will send out a conference number later for next Friday. Jody Lando will definitely watch and I will try as well. Have to see if Ben Zelinsky and others have the time. Scott said that FPC will be commenting on the size selectivity passage topic but not on their review of your paper.

I' m confident that you will be prepared to summarize your work and address anything that comes up.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, January 18, 2021 2:11 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] FW: ISAB Assignment to review Welch et al. 2020

Hi Christine—

FYI, below. Just keeping you in the loop.

I assume that you have seen the Schaller et al memo that we have to address as well? (If not, I can send you a copy, but it might be more appropriate to get it from Erik Merrill directly; as my email to him below says, I don't really understand where it was submitted to).

I am looking forward to the ISAB review because this will be (finally!) a chance to professionally call out the FPC and demonstrate just how questionable their credibility is—their 21-page critical memo is chock-full of deceptive claims and (in some cases) even deliberate lies. Refuting this in public is going to be a good thing, and the Schaller et al memo demonstrates that those folks still aren't thinking through the key issues.

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers–

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

From: David Welch <David.Welch@Kintama.com>
Sent: January 18, 2021 2:01 PM
To: Erik Merrill <emerrill@nwcouncil.org>
Subject: RE: ISAB Assignment to review Welch et al. 2020

Hi Erik–

Thanks for your email last Friday. I asked my co-authors to complete the Doodle poll and be prepared to make themselves available for the virtual review meeting with the ISAB.

I do think that the suggested time line of ~ 90 minutes is unreasonably short—our actual initial meeting could actually run closer to at least half a day and possibly a full(!) day. As things currently stand, we have to present our paper and our response to the FPC memo and (now) the Schaller et al memo. (You can tell the ISAB members that, on the bright side, we will be saving them a lot of work—by addressing the FPC & Schaller memos point by point, they get to sit back a bit and adjudicate on whether in their collective opinions the FPC/Schaller criticisms or our rebuttals are more credible, so we get to do the heavy lifting and then they get to assess whether our rebuttals are on point and hold water).

I wonder if you and I could have an initial call to discuss the issues, and get a sense of direction as to what is most important for the NPCC review? My draft rebuttal of the FPC (21 page) memo is now in the hands of my co-authors and was (at last count) now ~48 pages long (that includes the ~19 pages of text pasted in from the FPC memo so that we can't be accused of avoiding something the FPC wrote). To this we now add the 16 page Schaller et al memo that we also need to address. Fortunately, that memo mostly covers similar ground but with a different emphasis, so will be quicker to deal with.

A couple of questions here:

(1) The Schaller et al review doesn't say where it was sent to. How should I reference it… as a memo sent by Schaller et al to the Council? (It doesn't say).

(2) What is going to be the most effective format for presenting (and defending our work)? This is the main reason for asking to set up a phone call—it is more of a discussion bouncing back and forth the pros and cons of what is going to work best for the Council/ISAB. I am not looking for unfair advantage here, but if time is short I don't want to put much if any, time on presenting our paper if we have the publicly released FPC memo to deal with—there are a mix of downright lies in it and deliberate misrepresentations that we need to address, so from Kintama's perspective if time is very short we have to devote it to demonstrate that the FPC (& now Schaller) memos are clearly off-base and why.

Like the rest of the planet, I am working from home for the duration of the pandemic. My cell doesn't work well at the house, so try my landline first. (Or specify a time and I can call you).

Regards, David

David Welch,

Kintama Research Services

4737 Vista View Crescent

Nanaimo, BC

Canada V9V 1N8

Home Tel: [redacted]

Mobile: [redacted]

From: Erik Merrill <emerrill@nwcouncil.org>
Sent: January 15, 2021 7:51 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Gregory, Stanley Vincent <stanley.gregory@oregonstate.edu>; Erik Merrill <emerrill@nwcouncil.org>; Leslie Bach <LBach@NWCouncil.org>
Subject: ISAB Assignment to review Welch et al. 2020

Hi David,

The ISAB assignment to review your and your co-authors' article "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" has been approved, and we are gathering review materials and scheduling briefings for that assignment and three others.

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Please see the ISAB's assignment description and references below, and please send any other key documents to ISAB Chair Stan Gregory (copied) and me to share with the ISAB and others. From our previous email discussion, I know you have the FPC's response to your article and plan to develop a rebuttal. The ISAB will also consider a review by Howard Schaller, Charles Petrosky, and Margaret Filardo, which is attached.

Thank you for considering our invitation, and please share the message and Doodle poll with your co-authors.

Stay well,

Erik

Evaluate "A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon" (Welch et. al 2020) and its interpretation of the implications of smolt-to-adult return values as well as the Fish Passage Center's review of the paper (FPC 2020)

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In response to requests from the Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife, the Fish Passage Center conducted a technical review of the Welch et al. paper and raised issues about the paper's methods, results, and interpretations (FPC 2020).

A review by the ISAB would provide information for the Council and regional policy makers for interpreting the findings of the Welch et al. paper about SARs, salmon survival, and appropriate management actions and the Fish Passage Center's criticism of the paper.

Review questions for the ISAB:

1. Was the Welch et al. analysis scientifically sound, and were the data it used appropriate for addressing the question?

2. Were the conclusions drawn by Welch et al. supported by their results?

3. Does the ISAB have recommendations to improve the current analysis and interpretation of SAR values in the future?

4. Are the criticisms raised by the Fish Passage Center supported by the evidence and do any of those criticisms weaken Welch et al.'s results or conclusions?

5. What are the management implications of the ISAB's conclusions and recommendation?

If feasible, we would appreciate a completed review by April 23, 2021.

References

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Welch, D.W, A.D. Porter, and E.L. Rechisky. A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha,* Salmonidae). *Fish and Fisheries* 2020; 00: 1– 18. https://doi.org/10.1111/faf.12514

Erik Merrill

Independent Science Manager

Northwest Power and Conservation Council

851 SW 6th Avenue, Suite 1100

Portland, Oregon 97204

503-222-5161

800-452-5161 (toll-free)

From: David Welch

Sent: Wed Feb 03 09:15:36 2021

To: emerrill@nwcouncil.org; Gregory, Stanley Vincent

Cc: Erin Rechisky; Aswea Porter

Bcc: bdzelinsky@bpa.gov; jcsweet@bpa.gov; chpetersen@bpa.gov

Subject: [EXTERNAL] Kintama's Response to recent criticisms by the Fish Passage Center and Schaller et al

Importance: Normal

Attachments: Kintama Response to FPC-Overview Letter (2 Feb 2021).pdf; Appendix I-Kintama Response to Fish Passage Center (2 Feb 2021).pdf; Appendix II-Kintama Response to Schaller et al memo (2 Feb 2021).pdf; Appendix III-Reviewers' Comments on F&F Journal Article.pdf; Appendix IV-Questions posed by Kintama to the CTC & Responses.pdf; Appendix V- Letter to Michelle DeHart (FPC) formally requesting the CSS' Survival Estimates.pdf

Dear Mr Merrill & Professor Gregory-

My colleagues & I look forward to our presentation and discussion with you on Friday concerning our recent paper in Fish & Fisheries comparing the coastwide survival of Chinook..

As a preliminary to that presentation, we are attaching to this email several documents that should assist the ISAB in their review of our paper and their assessment of the criticisms recently levelled at that paper by the Fish Passage Center and separately by Howard Schaller, Charles Petrosky, and Margaret Filardo.

These documents represent our formal response to the two memos, plus background documents that backup our general point-by-point response. However, we have also prepared an overview letter that should be read first, as it contains our broader reflections on why progress on achieving the Council's salmon conservation goals has been so slow. We suggest that this is read first, followed by the appendices detailing our point-by-point rebuttal of the Fish Passage Center and Schaller et al critiques.

Please share these documents with the other members of the ISAB and more broadly as you see fit. Kintama views our responses as public documents and will be making them widely available from Kintama's website. (There are embedded hot links to the components of our response within the documents themselves).

Sincerely,

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

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1 February 2021

Mr Erik Merrill
Manager, Scientific Review Program
Northwest Power and Conservation Council

Re: Rebuttal of Fish Passage Center Memo 53-20 & Schaller et al. Memo

> *"A wise man, therefore, proportions his belief to the evidence." -David Hume*

> *"Nothing is more dangerous than a dogmatic worldview—nothing more constraining, more blinding to innovation, more destructive of openness to novelty." -Stephen Jay Gould*

Dear Mr. Merrill,

The Fish Passage Center (FPC) released memo 53-20 criticizing our recent paper published in Fish and Fisheries. The Independent Scientific Advisory Board (ISAB) has now been charged with reviewing our paper and the FPC's memo. Here we provide a detailed response to the FPC's claims (Appendix I).

In your earlier email advising us of the ISAB's remit, you also included a separate review by Howard Schaller, Charlie Petrosky, and Margaret Filardo dated 23 Nov 2020. Although many of the comments are similar to the FPC's claims, these authors raise some important additional issues. We have provided a separate point-by-point response to the Schaller et al. review as well (Appendix II).

We have also attached three additional appendices documenting some of the correspondence generated while drafting our paper or while preparing our response to the FPC memo (Appendix III, Appendix IV, & Appendix V). See the last page of this letter for a summary of what each appendix contains. All appendices are hosted on Kintama's website and can be accessed via embedded hyperlinks from this letter.

The FPC memo is oddly misleading in places, leading us to wonder how they came to the conclusions they did. For example, they state that we did not separate important ecological groups of salmon in our analysis when we explicitly stated in our paper that we did just that. In other cases, the FPC simply ignored without explanation our finding that significant amounts of their own data do not support their past claims. Their rather rushed reading may explain why they felt that our methods of analysis were inappropriate. The Schaller et al. memo is more nuanced. Our responses are intended to add perspective on why we believe that the conclusions we reached in our paper remain valid. We recognize that our results do not align with current management approaches and that many interested in salmon conservation may lack the technical background to judge between these competing views. We hope the ISAB review will provide some needed clarity on this debate.

Please feel free to distribute our response beyond the ISAB members as you think this would be useful. We are distributing our response more widely to promote broader discussion of the issues (see Distribution section below).

In the remainder of this letter, we wish to place the results in our paper in a broader context. In our paper, we pointed out that survival to adult return (SAR) estimates for Chinook salmon stocks from many regions have fallen to roughly 1%, which is similar to levels reported for the Snake River populations. That biologists did not raise this issue earlier is remarkable—one would hope that they would either have investigated their monitoring programs to see why they were producing such "bad" numerical estimates or raised the alarm earlier that reported survival levels were in serious trouble coastwide. Neither happened. It is for this reason that in our paper we called on the funding agencies (and not the fundees) to drive a review of the programs. We welcome the ISAB's review as an important first step towards that debate.

These are the issues/conclusions we see as most important:

(1) If coastwide Chinook SARs are numerically similar to the Snake River, then it is difficult to argue for a major role of regional freshwater factors (such as the Snake River dams) as driving the current low survivals. This does not mean that freshwater habitat is unimportant, as the FPC claims we said. It does mean that if the major problem is in the ocean then "fixing" something else may be ineffective, no matter how well-intentioned those efforts are. We made an interesting advance here when considering the FPC's argument that differences in the number of data points used in our 2010-2014 comparison of regional SARs relative to the Snake River region somehow erroneously resulted in similar SARs. To address this, we assessed relative survival between regions on an annual basis using all available years in the time series. We found that the year-by-year comparison of regional SARs to the Snake River resulted in the same conclusion of similar or lower SARs in most regions. We also found that SE Alaskan hatchery and wild yearling Chinook SARs fell in parallel over the available record. As Alaskan hatchery Chinook have no freshwater phase (hatchery smolts being released directly into the sea), this excludes freshwater smolt survival as a component of the decline in survival. This is an important new result, strengthening the results in the original paper.

(2) The assumption underlying the delayed mortality theory (namely, that earlier hydrosystem experience is the cause of poor marine survival of Snake River populations relative to downstream populations), is unsupported when a wider range of populations is examined. Higher returns relative to Snake River populations are unique only when comparing wild Snake River spring Chinook to wild Yakima and John Day River spring Chinook which the FPC consistently report (and cited again

in their memo as evidence for delayed mortality). The FPC dismiss the multiple PIT or CWT tag-based survival comparisons we discussed in our paper because our examples extend to hatchery spring Chinook and fall Chinook from the Snake River. For example, wild Snake River fall Chinook (and wild upper Columbia River fall Chinook) have higher PIT-tagged based SARs than two wild mid-Columbia River fall Chinook populations. What is the rationale for limiting the delayed mortality theory to only *wild* Snake River spring Chinook? When the productivity of other populations is considered, evidence for delayed mortality diminishes or vanishes. This is a critical issue in our view, because if the delayed mortality theory is wrong Columbia River salmon management can probably focus on ensuring adequate levels of smolt survival in the river and not be held accountable for poor marine survival.

(3) Since 1999, the terms of the renegotiated Pacific Salmon Treaty have acted as a negative feedback system (increasing harvest when survival is good and decreasing harvest when survival is poor). If the CSS reports fail to incorporate harvest into PIT tag-based SARs, statistical correlations of freshwater effects such as water travel time or spill on projected SARs[1] are compromised, obscuring and countering the effects of FCRPS operations on survival. The FPC acknowledges in their memo that they are aware of the high ocean harvests of fall Chinook and the (likely) low levels of ocean harvest on spring Chinook, but they are silent on potential biases in their SAR estimates that will result from ignoring harvest. Given the harvest levels we reported, we believe that the ISAB should provide its advice as to whether it is scientifically defensible to ignore harvest in statistical assessments of how freshwater manipulations may influence adult survival.

Current NWPCC recovery standards for the Columbia River Basin are essentially based on returning to the now ancient levels of productivity documented by Raymond half a century ago. Those levels are not reached anywhere else in western North America, apart from a few clearly exceptional individual populations (see our paper). It may now be impossible to reach past survival levels because they reflect older levels of productivity obtained in a colder ocean. It will likely be impossible to reach them until we understand why the few populations (highlighted in our paper) that do achieve them are successful.

Another barrier to salmon recovery in the Columbia River is that many of the players are deeply vested in supporting an outdated approach which almost reflexively blames the dams. Our paper shows that few regions along the west coast of North America are doing better than the Snake River and many are doing worse. This is probably because past issues caused by the dams have likely been fixed. What remains to be fixed during downstream and upstream migration is tiny… and far too low to reach current NWPCC SAR targets (see below). Twenty-one years ago, Kareiva et al (2000) wrote that "*even if main stem survival were elevated to 100%, Snake River spring/summer chinook salmon would probably continue to decline toward extinction*". Remarkably, salmon conservation in the Columbia River Basin has not significantly progressed since then beyond freshwater studies.

[1] For example, if managers overshoot in their harvest modifications relative to perceived Chinook abundance prior to Chinook recruiting to the fisheries, they will overharvest in years of high abundance and underharvest in years of poor survival. This will flip the sign of any statistical exercise correlating freshwater conditions and returning SARs unless harvest is accounted for.

Failing to question current thinking also means that the possibility of generating efficient, cost-effective, and CO_2-free hydroelectric power in support of the growing use of sources of intermittent renewable power (wind and solar) is also constrained—past problems associated with the dams may have been fixed, but large elements of the salmon conservation community are reluctant to move on and address the ocean issues that are now the major issue because they are still fighting yesteryear's battles.

We have recently written elsewhere (Welch, 2020) that the Columbia does not have a problem with smolt survival in freshwater (which is high), but rather with the insufficient adults returning from the ocean (which is low). It is straightforward to show that smolt survival levels cannot be manipulated to achieve high adult returns and it is worthwhile to take the time here to briefly demonstrate why.

Average survival through the FCRPS for out-migrating Snake River Chinook smolts is ~53%, while adult returns (SARs) average 1.0% (Haeseker, McCann, Tuomikoski, & Chockley, 2012). These numbers immediately demonstrate that the Columbia does not have a freshwater survival problem caused by the dams; rather, it has a lack of sufficient adults returning from the ocean to satisfy demand.

Consider how the current low SARs of ~1% is achieved:

$$SAR_{Current}=S_{FCRPS}\cdot S_{LRE}\cdot S_{Ocean},$$

The PIT tag-based SAR level is the combined product of survival in the FCRPS, the lower river and estuary (LRE), and the ocean. Investing in further changes to the FCRPS that significantly increased hydrosystem survival would result in an increase in the future SAR level to

$$SAR_{Future}=S_{FCRPS}\cdot(1+\Delta)\cdot S_{LRE}\cdot S_{Ocean}$$

Thus, the future SAR level will be only:

$$SAR_{Future}=SAR_{Current}\cdot(1+\Delta)$$

Even substantial further improvement in smolt survival through the FCRPS of, say, Δ=10%, has only a tiny effect on the adult return rate, increasing the SAR from 1.0% to 1.1%. Precisely because hydrosystem survival is already so high ($S_{FCRPS}\approx$53%), future SARs can only increase to $(0.53)^{-1}$=1.9%. Yet increasing the SAR from 1% to 1.9% would require eliminating all sources of mortality in the FCRPS: wiping out all predatory animal life (e.g., all birds and fish), vanquishing all diseases, and eliminating all direct dam impacts so that FCRPS survival increases from 53% to 100%.

It is for this reason that the theory of delayed mortality plays such an important role in the Columbia River Basin—the theory is critical to maintaining a focus on the dams as the way to "fix" poor ocean survival. Without delayed mortality there is no mechanism for current SAR recovery targets to be achieved. (Incorporating lower river and estuary survival ($S_{LRE}\approx$80%)

measured by the previous JSATs or POST telemetry arrays makes little difference, so for simplicity we subsume this in the ocean estimates of survival).

We remain concerned that most regions of the west coast, including the Columbia, are ill-prepared to deal with the coming levels of ocean climate change and resulting poor marine survival of salmon populations. The inability of any region of the west coast to improve freshwater survival by an amount anywhere near sufficient to compensate for past decreases in marine survival (let alone counteract the far greater decreases in survival likely coming) should be considered evidence that current approaches are not working.

SUMMARY

In WW2, analysis of returning U.S. warplanes identified where most shrapnel or bullet holes were found. That analysis was initially used to prioritize regions of the plane that should be better armored. However, eventually Abraham Wald—a brilliant statistician attached to the classified Statistical Research Group at Columbia University—pointed out that the study was looking at data on where a plane could survive being struck and still return. Only when the analysis was re-framed did it become clear that returning planes were rarely struck in the cockpit, the engines or fuel tanks… something that was lost to those studying the holes (Ellenberg, 2015).

In the example above, two radically different interpretations of the same data were possible. The same is true of Columbia River salmon conservation work and similar efforts coastwide. Collectively, we focus great efforts on highly visible freshwater habitats that now form the central pillar for salmon stewardship because freshwater habitat is important to the salmon's life cycle. However, being good freshwater stewards is not the same thing as addressing the major conservation challenges. Compensating for declines in marine survival may require enhancing freshwater habitat to an impossible degree. First, if survival levels are now similar coastwide, then regional declines likely cannot be compensated by fixing situations unique to one area, such as dams in the Snake River. Second, we are unaware of freshwater habitat restoration work that is identifying *improvements* in survival anywhere near the magnitude needed to compensate for worsening marine survival; see, for example, (Krall, Clark, Roni, & Ross, 2019).

2020 is already the 5th year in the 7 year period 2014-2020 to be defined as having extensive marine heatwaves (2020 was the 2nd largest since 1982). Further large increases in north Pacific sea temperatures over the next decade are forecast (Arguez et al., 2020). The analysis of SAR data in our paper stopped in return year 2014 because of lags in data production and thus mostly exclude the SARs experienced under recent marine heatwaves. The decreased adult returns from those conditions are just returning now and have been catastrophic in many regions. Decreases in marine survival are not restricted to the Columbia with its extensive network of dams; British Columbia is now seeing the lowest salmon returns in a century and Washington State is experiencing similar low levels of salmon returns in regions unaffected by the Columbia River dams. Unfortunately, things are likely going to get even worse in future.

If marine survival drops to zero, the current normative river philosophy of speeding smolt entry into the ocean will expedite extinction. Somewhat less extreme, increasing spill to speed smolts entry into the ocean will also decrease adult returns unless survival during the extra time spent in the ocean is better than the losses smolts would otherwise experience during the extra time spent migrating downstream. Such considerations are not factored into the current debates about improving salmon returns.

No matter how admirable the intent, modifying conditions in a different part of the life history will not improve salmon returns unless those modifications can pass two tests: (1) they actually improve survival (i.e., are not just assumed to do so), and (2) they are large enough to materially contribute to compensating for the large decreases in marine survival. Few freshwater survival studies demonstrate either; the important Krall et al (2019) study in Washington State, for example, found no material improvement. They concluded that their carefully designed, decade-long study was statistically underpowered. Yet the data they reported showed no meaningful change in abundance in response to freshwater habitat improvements, not that increases in abundance occurred, but were statistically insignificant.

Our paper points out that in most areas of the coast survival has fallen to about the same level. Understandably, people are upset and angered by the implications of that message. However, one of our major points is that simply redoubling efforts on initiatives *in life history periods not causing the decrease* is unlikely to succeed. There needs to be a broader conversation about whether the large public expenditures in salmon recovery are actually working, rather than simply accepting that ever-increasing amounts of money will fix survival. It is our hope that the ISAB and others reading this reply will comment on these broader conclusions as well as assessing the technical credibility of our paper and the criticisms that have been levelled at it. It is past time for an adult conversation.

Sincerely,

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Kintama Research Services Ltd.
david.welch@kintama.com

Appendix I Our response to the FPC memo.

Appendix II Our response to the Schaller et al. memo.

Appendix III Comments received from five anonymous peer reviewers and the journal's Editor prior to publication, as well as our detailed responses. We include this in the interest of transparency and to partially address the FPC's claim that our paper fails to meet the journal's standards.

Appendix IV Correspondence with the Pacific Salmon Commission's Chinook Technical Committee to clarify the FPC's claim that we misrepresented that data source.

Appendix V Our letter to Ms DeHart of the FPC dated 18 September 2019, formally requesting that the FPC provide us with the CSS's PIT tag-based SAR estimates incorporating smolt survival above the topmost dam. We include this because the FPC argues in their current memo that differences between the PIT and CWT-based SAR estimates means that comparison of the two survival estimates is "apples to oranges". For the record, we never received any response to our request for the data in a way that would have reduced the disparity.

DISTRIBUTION:

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FPC: Our overall conclusion of this review is that Welch et al. (2020) is technically flawed. Therefore, their contentions that Columbia River rebuilding targets may be unachievable, that broad oceanic factors are a primary driving force in Chinook salmon survival coast-wide, and that freshwater management and mitigation activities are misdirected are not supported by the considerable body of available scientific information. Quantitative analysis of their own selected data sets does not support their conclusions. Our primary conclusions are listed below, followed by detailed discussions of each point.

KRS: The CWT dataset is the product of >50 years of collaborative efforts. Below, we respond to all the primary points in the FPC memo. We have also pasted sections from the memo's detailed discussions below their corresponding primary points to marshal related material into the same place.

1. The authors fail to meet the most important requirements of a synthesis or meta-analysis, which is clearly establishing that the data and results utilized are comparable. Failure to understand, acknowledge, and address assumptions, objectives, uncertainty, and details of the data that were used results in comparisons that are uninterpretable. Their approach results in an "apples to oranges" comparison at best, and a misrepresentation of the data utilized and erroneous conclusions at worst.

   KRS: Our goal was not to complete an exhaustive literature review of correlation-based studies linking freshwater events with adult survival, but rather to look at the coastwide patterns of survival. The paper went through two rounds of anonymous peer review, with a total of five peer-reviewers (one reviewer participated in both rounds of reviews). Neither the reviewers nor the editor stated there was a problem with the manuscript meeting the journal's requirements (See Appendix III).

   By requiring that we address all the details in the survival data collected by many government organizations over nearly half a century, the FPC is setting an impossibly high bar—essentially rendering it impossible to synthesize salmon survivals across time or regions. There are too many populations and too many years of data to trace all individual differences. We used the CTC indicator stocks for the main analysis because their CWT-based estimates use a relatively consistent methodology and were collated for international decision-making; they are the best available. The CTC estimates were not provided to us with estimates of error likely because calculation of the real error structure is not currently possible. Additional CWT datasets for the Columbia River Basin were included only after discussion with hatchery biologists. As stated in our paper, we did not calculate SARs directly from the RMIS database because "*we could not verify that adult return numbers from all possible significant components were correctly incorporated and expanded for sampling effort*." We also presented PIT tag-based estimates, but the CWT-based SARS estimates and PIT tag-based SAR estimates were kept separate because of obvious methodological differences.

2. The authors only report results that support their conclusions. They fail to report results of a significant body of analyses that actually evaluate the effects of oceanic and freshwater factors

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and the importance of these factors to Chinook salmon survival. The results of these analyses, which are ignored by the authors in their synthesis, conclude that freshwater factors are an important driver of survival for many Chinook salmon populations.

The authors have carefully selected data and analyses in an attempt to support their conclusions. They fail to include a significant body of analyses that actually include ocean conditions, and fresh water conditions and the importance of these variables in resulting survival of chinook salmon. These analyses which are ignored by the authors, conclude that the fresh water life stage environment affects survival to adult.

Important studies on the effects of environmental factors on freshwater survival, ocean survival, and SARs were ignored (Haeseker et al. 2012, McCann et al. 2018, Michel et al. 2015, Cordoleani et al. 2018, Michel 2019). The paper provides no quantitative analysis to refute the results of Haeseker et al. (2012) or McCann et al. (2018) on the importance of environmental factors for explaining patterns in freshwater survival, ocean survival, and SARs. The authors fail to recognize the documented correlations between freshwater and marine survival (Haeseker et al. 2012) or the associations between freshwater environmental conditions and marine survival and SARs (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Michel 2019)

KRS: Our datasets were from reputable sources (documented in SI Table 1) including published papers, the CTC, and the FPC (CSS) itself. Our analytical methods were deliberately minimal, relying on the statistical comparison of median survival levels, in order to minimize the risk of distorting the data. We used all of the data from all of the indicated sources, with the few exceptions documented in the supplementary information section of our paper.

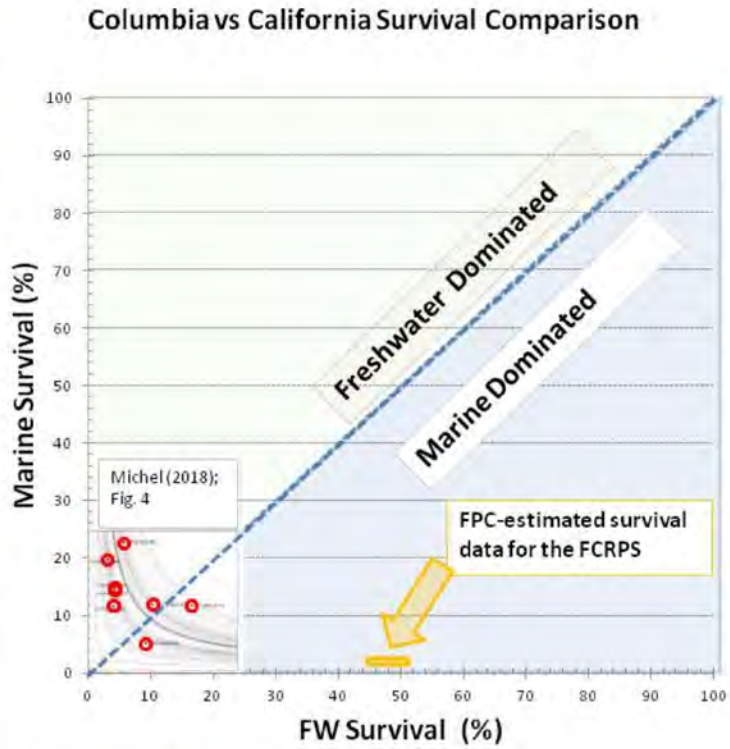
The studies the FPC cites are correlation exercises examining the statistical association of SARs (adult returns) with freshwater conditions when the smolts went to sea. This was not the focus of our study and thus the reason we did not do an exhaustive literature review of this issue, although we did cite two of the listed papers (Michel et al 2019 and McCann et al 2018).

Our view is that the cited studies are incapable of resolving the relative degree that freshwater and marine events control the SAR, because both environments are correlated. At the most basic level, for example, in a La Niña year snowpack is greater and sea temperatures are colder, while in an El Niño year snowpack is lower and sea temperatures are higher. These large-scale shifts change both the timing and amount of freshwater flows and many aspects of the ocean ecology that are only dimly understood.

It is thus not possible to statistically disentangle whether higher flow during outmigration or colder sea temperatures are responsible for higher adult returns without additional information. Correlation studies such as the papers the FPC cite measuring the returning adult numbers cannot do so. This is not an attack on these papers but simply a statement that such exercises cannot resolve whether it is some aspect of flow that drives the relationship or something in the ocean that is doing so.

The Michel et al. (2019, published online in 2018) study the FPC cites is indeed important to the Columbia River issues, but not in the way that the FPC thinks. Michel et al. (2019) reports extremely low freshwater survival for California Chinook; we stated this in our paper: "*The SARs of California Chinook are particularly noteworthy because freshwater survival is exceedingly low*

(Michel et al, 2018); for overall SARS to be higher than Snake River stocks suggests much higher survival during the marine phase".



To clarify this further, we have attached a graph from some of our as-yet unpublished work where we examine the roles of freshwater and marine survival for determining salmon survival. When we compare data for the Columbia and California populations there is far more room for improvement of California SARs. The attached graph compares the two systems with the inset showing the Michel et al. (2019) paper reporting California SARs that both we & the FPC cite. Michel et al. report freshwater survival in the 2~20% range, whereas the FPC's CSS study reports FCRPS survival in the ~50% range. (In the graph the CSS values for FCRPS smolt survival have been multiplied by the below Bonneville smolt survival to the river mouth of ~80% measured by both the JSATs and POST studies to give a more representative comparison).

In the California case, there is far greater scope for freshwater modification to improve adult survival precisely because freshwater survival is already so low (slightly lower than the marine survival; the red dots are scattered near the 1:1 line of equal magnitude). In contrast, the Columbia has far higher freshwater survival than the Sacramento case and much lower marine survival (1/5th to 1/10th the California case). As a result, the scope for significant improvement in Columbia Basin SARs rests on improving survival in the ocean, as doubling freshwater survival to 100% (perfect survival, which would require exterminating all fish-eating bird & resident fish populations as well as removing all 8 dams) can only double the SAR. Thus, unlike the situation reported for California, there is little scope for substantial improvement in adult returns from further increasing freshwater survival in the Columbia unless "delayed mortality" really does exist and is large.

3. There is no doubt that the ocean is important and affects numbers of returning adults. However, the number of smolts that enter the ocean is dependent on freshwater survival and management strategies that result in the highest freshwater survival possible, because not even the best ocean conditions can resurrect a dead fish.

KRS: There is no doubt that fresh water is important, but currently it does not seem to have a large effect on the of proportion of Chinook returning as adults for the majority of populations.

Here is an example:

> Since SARs in the Columbia R area are about 1%, then even a substantial improvement in smolt survival through the FCRPS of, say, Δ=10%, has only a tiny effect on the adult return rate, increasing the SAR from 1.0% to 1.1%. Precisely because hydrosystem survival is already so high ($S_{FCRPS}\geq 50\%$), future SARs can increase to, at best, 2%. Yet achieving this small benefit would require eliminating all sources of mortality in the FCRPS: eliminating all predatory animal life (e.g., all birds and fish), diseases, and direct dam impacts so that FCRPS survival increases from ≥50% to 100%.

Despite the importance of the ocean, we do agree that salmon need good freshwater habitats. In the past, many rivers were degraded by human activities. It took great effort to reverse the damage and continued vigilance is still necessary. Our intention is not to detract from these achievements or to discourage freshwater restoration when it will benefit salmon. However, we are advocating that we approach decision-making in a smarter and more objective way. In the case of the Columbia, those aspects of freshwater habitat affecting survival during the migratory phase (such as the dams) are unlikely to have much influence on determining the poor survival to adult return precisely because other regions have similar survival.

4. Wild spring Chinook stocks in the Columbia River Basin that experience less hydrosystem impacts (e.g., John Day River and Yakima River) have much higher survival than stocks that experience greater hydrosystem impacts (Snake River, upper Columbia River). These examples, which enter the ocean at the same location, clearly demonstrate the impacts of the freshwater environment on Chinook salmon survival.

"When the facts change, I change my mind. What do you do?" John Maynard Keynes

KRS: The FPC are ignoring one of the main points of our paper. In several places, we state that John Day and Yakima "have much higher survival" than Snake River stocks. However, we also pointed out that the FPC's CSS report also estimates PIT tag-based SAR for other populations not migrating through the Snake River dams that have similar survival to the Snake River populations. These additional FPC estimates contradict the FPC's claim that there is delayed mortality.

We also showed that *none* of the CWT-based SAR datasets for the Columbia Basin that we collected to date showed a survival disparity consistent with the delayed mortality theory. Furthermore, two out-of-basin populations (Chilliwack in the Fraser River and an experimental UW hatchery population) also had much higher SARs than other populations in regions where there are no dams. The FPC do not even mention these points, let alone provide a reason why they should be ignored, but are simply reiterating their long-held belief that the two populations they cite fit their preferred theory.

Our observations were thus that (a) dam passage was not necessary for a persistent large disparity in survival to occur between populations, and (b) that of the population pairs that could be compared that did involve Snake River dam passage for one of the pair, all but the two populations the FPC cite *do not* show evidence of the delayed mortality deficit.

Despite having the opportunity to address this point and provide a rational argument for why these counter-examples are wrong, the FPC remain silent about why the other populations in their CSS study do not show the delayed mortality signature. They also have not provided any discussion of why the various CWT-based survival comparisons fail to show signs of delayed mortality for Snake River stocks. (See also our response to some similar claims made in the Schaller et al memo, Appendix II)

5. Historical and recent analyses indicate that freshwater management alternatives that include increases in spill levels and breaching the lower Snake River dams could achieve the NPCC regional SAR goals for Snake River spring-summer Chinook salmon.

"Nothing is so treacherous as the obvious." — Joseph Schumpeter

KRS: Simply put, correlation is not causation. Secondly, the "historical and recent analyses" the FPC refers to often omitted harvest from their correlation exercises assuming it was trivial. However, we found that even for Snake River Spring Chinook (where harvest rates appear to be lowest) the variation in harvest levels over time was large enough to potentially distort statistical analyses using SARs rather than survival. At this point, no one can foretell whether even the sign of these statistical relationships will remain the same once harvests are properly incorporated into studies were based on SARs rather than survival (i.e., where survival is calculated as SARs + harvest).

For example, the important study by Haeseker et al. (2012) examines the effect of spill, water travel time, and hydrosystem survival of smolts on SARs. They concluded that freshwater management alternatives could indeed achieve the NPCC regional SAR goals but they did this by extrapolating well beyond the extent of their independent variables. "Survival" in the Haeseker et al paper is defined for three different life history periods as: "*The life stages that were assessed included freshwater survival (SH, defined as survival from the tailrace of LGR to the tailrace of BON), ocean-adult survival (SOA, defined as survival from the tailrace of BON as a smolt to adult detection at LGR), and life cycle survival (smolt-to-adult survival or SAR, defined as survival from the tailrace of LGR as a smolt to detection as an adult at LGR)*" (p. 123). Neither of the two adult "survival" measures includes harvest before the returning adults reach LGR and are censused, with Haeseker defining the SAR as "*the number of adults that return to LGR divided by the number of smolts that were released at LGR*" (p. 124).

Thus, in Haeseker et al (2012) "*SAR*" really does mean what escapes the fisheries to ***return*** to the dam and harvest is excluded from consideration as a factor influencing "adult return" numbers. This is an important oversight, even for the relatively low levels of harvest we reported in our paper for Snake River spring Chinook.

6. Quantitative analyses of the data sets collated by the authors in this study do not support their conclusions of a coast-wide decline of Chinook salmon survival, that broad oceanic factors are a primary driving force in coast-wide survival of Chinook salmon, or that the SARs of Snake River spring Chinook populations are higher than estimates reported from many other regions of

the west coast lacking dams.

- If Chinook salmon survival across the West Coast is determined in the ocean by common processes, we would expect that common year effects would explain a substantial portion of the variability in SARs. We found that common year effects explained only 14% of the variation in SARs, indicating little support for the claim that common ocean processes are a primary driver of Chinook salmon survival along the West Coast.

KRS: The FPC is taking a simplistic view of oceanic processes. Their analysis assumes that a common process operates on all populations in the same year across the available record. Instead, there appear to be time lags as in the south to north decline in survival that has only recently reached Alaska. Also, a very few populations so far appear to have escaped conservation concerns. Our message is that because survivals are currently similar in most areas including pristine environments, it is difficult to ascribe the cause of the decline to those unique factors whose effects are constrained to specific regions (freshwater habitat degradation in the southern part of the range, and dams in the Columbia River).

- Of the 77 Chinook salmon stocks collated by Welch et al. (2020), 66.2% showed no significant temporal trend in SARs, 14.3% showed significant increases in SARs over time, and 19.5% showed significant decreases in SARs over time. Four of the stocks that showed significant declines over time were hatchery Snake River spring Chinook, wild Snake River spring Chinook, wild Snake River summer Chinook, and wild upper Columbia River summer Chinook.

KRS: There are several reasons why the FPC's trends are not consistent with Kintama's conclusions. First, the FPC takes our conclusions out of context and presents the results on the incorrect scale. We provided a list of the specific regions to which we were referring: "*This [threefold decrease in SARS for hatchery populations] applies to hatchery subyearling Chinook from west coast Vancouver Island, the Strait of Georgia, Puget Sound, and the mid-Columbia River; and to hatchery yearling Chinook from SE Alaska, the lower and upper Columbia River, and the Snake River (upper Columbia and Snake rivers are relative to the historical freeze brand data from Raymond (1988))*." Other regions either have no trend or are generally increasing with time.

Second, the FPC analysis does not match the trends with time visible in the manuscript (our Figure 2) because they fit an exponential curve e^{-bt} to the survival data (or, equivalently, a straight line with slope -b to the log-transformed survival values). This approach is flawed because there is no simple linear pattern between log(SAR) and time (see Figure 2 of our report), violating the basic premise of linear regression that the model is a reasonable fit to the data.

It should not be surprising that such a simple model fit to a wide range of populations failed to show a consistent rate of decrease with time. The log-linear model the FPC chose fails to account for the stanzas of changed marine survival associated with the various recognized ocean regime periods (post-1977: decreased marine survival; post-1989-further decreases and expanded geographic expression; post-1998: improved marine survival; circa 2004: drop to extremely poor marine survival again; post-2008: improved marine survival).

Third, many of the recently developed (and thus shorter) SAR monitoring time series will show an increase in survival with time. This is a consequence of the rapid increase in the number of populations being monitored by various agencies with time, as we showed in Figure 8 of the paper, and some improvement in marine survival in the post-2008 period. The FPC's fitted trends are basically the result of adopting a flawed methodology and uncritically accepting the results because it fits with their wishes, not because it reasonably captures the actual dynamics.

- Welch et al. (2020) claim "most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift show an approximate threefold decrease in SARs for hatchery populations" and that "overall, Chinook salmon survival (SAR) has decreased by roughly the same amount everywhere along the west coast of North America," but did not conduct a quantitative analysis to test these claims.

KRS: Our statement that "*overall, Chinook salmon survival (SAR) has decreased by roughly the same amount everywhere along the west coast of North America,...*" was in reference to the current similarity of survivals in most regions to those in the Snake River (i.e., we were referring to Figure 4 which uses data from 2010-2014 rather than the overall time series in Figure 2). Here we should have written "...has decreased *to* roughly the same amount" as we did at the start of the Discussion and Conclusions sections. We apologize for that error. Our most important finding is that SAR levels are now similar, not that they have declined by the same amount. The statistical analysis is described in section 2.8 in our paper (Comparisons between regions).

- The majority of spring Chinook stocks collated by Welch et al. (2020) demonstrate significantly higher SARs than the Snake River stocks, particularly those hatchery and wild stocks from the southeast Alaska region that are not impacted by dams.

KRS: This is pure fantasy. The FPC claim is based on ignoring our methods. Our analysis used only the most recent years of data (2010-2014) to illustrate the current similarity in coastwide SAR, while their analysis obscures the point by pooling all years together.

The FPC's statement that SARs in Alaska are higher than in the Snake River, is also false. They apparently have made this claim based a comparison of the SARs for wild-origin stocks from southeast Alaska with those of hatchery-origin stocks from the Snake River without telling the reader that this is what they did. (See the column and row titles in the FPC memo Table 1 for the evidence that they pooled hatchery and wild stocks). Thus, the FPC are engaging in exactly the sort of "apples to oranges" comparison that they accuse us of doing. We kept hatchery and wild-origin SARs separate in our analyses.

Further, our paper specifically describes and explains the higher SARs of hatchery-origin Alaska stocks relative to Snake River stocks: "*California, northern BC, and SE Alaska yearling SARs were significantly higher than Snake River yearling populations*." We then went on to note that the Alaskan hatcheries used in our analysis "*...are located at sea level and release smolts directly into the ocean after several weeks of seawater acclimation in holding pens, eliminating losses in freshwater*". For wild-origin stocks, we state that "*The median SAR of four wild Alaskan stocks is slightly lower than the median SAR of three Snake River wild stocks when all years of data are considered (Figure 3) and markedly lower when the comparison is restricted to the 2010–2014 time period...*".

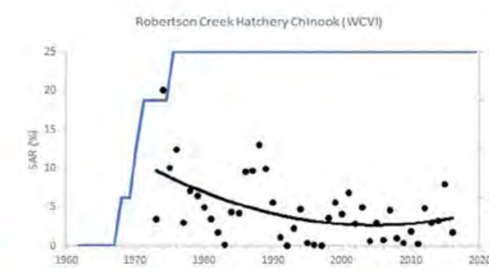
Note that the FPC did not extend their test of our results to subyearling stocks, where SARs for all regions except Oregon were higher than the Snake River region (Figure 4 top panel). A casual reader might mistakenly interpret their point as applying to our results rather than just those selected by the FPC.

- [FPC memo] Figure 3. SARs for Upper Columbia summer Chinook, wild Snake River spring Chinook, hatchery Snake River spring Chinook, and Snake River summer Chinook (points) and fitted regression trend lines that indicated a significant decline in SARs over time. Blue lines represent the number of dams in place during each smolt outmigration year.

"Whenever a theory appears to you as the only possible one, take this as a sign that you have neither understood the theory nor the problem which it was intended to solve."—Karl Popper

KRS: In their memo, the FPC illustrated correlations between dam completion and declining salmon survival as evidence for causation. In the spirit of using this same standard for scientific proof, we have plotted two datasets from outside the Columbia River basin which extend back to the 1970s that show the decrease in salmon SARs for total North Atlantic Salmon abundance and British Columbia WCVI Chinook (Robertson Creek) and the increase in the number of Snake River dams over time. Although these data sets do not extend back to the completion of the earliest Snake River dams, both panels show a decline in SAR/abundance during construction of the two final dams and following completion of the dams. One might conclude, using the FPC's logic, that the construction of the Snake River dams even caused the collapse in salmon productivity beyond the Columbia basin and even in a different ocean.

We have two choices here: we accept the FPC's standard for scientific analysis (correlation), in which case we conclude that reducing the number of dams in the Snake River will also improve the status of a wide range of salmon populations in both the Atlantic and Pacific Oceans, such as those we have plotted. Alternatively, we accept that there are widespread declines in salmon survival, most of which have nothing to do with the number of dams constructed in the Snake River.



Occam's Razor dictates that we should take the most parsimonious scientific explanation, which is that a common driver is primarily responsible for the similar declines in many populations, as we found in our paper. The scientific issue then becomes: "By how much do the Columbia/Snake River dams actually affect Snake River survival separate from climate issues?" These are greatly different perspectives. And to remind the reader of the central premise from our Fish and Fisheries paper, if nearly everywhere is now reporting the same low levels of survival, then a serious re-thinking of current salmon conservation strategies is called for.

7. The authors' comparison of PIT-tag data and CWT data is misleading and reflects the authors' lack of understanding of both types of data and their application.

KRS: We present region-wide CWT-based SARs (Figure 3) and we separately present PIT tag-based SARs for the Columbia River region (Figure 5). The conclusions of our paper are largely based on the CWT data. While we dedicated a section of our paper to comparing CWT-based SAR estimates to PIT tag-based SAR estimates to illustrate the nature of the differences (Figure 6), we do not otherwise draw conclusions based on a comparison of the datasets.

We specifically compared the few available SAR estimates we could find where both stock and outmigration year match across the data types (Fig. 6 of the paper). The slopes of those linear regressions were population-specific but had R^2 values ranging from 87%~99% for subyearling populations and 82-97% for yearling populations. We view these surprisingly high R^2 values as good evidence that both tagging methods give similar survival estimates once harvest and above-dam losses to smolts and adults are taken into account in the PIT-based SAR estimates.

- The author's neglect to address and present the considerable uncertainty associated with CWT SAR estimates. In addition, the authors do not recognize the purpose or the management application of the PIT-tag SARs in the Columbia Basin. Because PIT tags are detected and recorded without the necessity of lethal sampling of the fish, which is required for CWT recoveries, PIT tags are detected multiple times at multiple life stages and provide more extensive life history data and more precise, estimates of SARs.

KRS: We reject the FPC's claim and point first to the three pages (p. 12-14) in our paper where we specifically discuss these issues: Section 4.2 ("*Credibility of SAR Estimates*") and the Conclusions. We used the CTC indicator stocks for our main analysis because their estimates use a relatively consistent methodology and were collated for international decision-making. While imperfect, right now they are the best that are available. CWT-based survival estimates are also the only methodology available for measuring survival outside of the Columbia Basin.

The CTC estimates were not provided to us with estimates of error on the individual SAR estimates, likely because calculation of the real error is not realistically possible. As a result, we used bootstrap resampling of the point estimates to calculate the uncertainty in median SAR levels because if the individual SAR estimates have substantial inherent uncertainty then presumably that additional variability will be captured in the bootstrap resampling of the point estimates. Bootstrapping is an accepted mainstream methodology; for example, Haeseker et al. (2012) employed it and the FPC certainly seem to have embraced its use.

The FPC claims that we do not recognize the purpose or the management application of the PIT-tag SARs in the Columbia Basin. In fact, one of our important conclusions was that the exclusion of harvest may be compromising the use of PIT tag-based SAR estimates underpinning NWPCC recovery goals. We have no reason to question the relevance of PIT tags for measuring *smolt* survival in the hydrosystem, but their use to measure adult survival is fundamentally compromised because the PIT tag system excludes harvest. Nearly a quarter century of interpreting SARs as "*survival*" instead of "*what is left over from the fisheries*" went unrecognized.

In summary, the FPC are essentially saying that it is not possible to use the CWT-based SAR estimates because there is too much uncertainty in the data. Our position is that the CWT dataset has weaknesses (which we discuss in the paper) but that it is also an important scientific resource. We certainly need to adapt as and when we get better information. Neither PIT tags nor CWT tags are perfect. We used both tag types to demonstrate that (a) survival has fallen to similar levels, (b) concerns with using PIT tags as measures of adult survival—but probably not smolt survival—are serious, and (c) CWT and PIT tag-based survival estimates track each other surprisingly well at the level of individual populations. The deviations from a perfect 1:1 relationship seem to be primarily in aspects of survival that PIT tag-based estimates currently fail to track.

8. The authors have misrepresented Pacific Salmon Commission and Chinook Technical Committee (CTC) data sources. The CTC does not maintain a smolt-to-adult-return database, contrary to the authors' statements.

    - CTC does not maintain a database of smolt-to-adult return rates based on CWT data. The attribution of the CWT SARs to the CTC is not accurate. Furthermore, the CTC chairperson advised that the authors assigned incorrect smolt-ages for three stocks (NSF, SKF and SQP). The CTC expressed serious concerns with how the CTC data were characterized in the Welch et al. (2020) paper. The CTC uses and maintains various data sources that contain the information necessary to calculate the SARs calculated in Welch et al 2020, as they are defined in the paper, but they were not developed for this purpose. According to the CTC chair, no current CTC members were afforded the opportunity to review Welch et al.'s 2020 manuscript prior to publication.

    - Welch et al. (2020) define the smolt to adult return rate (SAR) as "the threefold product of freshwater smolt survival during downstream migration multiplied by the marine survival experienced over two to three years in the ocean and multiplied by adult freshwater survival during the upstream migration to the final census point." It is important to recognize that this definition of the SAR includes the combined impacts of freshwater and marine survival factors, and does not separate the effects of the two environments. Therefore, the characterization that SARs only reflect marine processes is a mischaracterization. The CWT recovery data used by the Pacific Salmon Commission (PSC) Chinook Technical Committee (CTC) are not compatible with this definition of SARs and the CTC does not use their CWT recovery data to calculate SARs. CWT recoveries in ocean fisheries overestimate survival to adult return because these data represent harvest mortality (not survival to adult return in terminal areas) and the natural mortality that occurs in the marine environment prior to adult return in freshwater is not incorporated. CWT recoveries in freshwater also likely underestimate survival to adult return because straying and enumeration of hatchery fish on spawning grounds is often incomplete.

KRS: The FPC suggests that we were misleading about the source of our CWT SARs estimates. After reading the FPC's claims about the CTC concerns, we emailed the two current co-chairs of the CTC (John Carlile & Antonio Velez-Espino) asking for clarification. The email trail with the current CTC chairs (with our summary and analysis of what measure of adult abundance is appropriate for our analysis) is included as Appendix IV.

The SAR data we attribute to the CTC were sent to us by Dr. Gayle Brown, the Canadian Co-Chair of the CTC until her retirement in July of 2020[1]. Gayle retired after we had submitted our paper. She also met with us multiple times to explain its use and clarify our questions. Dr. Kristen Ryding, who is a US member of the CTC, also assisted us and provided us with the formula that had been used to calculate the estimates. Neither were asked to review the manuscript as we expected that would be done by the journal's reviewers.

Despite these conversations, we were unaware that the CTC did not consider the SARs estimates we presented as "official products". However, they were calculated using a transparent formula (section 2.2 in the paper) from vetted CTC data sources. As per the CTC response to our request for clarification on what the FPC is claiming (Appendix IV), the CTC "*uses and maintain various data sources that contain the information necessary to calculate SARs as they are defined in the paper*". The FPC are making a mountain out of a molehill.

The email trail with the current CTC chairs (with our summary and analysis of what measure of adult abundance is appropriate for our analysis) is included as Appendix III of this document and on our website. As for the other point about "not consulting" with current members of the CTC, the SAR data we attribute to the CTC were sent to us by Dr. Gayle Brown, the Canadian Co-Chair of the CTC until her retirement in July of 2020[2]. Gayle retired after we had submitted our paper. She also met with us multiple times to explain its use and clarify our questions. Dr. Kristen Ryding, who is a US member of the CTC, also assisted us and provided us with the formula that had been used to calculate the estimates. Neither were asked to review the manuscript as we expected that would be done by the journal's reviewers.

We used the measure of SAR we chose because it is calculated similar to our other CWT data sources (sections 2.3 Agency estimates and 2.4 PSMFC estimates), with the exception that it is adjusted for incidental mortality from harvest. It is also similar to our definition of SAR as the "*threefold product of freshwater smolt survival, marine survival, and adult freshwater survival*". The alternative measure from our CTC data source was the CTC's brood year survival rate estimates from release until entry to the fishery at age 2 or 3 (section 2.1.3 of TCCHINOOK (19)-02) that are calculated for the purposes of harvest management. These values are a "formal product" of the CTC and estimate the ocean abundance of young salmon prior to the start of the fisheries. See our direct response to the CTC (Appendix IV), where we compare the measure of adult returns we used with the abundance of immature Chinook in the ocean prior to the start of fisheries, the "pre-fishery" abundance the CTC consider an official product; there is a strong relationship between the two estimates of abundance. We believe that the measure we used is more appropriate than an estimate of abundance prior to fishing.

[1] The Acknowledgements section of our paper states (in part): "We particularly thank **Dr Gayle Brown** (DFO; retired) for providing access to the Chinook Technical Committee's SAR database and for many discussions clarifying the interpretation and use of the data. We also received significant assistance in understanding critical details of many SAR and harvest data sets from scientists from *[deleted]* ...**WDFW (Kristen Ryding)...**". Both Brown & Ryding were members of the CTC. The FPC were presumably aware of this when they worded their criticism.

We never stated that *"SARs only reflect marine processes"*. In fact, we explicitly said the opposite (see the quote above about the SAR being a "three-fold product"). What we did say—and still stand by—is that if regions with excellent freshwater habitat have the same low SARS as regions with compromised freshwater habitat then the common problem must be in the ocean, not freshwater. See the expanded analysis we report below of Alaska hatchery SARs relative to the Snake River region for fresh evidence that the decline in SARs really is occurring in the ocean and not in freshwater.

Finally, the FPC claims that we assigned incorrect smolt-ages for Nooksack spring fingerling, Skagit spring fingerling, and Squaxin pens fall yearling Chinook. The age at migration as yearling/subyearling was correctly assigned according to the CTC reports. Subsequent discussion with the CTC clarified the source of the error, which is that the year of outmigration is offset by +1 for the two spring stocks and -1 for the fall stock. The data were sent to us with this error. Fortunately, it makes no material difference to our results and does not affect our conclusions (Appendix IV).

9. The authors conflate fall Chinook and spring Chinook and misrepresent the Northwest Power and Conservation Council (NPCC) regional 4% average, 2% to 6% SAR goals. The authors ignore the fact that these two different races of Chinook salmon have different life histories and have a very different presence in ocean fisheries.

   - While Welch et al (2020) referenced early work by Marmorek et al. (1998) regarding the 2-6% SAR goal they failed to take into account multiple years of analyses on Snake River populations published in CSS reports such as Chapter 5 of McCann et al. (2018). In those reports, the CSS demonstrates the applicability of those SAR targets to the Snake River wild spring/summer Chinook and steelhead. The SAR goal applies to populations in a very specific life segment and takes into account population productivity in spawning areas. A SAR target appropriate for Snake River spring summer Chinook salmon, measured through a very specific life phase, was not developed for, and is not appropriately applied to, CWT populations up and down the Pacific Coast. It is extremely difficult to match the exact life stage and mortality that populations would have occurred prior to entry into that life stage and subsequent to it.

   - Mortality prior to the upper dam and terminal fisheries are different throughout the various river systems.

   - Welch et al. (2020) make assumptions about SAR goals and then make conclusions based on a lack of information. For example, they state in their discussion section regarding the importance of ocean harvest "Unfortunately, what went unrecognized was the effect on the many Columbia River studies based on PIT tags." However, the CSS, recognizing the importance of ocean harvest for fall Chinook salmon, does not consider the 2-6% SAR goal appropriate for fall Chinook. This lack of understanding of CSS PIT-tag analyses makes these broad concluding statements nonsensical.

KRS: The FPC has worded this point to suggest that we ignored the life history differences between fall and spring Chinook. Instead, what they mean is that we were not sufficiently clear on how we used the 2-6% recovery goals.

We split our analyses into separate sections for fall and spring Chinook. We can find nowhere in our published paper where we "conflate" the results as the FPC claims. Section 2.7 ("Division by Life History") explains at length why we kept the two major life history types separate, but to quote briefly from the paper: "*These life history types are examined separately in our analysis because there are important ecological differences between them*" (p.198).

As for the NPCC 2-6% SAR goals, we have shown these as bands on all regions and both major life history types, not because we wish to misrepresent the applicability of the NPCC's goals but because they represent the only explicit SAR recovery targets for the west coast of North America. We showed these recovery goals as bands on all the regional fall Chinook SAR estimates as well as the spring Chinook regions (Figs. 2, 3, & 5) because they are relevant to the debate about whether they can realistically be attained. The text makes repeated mention of how the recovery targets apply to spring Chinook. Because the various plots show that these goals are not being reached in other regions, then surely the debate in the Columbia should begin to take into account the point that other regions without dams are not achieving these goals either... including the more productive fall Chinook stocks.

The FPC say it is "nonsensical" of us to conclude that exclusion of harvest may affect Columbia River studies based on PIT tags. We disagree. Our conclusion about the effect of harvest was not so much related to the 2-6% objectives but based on our concerns that the unexpectedly high and variable levels of harvest over time plus the Pacific Salmon Treaty's abundance-based harvest management system may set up a negative feedback system that distorts the adult return levels in complex and important ways. In combination, these two concerns could partly or completely mask fluctuations in the number of returning adults, which is the current metric that the Columbia River Basin sets for recovery. (Incidentally, in-river harvest management in the Columbia River could potentially also lead to the same sort of feedback system, not just the Pacific Salmon Treaty).

Unless the issues concerning the failure to incorporate adult returns can be sorted out it may be more realistic to set smolt survival goals under the ESA relative to hydrosystem operations than make hydrosystem operations dependent on what escapes from unmonitored fisheries.

10. The analytical techniques and underlying data used by the authors are inappropriate, misleading, and unreliable.

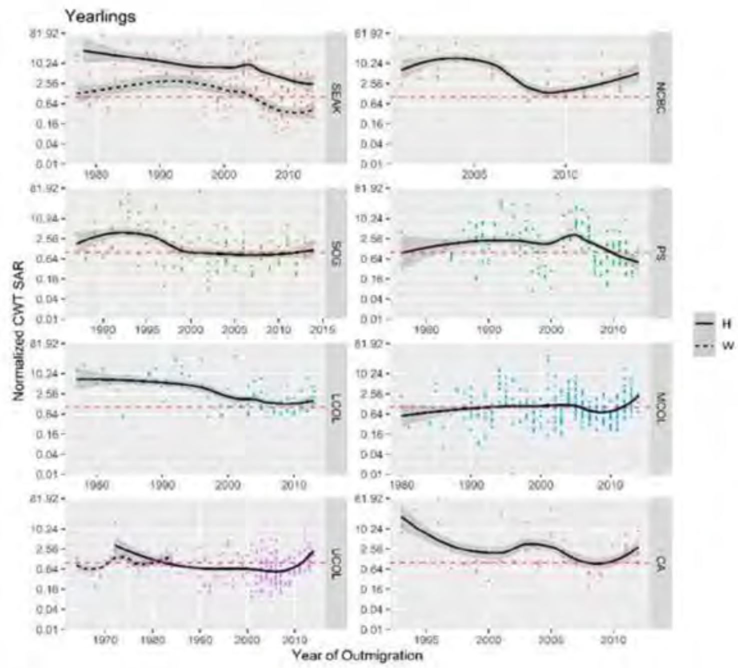
    - The sample sizes in these groups are concerningly unbalanced and small varying from 0 to 11 (Table 2) and from 3 to 49 (Table 3), despite the fact that these groups were visually weighted equally with uniform confidence estimates.

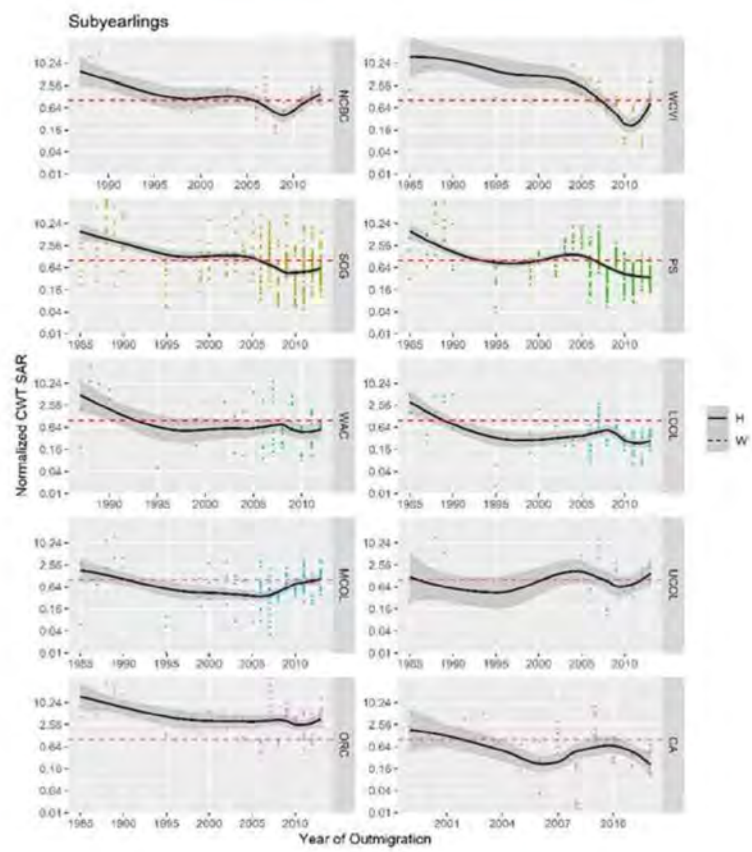
    - The replication process relied on unbalanced sample sizes between years which skew the expected draws within regions and weights SARs to years that are more heavily represented within the sampling distribution. For example, drawing at random from the 2010-2014 SAR distribution for the Snake River (N=46), a SAR value from ocean entry year 2012 would be 5.5 times more likely to be drawn than an SAR value from 2014.

- The lack of any attempt to include or evaluate a year effect within the Welch et al. (2020) analysis significantly dilutes the level of insight we can obtain from the visual comparisons presented in their Figure 4.

KRS: The five reviewers and the journal editor did not find that our techniques and data were inappropriate.

Regarding sample size, the CWT dataset is what it is: the number of populations monitored in each region varies. It is reasonable to assume that the CTC has enough indicator stocks to adequately monitor each region. More is always better and balanced designs are better, but we work with what is available.





Our original analysis was simply focussed on representing 'recent' survival; within the 5-year period 2010-2014 (Fig. 4 of the paper), we did not view it as particularly important if more samples came from certain years. Here the FPC raise an interesting point: the imbalance between years in the number of SAR estimates could potentially distort the results if some years have better ocean survival and not all regions have sufficient data submitted to properly capture this.

To examine the FPC's criticism, we redid our analysis using all years in the time series but this time restricting the comparison to individual years. The number of datapoints available for each year was small, so instead of bootstrap resampling, as we did in the paper, we calculated the annual SAR ratio $SAR_{i,t}/SAR_{Snake,t}$ for each of the i regions, with each year t treated separately for all possible combinations of SAR$_{i,t}$ and SAR$_{Snake,t}$. (In other word, if two regions have three SAR estimates each in the same year, (a,b,c) and (f,g,h), we calculated all of the possible unique ratios: (a/f, a/g, a/h, b/f, b/g, b/h, c/f, c/g, c/h)).

The figures to the right use a separate panel for each regional comparison with the Snake River. We used the standard loess smoother in R to highlight the trend over time in the SAR ratios (hatchery populations: solid black line; wild populations: dashed black line). The grey bands show the 90% confidence intervals of the smoothed average; they do not include any underlying error in the SAR estimates themselves because CWT-based SAR estimates do not include these values, so it is the variability among the annual point estimates of the SARs for a region that is used to define the uncertainty.

We specified the 90% confidence interval because the two limits are the appropriate test statistic for a one-sided test at the 95% confidence level of the hypothesis that the i^{th} region's SAR values include the Snake River level. The horizontal dashed red line shows the null hypothesis of equal SARs with Snake River values (i.e., $SAR_i/SAR_{Snake}=1$). Consistent with our 5 year analysis, all regions except for north-central BC and SE Alaska hatchery yearling populations and Oregon coast subyearlings have median SARs trending down over time either reaching or falling below Snake River values. (Note that the y-axis scale is logarithmic and that the span of years on each x-axis changes).

As described in our paper, the five SE Alaska hatchery populations are reared at sea level and only released after a period of acclimation to seawater in netpens; as a result, SE Alaska hatchery SARs do not include any component of freshwater smolt survival. Although the higher SAR values of Alaskan hatchery Chinook relative to the Snake River needs to be qualified by this caveat, the downwards trend to more similar SAR ratios with time is clear.

This approach extends the SAR comparison from the recent 2010-2014 aggregate period reported in our paper to all years of available data with each year treated individually. Our original conclusion for 2010-2014 thus stands, but the longer time series also shows that other regions were formerly far more productive than they are now (SAR ratios relative to the Snake River $\gg 1$) and that relative productivity fell over time to levels at or below the numerical SARs reported for the Snake River in many regions. Even hatchery SARs for SE Alaska, which exclude migration losses in freshwater, show a large reduction over time in survival relative to the Snake River, and this reduction parallels the decline in wild Alaskan SARs over time.

This is additional evidence that the survival decline occurs in the marine phase because the rearing strategy for the Alaskan hatchery populations excludes exposure to freshwater in the smolt phase.

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Review of: Welch DW, Porter AD, Rechisky EL. A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae). Fish Fish. 2020; 00:1–18. https://doi. org/10.1111/faf.12514

Review by: Howard Schaller, Ph.D. Retired Project Leader of the Columbia River Fish and Wildlife Conservation Office, US Fish and Wildlife Service; Charles Petrosky, Ph.D. Retired Fisheries Biologist, Idaho Department of Fish and Game; and Margaret Filardo, Ph.D. Retired Senior Fisheries Biologist, Fish Passage Center

November 23, 2020

"The lot of critics is to be remembered by what they failed to understand" -George Moore

Kintama note to readers: We have chosen to respond point by point to Schaller et al.'s detailed critique, which followed the "Summary points" below and begin on page 4.

As an overview, we disagree with Schaller et al. for two main reasons. We acknowledge and respect the authors as solid scientists, but they put too much faith in (a) statistical exercises correlating adult returns (not survival) from the fisheries (SARs) and (b) the use of simplifying assumptions about where salmon survival is determined. We now know that (a) has serious flaws (see our paper). The critical period concept (b), has been a simplifying assumption used by fisheries scientists since Hjort first proposed it in 1914, but has never been proven. It is unwise to predicate the success of multi-billion dollar salmon conservation efforts on an unproven hypothesis.

Summary points

(Note: Three pages of summary points by Schaller et al have been deleted because we respond to the detailed "Specific Comments" section below, which expands on each of the summary points).

Specific comments (by section)

Abstract

The authors state "Given the seemingly congruent decline in SARs to similar levels, the notion that contemporary survival is primarily driven by broader oceanic factors rather than local factors should be considered." In fact, numerous studies have directly considered local and oceanic factors for PIT tag SARs and life cycle survival rates (which the authors don't cite). These studies have shown that both freshwater migration conditions and marine conditions are highly influential to survival (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020).

The authors state: "Ambitious Columbia River rebuilding targets may be unachievable because other regions with nearly pristine freshwater conditions, such as SE Alaska and northern BC, also largely fail to reach these levels." This authors' conclusion was based primarily on hatchery stocks from these regions, which are irrelevant to wild Interior Columbia stream-type Chinook SAR goals.

The authors claim that PIT tag SAR estimates from the Columbia River Basin are generally consistent with CWT findings is a questionable conclusion. Their primary analysis is based on five years of data, with limited environmental contrast. Studies that have found that both freshwater and oceanic factors are influential to salmon survival are based on long time series, encompassing a large degree of variation in environmental and management conditions (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020).

The authors statement that PIT tag-based SARs are not adjusted for harvest which compromises their intended use, is extremely misleading. The authors fail to point out the several advantages that PIT tags have over CWT, which are especially important in systems with dams and allow for detecting tags in ESA listed fish without having to sacrifice fish to recover a CWT. Including harvest in PIT tag SARs is a relatively simple matter for Interior Columbia stream-type Chinook. In addition, many published analyses have incorporated harvest into PIT tag-based SARs (Schaller et al. 2007, Petrosky and Schaller 2010, McCann et al. 2017, McCann 2018, and Petrosky et al. 2020). These studies illustrate different temporal and spatial patterns in survival rates and document a strong influence of both freshwater and marine conditions on SARs and life cycle survival rates.

KRS: Our paper extends beyond the Columbia River basin. We cited Haeseker et al. (2012). The Petrosky et al. (2020) paper was published nearly concurrently with ours.

Our conclusion regarding rebuilding targets is based on all data presented in Figure 3 of our paper-hatchery, wild, fall, and spring Chinook (treated separately). Surely Schaller et al should be concerned that wild spring Chinook from Alaska have mean/median SARs below that of wild Snake River spring Chinook, as well as all of the hatchery comparisons that showed similar patterns? It is all very well to talk about the complexity of the CWT data, but neither Schaller et al nor the FPC in their critiques have provided any mechanism that would explain why decades ago other regions had higher SARS than the Snake River (which everyone cheerfully accepts) but these regions then drop to equivalent to or lower survivals than recent Snake River levels.

The high R^2 values (between 0.82-0.99) we found between CWT and PIT tag-based SARs for individual populations are an important result. The high correlation should be viewed as indicating that the two survival monitoring technologies track each other well. If Schaller et al would like to present actual reasons to back up their claim that this result is "questionable", we would be happy to consider it. In any case, their stated rationale that we rely on "...five years of data, with limited environmental contrast" (Fig. 4) is incorrect; the CWT-PIT tag comparison was based on all years of data we could find "...*where both tagging methodologies were employed in the same year*" (Fig. 6).

We recognize that harvest is incorporated into several peer-reviewed publications cited by Schaller et al and is included in the CSS's lifecycle model for Snake River spring Chinook; however, the main product of the CSS report, SAR for numerous populations of Chinook, do not include harvest. According to McCann et al (2018): "*The NPCC (2009 and 2014) SAR objectives did not specify the points in the life cycle where Chinook smolt and adult numbers should be estimated. However, the original PATH analysis for Snake River spring/summer Chinook was based on SARs calculated as adult and jack returns to the uppermost dam (Marmorek et al. 1998)….We have made preliminary comparisons of the overall SAR estimates for wild groups to the NPCC 2%–6% SAR objectives, recognizing additional accounting for harvest, straying and other upstream passage losses may be needed in the future as NPCC and other SAR objectives are clarified.*"

Thus, if the NPCC SAR goals are based on CSS SAR estimates features in their reports, harvest should be included. According to NOAA's Recovery Plan for Snake River Spring/Summer Chinook (NOAA 2017): "*Harvest exploitation rates have been relatively low on Snake River spring and summer Chinook salmon, generally below 10 percent, but have increased in recent years due to the continued large returns of hatchery spring Chinook salmon to the Columbia River basin. These large returns triggered increased allowable harvest rates under the abundance-driven sliding-scale harvest rate strategy guiding annual fishery management.*" Our view is that ignoring harvest is a serious omission in studies examining how SARs are impacted by hydropower operations. While not all studies make this error, many do.

1. Introduction

Welch et al. sets up a false dichotomy of ocean versus freshwater influences on salmon survival in literature (whereas a wealth of existing literature shows it can be both in altered systems).

Not sure they accurately reflected NPCC 2-6% SAR goals; they do not acknowledge the parallel objective of understanding ocean influence so that actions taken in freshwater can help ensure salmon can survive in face of varying ocean conditions.

The introduction seems to be setting up a means to discredit NPCC SAR goals for wild interior Columbia stream-type Chinook, but they then focus most of the analysis on hatchery ocean-type Chinook. Recent analysis in Petrosky et al. (2020) gives more direct evidence supporting NPCC goal relative to Marmorek et al (1998) and NMFS Interior Col. River rebuilding goals (ICRTRT 2007). This support is for stream-type Chinook and by analogy steelhead. It is well understood that 2-6%SAR goal applies to stream-type Chinook and steelhead given similar life history expressions. One wouldn't expect ocean type fish that emigrate shortly after hatching to have similar goals. This is complicated by their analysis which relies on hatchery ocean type Chinook, which have nothing to do with wild stream-type Chinook.

Welch et al. misleadingly states that harvest is not included in PIT tag-based survival estimates. They further state that the "*previously unrecognized limitation* of PIT tagging methodologies is critical to current conservation efforts in the Columbia River Basin because of changes to the terms of the US-Canada Pacific Salmon Treaty..." This is completely false; users of the PIT tag data are fully aware of the portions of the life cycle incorporated in PIT tag estimates. Note that it is a trivial matter to incorporate harvest effects for Snake/Columbia stream-type Chinook populations, which are not intercepted in ocean fisheries. In fact, harvest has been accounted for in many published analyses using PIT tags (which they neglect to cite).

The authors describe a 3-fold process for calculating CWT based SARs (which they don't apply), then they criticize PIT tag SAR methods that doesn't include animals removed by fisheries. However, this statement is false, because in many instances PIT tag SAR methods do include fishery pacts (Petrosky and Schaller 2010, McCann et al. 2017, McCann et al. 2018, and Petrosky et al. 2020.

At broadest level of stock comparison, they claim most of the population decline is due to the ocean via common processes. Their broadest level comparison of populations ignores the different life-history types for these stocks. They don't do any direct analysis of how ocean conditions influence patterns for SARs (the authors comparison employs a very short time series of SARs). The authors conclude that ocean conditions drive these coastwide SAR patterns and freshwater conditions have limited influence on SARs. The authors ignore numerous published studies that have directly considered local and oceanic factors for PIT tag SARs and life cycle survival rates. These studies have shown that both freshwater migration conditions and marine conditions are highly influential on Chinook survival rates (Petrosky and Schaller 2010, Haeseker et al. 2012, Schaller et al. 2014, Petrosky et al. 2020). For these reasons, the broad generalization (by the authors) that most salmon conservation problems are caused by ocean conditions is extremely misleading.

KRS: Many of the points raised here are discussed in subsequent sections.

2.1 Methods/Data Sources

The authors analysis heavily relies on hatchery subyearling Chinook groups. The comparison of survival estimates of these subyearling stocks to SARs for Interior Columbia stream-type Chinook is questionable, because of the difference in life history patterns and period of ocean residence. One may expect to see some general relation of patterns of survival due to large scale ocean conditions, but the authors' approach looked at very short time series of SARs, which would preclude looking at temporal SAR patterns in relation to variable ocean conditions (given past decadal scale oscillation of ocean conditions, Mantua et al. 1997) . However, with the very different life histories, tagging locations and ocean entry points, it's a stretch to expect magnitude of SARs to be similar.

KRS: Schaller et al's argument that we relied "heavily" on hatchery subyearlings is untrue. Although there are more subyearling datasets (n=50 total), the number of yearling datasets (n=33 total) was reasonable (Fig. 3). We kept subyearling and yearling analysis separate (see Section 2.7 Division by life history). It would be nice if the time series were longer, but we used all available data.

Authors claim PIT tags transmit a signal. PIT tags don't transmit – they're passive receptors after being energized thru antennae array to transmit. The large infrastructure of detection arrays in the Columbia River located at dams and instream sites is why they're used here. PIT tags are more accurate and precise for survival estimates. Using PIT tags, one can differentiate migratory pathways thru system.

With CWTs you need to kill a fish to recover the coded information, whereas PIT tags allow for multiple mark/recapture methods. Authors never present or use the large uncertainty surrounding CWT based survival estimates. The authors fail to mention any short comings of CWT resulting in a very one-sided presentation. Given the numerous ESA listed fish populations, PIT tags are a more conservation-oriented method since fish don't need to be killed to read a tag code.

KRS:

1) Schaller et al have the technology backwards. PIT tags do transmit the signal. When a PIT tag enters the EMF field generated by a PIT tag receiver's antenna, an internal copper coil is energized, providing sufficient electrical power for the tag to transmit its unique tag code back to the receiving antenna. Apart from tapping into the electromagnetic field, PIT tags have no technology capable of reception once manufactured—they simply blindly transmit their code when they have the power to do so.

2) "*PIT tags are more accurate and precise for survival estimates*". This is an important but false claim. Schaller et al.'s statement makes it clear that the full implications of the technical problems we identified with PIT tags are not yet understood[1]. If there was no harvest, Schaller et al.'s claim that survival estimates using PIT tags are more accurate and precise than CWTs would be correct—but there is harvest. We will formally spell out why Schaller et al. are wrong.

We define accuracy and precision using the standard statistical conventions. An accurate estimate is one with no bias, so that with sufficient sampling the estimate converges on the true value. A precise estimate is one with small variance. In the current context, the estimate of interest is the proportion surviving, S, and the estimated variance on the binomial proportion S is $\sigma^2 = N \cdot S \cdot (1-S)$, where N is the sample size. The standard error on the proportion is then $SE=\sigma/\sqrt{N}$, so an approximate 95% confidence interval on S would be $S \pm 2SE$.

In the absence of losses to harvest, survival would indeed equal the PIT tag-based SAR, SAR_{PIT}=Adults Returning/Smolts Released. The PIT-based estimate would then be *accurate* because harvested fish do not have to be accounted for. In practice, what the PIT tag system measures is the number of adults *surviving the fisheries to return* to the Columbia River dams and detected there. This is not survival but rather the escapement from the fisheries; the two are equal only if the harvest is either zero or is properly accounted for and added to the number of adults surviving to return to the dams and counted by the PIT tag receivers. Since PIT tag-based estimates do not account for harvest, Schaller et al.'s first claim that the PIT tag system is more accurate is false—it is a downwards biased estimate of survival and the degree of this bias is potentially large and varying with both time and between populations—at least for those populations for which we found data (see Fig. 8 of our paper).

Harvest needs to be added to what is censused at the dams by the PIT tag detectors. Although the degree of bias depends on the population, in the cases where we found harvest data the distortions caused by this bias <u>*were large when compared with the expected effect of dam manipulations*</u> on the number of subsequently returning adult (total returns, catch plus escapement) that scientists are trying to detect. Thus PIT tag-based estimates are generally not more accurate than the CWT-based estimates but less so because CWT-based estimates include harvest, even if the estimate is imperfect.

We will now explicitly demonstrate that Schaller et al.'s claim that PIT tag-based SAR estimates are more *precise* than CWTs is also probably wrong because the PIT tag-based SAR estimates must suffer from the same issues that they list for CWT-based SAR estimates.

The standard error on a binomial proportion, *p*, is simply $SE(p)=\sqrt{p(1-p)/N}$, where N is the sample size (# of smolts released in the case of the SAR). This is the "ideal" precision that can only be obtained when both the numerator and denominator of the survival proportion are known without error.

[1] We leave aside for the time being the equally (and possibly more) serious issue of the Pacific Salmon Treaty acting as a negative feedback loop distorting the adult return. We address that issue elsewhere.

In our paper, we reported that the fraction of the adult return that was harvested, h, was large and variable. We also showed that to turn the PIT tag-based SAR estimate into an estimate of survival required dividing through by the fraction not harvested, (1-h), so that

$$S_t = \frac{SAR_t}{(1-h_t)}.$$

(we disregard the complexities of the multiple age-structure and multiple ages at return and harvest to focus on the key issues). Survival corrected for the missing harvest is thus the ratio A/B, where A is the proportion of PIT tagged adults surviving to be censused at the dams (i.e., the currently used PIT Tag estimate, SAR_t), and B is the proportion of unharvested PIT tagged adults, $(1-h_t)$. A standard result from statistics is that the first-order (Taylor series) approximation to the variance of a ratio A/B is:

$$Var(\frac{A}{B}) = \frac{A^2}{B^2}\left\{\frac{Var(A)}{A^2} + \frac{Var(B)}{B^2} - \frac{2 \cdot Cov(A,B)}{A \cdot B}\right\}$$

Covariance of the SAR estimates and the fraction of adults unharvested is probably small, so we can reasonably ignore the third term. We can then re-write this equation in more concrete terms as follows[2]:

$$Var(\frac{SAR}{1-h}) \approx \frac{SAR^2}{(1-h)^2}\left\{\frac{Var(SAR)}{SAR^2} + \frac{Var(1-h)}{(1-h)^2}\right\}.$$

Only if harvest is zero does the variance on the estimate of survival collapse to the PIT tag-based variance term, $Var(SAR) = \sigma = (N \cdot S \cdot (1-S))^{-2}$. When harvest is positive, the true variance is larger. The first term outside the braces is an inflation factor $(SAR/(1-h))^2$. If, for example, harvest is 50%, this factor is 4X larger than the variance would otherwise be. Even in the best-case situation of the Snake River Spring Chinook where reported harvests are lowest, we found harvests varied from h=10%~25%, this inflation factor varies from $1/(1-h)^2$=1.25X~1.75X. This term alone means that the uncertainty in PIT Tag derived survival estimate is substantially larger than generally believed; rather than the standard large-sample assumption that a 95% confidence interval on a SAR estimate should be ±2SE, this term increases them to ±2.5 SE to ±3.5 SE for Snake River Spring Chinook in the last two decades; for Fall Chinook the increase is from ±2 SE to ±8 SE.

However, to this increase we still need to include the second term within the curly braces, $(Var(1-h)/(1-h)^2)$. As a result, the variance on an estimate of survival has to be larger than the variance on the SAR. How much larger? Although it is generally not explicitly discussed, almost all estimates of both harvest and harvest rate depend on allocating the catch from the various fisheries to specific populations... and that is generally done based on the CWT-based sampling of the harvest in the various fisheries. So, whatever the unknown variance structure of CWT-based SARs is,

[2] We thank Dr John Skalski for a discussion on the finer points of this derivation and for pointing out an error in our original starting point for the development.

Schaller et al.'s complaint about them being poorly defined also applies to the harvest.

In other words, despite Schaller et al.'s claims that PIT tag-based SAR estimation is more accurate and precise, it is neither—and it cannot be so long as fisheries intercept even moderate amounts of the salmon return and the degree of harvest is uncertain. So, whatever the concerns are about CWT-based survival estimates (and we acknowledge there are important concerns), those concerns also apply to a degree to the PIT tag-based survival estimates—and the degree that it applies depends on the (a) the harvest level and (b) the degree that harvest is determined using CWTs.

Given the way the Columbia River PIT tag system was set up to study smolt-to-adult survival, it cannot be otherwise. To avoid the problems with using CWT estimates will require using a separate source of more reliable information on how many Columbia River salmon of a particular population group were harvested in all the west coast fisheries than CWTs provide—the PIT tag system abdicated responsibility for providing this information to the CWT system decades ago when the choice was made not to survey the sport and commercial harvest for PIT tags.

In reality, the return of adults that escape from the various fisheries (the SAR as measured using PIT tags) *is not the biological question of interest* from a policy standpoint—it is the fraction of smolts surviving to adulthood. The allocation issue of distributing adult salmon to various fisheries versus leaving them to escape back to the river and to spawn is basically a political issue involving a negotiation amongst user groups to allocate salmon to their preferred use. However, science-based policy advice about salmon survival in the Columbia River basin surely has to at least acknowledge that those harvests are occurring to have credibility.

In summary, Schaller et al. (and many others in the Columbia) have put more faith in the PIT tag-based "survival" estimates than is warranted. We agree that the PIT tag detectors at the dams probably identify close to 100% of the PIT tagged adults returning to the dams and therefore give a nearly perfect estimate of what *returns*, but the adult return is a badly biased estimate of adult survival because it ignores the large and varying downward bias caused by ignoring harvest that we documented. The uncertainty (variance) surrounding those biased estimates is probably an even worse problem, but the relative degree is currently conjecture.

For reasons perhaps lost to history, the developers of the PIT tag systems chose not to develop the infrastructure necessary to identify PIT tagged fish in the sport and commercial harvest, which would have gone some way towards addressing the problem. As a result, we have to either rely on the CWT-based estimates to estimate the harvest fraction or pretend that they were zero. Thus Schaller et al. are incorrect in their assertion that the PIT tag-based SAR estimates "*are more accurate and precise*" than CWT-based estimates—they might be if, for example, spawning ground escapements are not monitored for CWTs, but this remains to be determined for each population used in our analysis—although we tried to avoid errors like this, it simply wasn't possible to certify that none of the 100+ populations used in the analysis didn't have some issues that we could not identify.

Finally, as a practical matter, although the last quarter century of SAR estimates may be irretrievably lost for use as reliable estimates of survival, this does not mean that this *has* to still apply in future—

the various coastal and river harvests could be surveyed for PIT tags or (more likely) sampled using DNA-based methods. Thus, even if the past estimates cannot be fixed, future estimates can be, at least in principle.

Summary of Methods and Data base problems in Welch et al.

Based on the description of Welch et al. in section 2.2, they calculate the SARs based on the equation in section 2.2. This is a very different estimation procedure than the brood year survivals the PSC calculates, which are the Age 2 survival rates. The age 2 cohort size is estimated through the CWT run reconstruction for a stock specific brood year for a PSC indicator stock. This Age 2 survival rate = (age 2 cohort estimate/CWT release numbers) for an indicator stock and brood year. This is in no way equivalent to SARs used in the Snake or Columbia River studies for stream type Chinook (CSS reports, Petrosky and Schaller 2010, or Haeseker et al. 2012). The Age 2 brood year survival rate was a convention used to estimate a survival factor to be used in the PSC projection model.

So, what Welch presents in the paper is an SAR based on his formula in section 2.2. These SAR estimates are not contained in any PSC documents or produced by the PSC Chinook Technical Committee. Welch carefully states in section 2.2 that the *"database was the source of CWT-based Chinook survival estimates for all regions outside of the Columbia River Basin and for a few stocks located in the Columbia River Basin."* He claims; *the PSC database provides several methods of SAR*. However, review of the supplemental material for the Welch paper provided no reference to a PSC document for his SAR approach. However, curiously in the Welch supplemental material (see attachment Table S1. Datasets of smolt-to-adult return (SAR) estimates for Chinook salmon (*Oncorhynchus tshawytscha*) used in this study: faf12514-sup-0002-tables1.docx) there is a reference to a personal communication with Gayle Brown of DFO (see reference below), **which is not a sanctioned PSC database.** Therefore, they appear to be using something produced by Canada DFO, which is not an official PSC document or database. Either way, it is not clear where the documentation for these data sources and SAR methods resides, or, if they do at all.

KRS: See Appendix 1 for our response to the similar comment by the FPC. See Appendix III for the email trail of our correspondence with the CTC to trace the source of the issue. To briefly summarise, the SARs data that we attribute to the CTC were sent to us by the (now retired) former co-chair of the CTC, Dr Gayle Brown. Although we talked with Gayle multiple times to make sure we understood the data, we were still under the mistaken assumption that they were official estimates from a database. It now appears they were at least calculated using a transparent formula and using data from CTC databases. Additionally, the values we used are closely linear to the CTC's official estimate of the number of immature age 2 (Spring) or age 3 (Fall) ocean age Chinook in the ocean prior to the ocean fisheries occurring. We don't use the CTC estimate of pre-fishery abundance because that measure doesn't estimate the abundance of mature adults and our scientific question is "*What proportion of adult Chinook salmon from the various populations survive from the smolts released?*", not *"What fraction of the smolts released survive to be in the ocean just prior to becoming vulnerable to the fisheries?"*.

Independent of Welch's misattribution of the source of SAR data and methods, there is a long list of problems with the data Welch uses and the inconsistency for SAR methods he employs. These problems include:

1- The dependence on comparing hatchery stock CWT based SAR performance with wild populations.

KRS: This is false. We never compared hatchery SARs with wild SARs and were careful to keep the comparisons separate throughout the paper.

2- The inappropriate summary and comparison of SAR survival performance using yearling and subyearling populations interchangeably.

KRS: We sequentially and separately discuss the two groups. If Schaller et al. want to identify a place in the text where we didn't do so, we are happy to have the discussion. Otherwise, this claim is false too.

3- - The inconsistent approach for calculating CWT based SARs for Columbia River populations versus the rest of the Oregon, Washington, B.C. and Alaska indicator stocks. Welch states in the paper under section 2.3 that for Columbia River Chinook stocks '*they collated some annual reports.to build up a partial inventory of CWT-based SAR estimates for Chinoo*k." However, by Welch's own description there are big differences from the PSC method and huge discrepancies from hatchery program to hatchery program within the Columbia River basin. Welch states that these supplemental Columbia River CWT based SAR estimates were not expanded for incidental mortality or interdam loss, a departure for the method he applies for estimating SARs for the other Oregon, Washington, B.C. and Alaska indicator stocks. In addition, the supplemental Columbia River hatchery program CWT based SAR estimates that Welch inventories have inconsistent methods applied across these programs. In particular, Welch states in section 2.3 that; 'Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish.' See Table S1 for details. Therefore, by Welch's own description, there are very different methodologies applied to estimating CWT-based SARSs across the regions and even within the Columbia River programs. It appears this fact alone would invalidate the conclusions of the range wide comparison on SARs, given that these discrepancies can impact SAR estimates and associated levels of uncertainty.

KRS: Yes, there are differences, which is the reason why we called for a review by the funding agencies (not the fundees) of how SARs are calculated. We were disappointed (and surprised) at the substantial differences in methods that we found in how groups calculate SARs and even in the terminology used. In many cases, the methodologies do not even seem to be documented. (For example, in at least one case we found promising CWT-based "SAR" estimates for a Columbia River hatchery only to discover that the "adult returns" reported were actually only the hatchery rack return number—the number of adults taken for broodstock purposes—and did not include the estimated number of hatchery-produced adults spawning on the spawning grounds). This is unfortunate given the ever-increasing appetite for instituting "SAR" monitoring programs in the Columbia River basin—see our Fig. 8. Similarly, we were equally disappointed to discover just how large harvest levels were and that the CSS often failed to incorporate this.

Some serious soul searching is needed here by the fisheries community because the monitoring programs are costing a substantial amount of public funds but need to be more carefully assessed for rigor and consistency.

However, to respond Schaller et al.'s main point—that there are discrepancies in how SARs are calculated between populations—we agree. However, we did talk with hatchery biologists at almost all Columbia River basin facilities for which we accessed data to ensure that all elements of the return were correctly incorporated. To our knowledge, the only differences between these estimates and those made using the CTC data were incidental mortality (should be small), and inter-dam loss (questionable if it should be included anyway) which are both described in our paper. Whether further data mining will reverse our conclusions is up in the air—this will take more work beyond where we could take the analysis with the available funding.

3 - These previous issues we identify do not touch on the subject of how the CWT-based SARs have a high degree of uncertainty given the problems of high variability in catch and escapement sampling rates that generate extremely wide confidence bounds in the CWT based SAR estimates. Welch does not report any confidence bounds for his CWT based SAR estimates failing to consider the potentially large uncertainty in his methodology. Welch et al. also ignores this uncertainty when comparing SAR estimates across regions and, therefore, draws tenuous conclusions.

KRS: The CTC does not report variance estimates on the survival values. Incorporating these variance estimates could be of interest for a future paper, but will likely be impossible to effectively implement on a coastwide basis owing to the data demands. We believe that the issue of primary policy importance is to look at mean (or median) survival levels along the coast; the variance of those estimates is a secondary issue appropriate for asking how likely is it that the Snake River values are actually lower than other regions despite what the medians indicate.

We did attempt to address the uncertainty in the relative CWT-based estimates in Fig. 4 two ways: (a) by relying on a comparison of median values (geometric means) which tend to be a more robust metric than means for comparison in the presence of outliers, and (b) by using boot-strap resampling of the annual population-specific SAR estimates to create and encompass the underlying uncertainties (Fig. 4). The assumption here is that if the individual CWT survival estimates have substantial variability because of issues with data collection then re-sampling the collection of estimates allows us to better identify how likely it is that some combination of samples lies outside the norm. (In this case, that the bootstrapped samples of regional SARs divided by the Snake River values for the same time period are significantly greater than 1).

The bootstrap technique is a standard approach in modern statistics. Whether it adequately encompasses the true level of uncertainty is obviously up for debate, but the key point of our paper was that the *median* SAR values in recent years are mostly similar or below the values reported for the Snake River. That observation, if true, has important policy relevance and is likely less impacted by the degree of underlying uncertainty in the relative SAR values. In other words, no matter what the as-yet unidentified sources of uncertainty are, they aren't likely to reverse the conclusion that hatchery Snake River subyearling Chinook have greater SARs than hatchery Puget Sound stocks, for example, or that hatchery Snake River yearling Chinook SARs are largely similar with other regions although they may change the width of the confidence limits around those regional medians. See our response in this document to the FPC criticism that imbalance in the number of annual SAR observations between regions might somehow result in our finding that SARs are similar in the five year period 2010-2014; there we extend the analysis back to the beginning of the available record, do the comparison of SAR ratios on an annual basis, and find much the same thing.

We hope that the ISAB will address the important sociological issue of why most scientists were not willing to investigate, much less point out, that the numerical values for the SARs for many regions were in many cases worse than the Snake River. (The answer probably lies in not wishing to have to write rebuttals to the FPC's 21 page memo and Schaller et al.'s 16 page memo).

2.2 Pacific Salmon Commission (CWT-based estimates)

Hatchery SARs primarily represent subyearling fall Chinook and are generally calculated from hatchery release to return to hatchery or spawning grounds plus harvested fish. An exception, are five Alaska spring Chinook hatcheries that release directly into ocean after seawater acclimation, which is very different from headwater Columbia River Chinook experience. The wild Alaska stocks are tagged during downstream migration (SARs exclude mortality from upstream natal areas). It would be informative to have the confidence bounds on these stocks (low mark numbers, high uncertainty, no mark/unmark ratio specific to the wild stocks).

KRS: We documented the point that the five Alaskan hatchery stocks are released directly to the sea and for this reason were likely not a good comparison (p. 197: "*Exceptions include five Alaskan hatcheries used in our analysis which are located at sea level and which release smolts directly into the ocean after several weeks of seawater acclimation in holding pens, eliminating losses in freshwater (see later).*") and *"p. 200: The wild yearling Chinook populations in SE Alaska tend to have lower survival than the hatchery-reared population; however, the Alaskan hatchery SAR estimate provided to the PSC is based on combined data for five hatcheries that all release smolts directly into the ocean after acclimation to seawater for several weeks, eliminating losses from freshwater migration").* We do not have data to develop the confidence bounds Schaller et al. mention, but it could make for an interesting follow-on paper. The data are presumably available from ADFG.

2.3 Agency estimates (CWT-based estimates)

Welch et al. used published estimates for fall, fall-winter, winter Chinook from Sacramento River. They collated hatchery reports to estimate SARs for Columbia Basin spring Chinook (SARs exclude upstream passage mortality). Questionable how well these methods align with Welch methods employed for PSC indicator stocks and quality control on CWT recovery methods. Methods and quality control for many of the supplemental groups differ dramatically. Some of the CWT based estimates were for experimental groups, which is inconsistent with PSC indicator stock estimates for production groups.

KRS: "Agency" estimates were used after discussion with hatchery biologists to ensure the data were representative and that all elements of the run were incorporated and properly expanded. Names of the hatchery biologists are included in the Acknowledgements. We were not made aware of any experimental manipulations that the hatchery biologists felt would bias their results.

We agree with Schaller et al. that having more consistent methods across datasets would be good thing. However, the relative survival values we report have been going on for years while more and more data was collected. No one seems to have thought it worthy to point out that the relative SAR levels don't fit with expectation. It was for this reason in our paper that we call on the funders to conduct a review and ask what has gone wrong. There seem to be two choices here: (a) The data isn't very good, raising the question of why 2,279 years of effort may have been wasted or (more likely in our view) (b) no one was prepared to point out that the collected data did not fit with some long-standing beliefs.

Given the importance of the implications stemming from the numbers, we agree that it would be a good thing to look further into how all these monitoring programs are being conducted. We even explicitly called for that in our paper.

2.4 Pacific States Marine Fisheries Commission Estimates

The authors used estimates for UCOL Entiat hatchery spring Chinook. It is unclear what data quality control was employed. The PSMFC source is a data base, and the authors don't describe how they calculated SARs. Entiat mark numbers were variable over years, and in recent years CWT marks were significantly reduced (no CWT estimates after brood year 2007). Entiat Hatchery moved to PIT tags to better estimate survival rates for the hatchery. It appears the Entiat CWT expansions done by authors had no explanation of approach, no Confidence Intervals provide for CWT based SARs, and no mark levels reported by authors. Entiat CWT marking ended in 2007 (Table S1), why is this reported then in 5 most recent years (2010-2014)? The authors' approach for estimating Entiat SARs appears to be a big outlier from the approach they employed to estimate the SARs for PSC indicator stocks.

KRS: As we state in the manuscript (Section 2.4), we used the PSMFC's RMIS database "...*only for Entiat Spring Chinook after consultation with Entiat Hatchery biologist on the integrity of the dataset*". We called Entiat Hatchery to ask if there was any reason the SARs calculated directly from the RMIS database might be biased (e.g. from use of experimental releases) and if all components of the run were included and were properly expanded for the sampling proportion. In retrospect, we might have been clearer on the specific method of data access from RMIS and subsequent calculation of the SAR ratio. At the time, it seemed straightforward and similar to methods we had described for the PSC and Agency estimates (Section 2.2 and 2.3): download and total the releases, download and total the expanded recoveries, and calculate the ratio. (Note that the recoveries are already expanded for the sampling effort in the RMIS database). Confidence intervals are not provided.

Entiat CWT marking for spring Chinook were excluded from the five most recent years (2010-2014) because the program ended in 2007. We don't know why Schaller et al. think they were included in this particular dataset.

2.5 Raymond (1988) estimates

Used estimates for Snake and upper Columbia stream-type Chinook (1960s-80s). Smolts indexed at uppermost dam, adults as returns to uppermost dam plus harvest loss (excludes upstream passage mortality as well as mortality of juveniles from natal areas to uppermost dam). Note, Raymond's SAR estimates for Snake stream-type Chinook have been re-calculated to also include upstream passage mortality in CSS reports, but these re-calculated estimates were not used by Welch et al. 2020.

They claim they use the Raymond data in conjunction with CWT estimates for a more complete time series. CWT's don't begin until 1979 when comprehensive PSC recovery began.

KRS: We didn't mean to imply that both the Raymond and CWT estimates were available at the same point in time. We included the Raymond data for a more complete (i.e. longer) time series.

We were unaware that the Raymond estimates had been recalculated to include upstream passage mortality. The Raymond estimates we used estimated adult returns fairly far up the river: to Priest Rapids Dam for the Upper Columbia stocks, and to Ice Harbor Dam for the Snake River stocks.

Note also SARs in upper Columbia and Snake had declined by the early 1970s in response to dam construction and operation, this decline was prior to the 1978 ocean regime shift.

KRS: As per Figure 2, there was some decline still occurring around the 1978 regime shift. We refer to the 1978 regime shift not as the cause of the decline, but as a reference point to classify "longer" time series. Construction of the dams likely reduced survivals, but these effects seem to be mitigated. SARS are currently fairly similar for most regions of the coast such that regional factors are not likely the cause of current survival levels.

2.6 Comparative Survival Study (PIT tag-based estimates)

Welch cites using SARs for Snake river Chinook estimated from Lower Granite back to Lower Granite. Note that SARs are also available from LGR to BON, which for wild stream-type Chinook represents primarily pre-harvest returns since the 1990s. (Since ESA listing, there is no directed harvest and limited catch and release mortality (about 2%) allowed below Bonneville dam).

KRS: Adult returns to Bonneville Dam are less representative of survival over the migratory cycle than LGR to LGR. (As the ISAB will know from our response to the FPC memo, several attempts to obtain more representative data from the FPC that included the above dam smolt survival component were stonewalled). Using LGR-BON survival estimates increases the dissimilarity from survival measured using other methods, so we didn't use it—as much as possible we wanted to minimize the potential criticism that the data weren't comparable.

Welch et al. cite CSS report language that SARs do not incorporate losses due to harvest because PIT tags not sampled in fisheries. They neglect to mention or cite that several published analyses (and Chapter 5) do incorporate harvest rates (and upstream passage loss) in stream-type Chinook and steelhead SAR estimates (a fairly trivial matter for stream-type Chinook and steelhead).

KRS: While the published papers may account for harvest, they are applicable only Snake River spring Chinook. As noted above, the CSS produces numerous SAR estimates. Further, Schaller et al.'s claim that the matter is trivial is not true, even for stream-type Chinook and steelhead. We found that Snake River wild Spring Chinook had the lowest reported harvest rates of any group. However, these harvest rates varied over time from ~10% to ~20% since 1998, resulting in the need to multiply SAR estimate by ~1.1X to ~1.25X to compensate, as we pointed out in the paper. For other populations the impact is much larger. These are substantial corrections compared to the tiny changes in adult survival expected from spill or dam modifications affecting the smolts.

2.7 Division by life history

Populations were grouped by subyearling/fall and yearling spring Chinook. When Welch et al. draw the conclusion that ocean conditions are primarily responsible for the patterns of Chinook survival coastwide, it is inappropriate to lump their SAR estimates for stream-type and ocean type Chinook stocks. In addition, they ignore the numerous studies that assess the ocean and inriver factors that best explain the variation in SARs and life cycle survival for wild stream type Chinook.

KRS: This criticism is false. As we noted in our response to a similar claim in the FPC memo, we devoted an entire section of the paper (§2.7) to discussing why we need to treat the two groups separately. As for the claim that we "*ignore the numerous studies*", we cited some of them, but all of these are statistical exercises based on either correlation or regression analysis (which is essentially the same thing—one mathematical way to calculate the correlation is as the geometric average of the slopes of the regressions of Y on X and of X on Y, $r = \pm\sqrt{b_{XY} \cdot b_{YX}}$, where b is the slope of the respective regression[3]). We can agree with the authors that they have identified interesting statistical associations amongst the variables, but correlation is not proof of causation. To achieve the latter will require conducting explicit hypothesis tests rather than correlations.

2.8 Comparisons between regions

The authors do not document how they generated consistent estimates for SARs within and across regions. In fact, the authors conclude that 'we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. This appears to be a fundamental flaw in the coastwide CWT based SAR analysis. This problem only compounds when the authors ignore the uncertainty for these CWT based SARs, then they attempt to evaluate patterns of survival across regions, and then compare and make judgement about the efficacy of much more precise PIT based SARs. The authors make no attempt at formally evaluating the similarity or difference in patterns of SAR estimates across populations. In fact, no attempt is made to estimate the CIs for any of the SAR estimates. The authors simply draw the conclusions for their interpretation of a visual inspection of figure 2. The conclusions drawn from similarities and differences from figure 3 do not provide an evaluation of the pattern of SARs. Also, given the differences in life histories, hatchery vs wild, and within hatchery groups experimental versus production groups the SAR comparisons are dubious at best.

KRS: Patently false. The claim here is that "*The authors make no attempt at formally evaluating the similarity or difference in patterns of SAR estimates across populations. In fact, no attempt is made to estimate the CIs for any of the SAR estimates.*" Actually, we used bootstrapping to derive the confidence intervals around the ratio of SARs between regions in the five year period 2010-2014 (Fig. 4 and Supplementary Info Fig. S1), which addresses the key issue—how similar SARs are from different regions? Fig. 2 shows the time series for the readers, so that they can visually look at the data. Fig. 3 is the box and whisker plot comparing the median CWT based-SARs and the distribution of the data

[3] See, for example, Chapter 300-9 of https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjSmK-nuqvuAhWjFzQIHV5zBp0QFjARegQIMxAC&url=https%3A%2F%2Fncss-wpengine.netdna-ssl.com%2Fwp-content%2Fthemes%2Fncss%2Fpdf%2FProcedures%2FNCSS%2FLinear_Regression_and_Correlation.pdf&usg=AOvVaw2zM294eKi_fjC6dCpO-yFt

around the medians. Fig. 4 then shows the statistical test of the SAR ratios. We arranged the analysis this way because it is good practice to look at the data before blindly calculating confidence intervals... The confidence intervals that Schaller et al. claim we didn't do are explicitly shown in Fig. 4.

We agree with Schaller et al.'s point that the uncertainty in the CWT-based SAR estimates is complex. One approach would have been to go into the underlying data and try to develop clear formulae for the uncertainties. But given that CWTs have been used for over half a century and this is not routinely done is probably sufficient warning that it cannot be successfully done without a plethora of assumptions. Instead, we opted to use resampling approaches to ask what the uncertainty was in the observed SARs. If the individual annual SAR estimates are inordinately variable, then the resampling approach should generate empirical 95% confidence intervals that are "unreasonably" wide compared to what we measured. First, they didn't. Second, the key policy issue is the relative survival levels amongst regions relative to the Snake River region. Schaller et al. are essentially hoping that the uncertainty is so large that the possibility of Snake River SARs being below the lower 95% confidence interval is still plausible.

Some perspective may be useful here. Schaller et al. (and the FPC) are arguing that because the data contain complexities "maybe" our results aren't real. Fair enough. But the basic data are pretty simple—how many adult salmon survived to adulthood divided by how many smolts went to sea? In order to generate consistent estimates, we included only PSC indicator stocks supplemented by published research and with agency estimates verified by personal communications with hatchery biologists. We think that the most serious problem is that although that ratio is now similar coastwide, no one was willing to make that statement before now, precisely because of the furor that pointing out the obvious generates. Arguing that the data are "complicated" doesn't explain why SARs have converged over time to about the same level.

The extremely short 5-year time series (employed by the authors) inhibits making robust and rigorous conclusions about ocean factors that influence survival patterns for Chinook populations. Because of different mark levels and recovery rates for different groups, the analysis should have directly considered the CI about the CWT SARs to reflect the highly uncertain nature of these estimates.

KRS: We chose the most recent five year period because we wanted to specifically show recent SAR levels across regions. In our response to the FPC (Appendix I), we added a new figure that shows the annual SAR ratio relative to the Snake River for individual years extending back for all available years on a region-by-region basis; our conclusions remain the same. The bootstrapping method we used, calculated across all the data, just do not show that results that will fit with what Schaller et al. believe.

The use of normalized ratio relative to Snake isn't clear whether this is for CWT. Analyses should directly incorporate the uncertainty in CWT and PIT SARs, to support rigorous and robust conclusions concerning temporal and spatial survival patterns for Chinook populations.

KRS: The first sentence in the legend to Fig. 4 helpfully states "*Regional CWT-based SAR estimates for Chinook salmon normalized relative to Snake River SARs for the 2010–2014 period*" The y-axis was similarly labelled as "*Normalized CWT SAR*".

As we have already pointed out, we used a bootstrap resampling method to incorporate the uncertainty in the CWT and PIT SARs. In the case of Fig. 4 the legend further states "*Horizontal red lines show the empirical 5% and 95% percentiles on the sampling distribution of the normalized ratio*".

Note: The authors acknowledged that SARs may not measure the same portion of life cycle for the various stocks employed in their comparison.

KRS: Indeed we did. Thanks. To remind the reader of what the issue is, we pointed out on p. 209 (paraphrasing): "*There are two reasons for this. First, for dam-to-dam estimates the survival losses incurred upstream of the dam can vary substantially between populations. Unless census points are located at the start and end of the migration period, the amount of excluded upstream survival acts as a population-specific random variable influenced by the excluded distance*" and "*The second reason is that Chinook harvested in fisheries prior to return are not accounted for in PIT tag-based estimates*". *From at least one perspective, both can be viewed as limitations imposed by the choice to use PIT tags (although above-dam smolt survival could readily be included in survival comparisons if desired). We view the deficiencies as being introduced by the choice to use PIT tags, although we acknowledge that CWTs have significant issues as well. In our view the matter comes down to one of focus—if survival for the migratory phase is desired, CWTs are probably preferable at present. If focus is restricted to smolt or adult survival while migrating within the hydropower system, then PIT tags are clearly preferable.*

2.9 Comparison between CWT and PIT tag-based SARs

It is not clear from Welch et al. how they made adjustments for release to LGR and harvest mortality PIT based SARs.

KRS: We made no adjustments. The regressions are for the unadjusted data (note the very high R2 values). As we state in our response to the FPC memo, we were stonewalled in attempts to incorporate adjustments in smolt survival from release to LGR. Also, the harvest rate data we found were so limited that we did not want to attempt to make partial corrections.

In the equation for the aggregate correction factor in section 2.9 it is unclear and undocumented where the estimates for the parameters S_{smolt} and S_{adult} originated, which are critical parameters that shape comparison.

KRS: Apparently, this section of the text was not worded clearly enough. These correction factors weren't calculated (in large part because the FPC stonewalled attempts to determine smolt survival upstream of the dams). What we are doing in the stated equation in section 2.9 is describing the three factors missing from PIT tag-based SARs. These missing components should be captured by CWT-based survival estimates. The slopes of the 12 separate regressions shown in Fig. 6 quantify those combined values for each population. The high R2 values demonstrate that the combination of the three missing factors from PIT tag-based SAR estimates is probably sufficient to closely match the CWT based estimates.

The second approach to estimate correction factor was to identify populations with both CWT based and PIT based SARs through regression analysis. The authors tried, but couldn't develop a relationship between PIT and CWT based SARs. They couldn't find much data from the same populations to compare CWT based to PIT based SARs, and all of these comparisons are from hatcheries. Where both SAR estimates were available, regression relationships were strong but biased. Subyearling CWT SARs were higher than subyearling PIT SARs (because harvest was not captured in PIT SARs). Yearling CWT SARs were lower than PIT SARs. A correction factor appears infeasible. All of these comparisons lack rigor, because the authors ignored the confidence intervals for CWT based SARs vs CI for PIT tagged based SARs. Ignoring uncertainty for CWT based SARs (which tends to be relatively high) vs PIT based SARS (relatively low) and the small amount of comparison data, brings the authors slim findings intoquestion.

KRS: *"The authors tried, but couldn't develop a relationship between PIT and CWT based SARs"*. We disagree—we found an excellent one, but it was population-specific. As Fig. 6 shows, all but one R^2 values are ≥88% (one of 12 populations had an R^2 of "only" 82%). This is excellent agreement and demonstrates two things: (a) that the differences between PIT & CWT-based SAR estimates are consistent for a given population, and (b) that the deficit is in the PIT tag-based estimates... as we stated in our paper (p. 202): *"...PIT-based estimates differ in two major ways from CWT estimates: (a) they exclude sport, commercial, and indigenous harvest and (b) they exclude smolt and adult losses in the region lying between the uppermost dam and the hatchery or spawning site."*. So there are excellent, simple relationships evident. What we could not develop was a *"one size fits all"* relationship because of the factors that the PIT-based SAR estimates exclude are population-specific. That is not at all the same thing as what Schaller et al. are stating.

3 Results

They used SARs from 94 hatchery populations, 26 wild and 3 hatchery-wild mixed populations. All populations outside Columbia are CWT-based. Within Columbia, CWT and PIT SARs were used.

3.1 SARs from coded wire tags

Independent of Welch's misattribution of the source of SAR data and methods, there is a long list of problems with the data Welch uses and the inconsistency for SAR methods he employs. These problems include:

1- The dependence on comparing hatchery stock CWT based SAR performance with wild populations.

KRS: False. We never compared hatchery populations with wild populations. There is simply nowhere in the paper where that is done.

2- The inappropriate summary and comparison of SAR survival performance using yearling and subyearling populations interchangeably.

KRS: We don't mix up the two life history types, despite what Schaller et al claim. See section 2.7 for an explicit discussion of the reasons why we kept them separate.

3 - The inconsistent approach for calculating CWT based SARs for Columbia River populations versus the rest of the Oregon, Washington, B.C. and Alaska indicator stocks. Welch states in the paper under section 2.3 that for Columbia River Chinook stocks *'they collated some annual reports......to build up a partial inventory of CWT-based SAR estimates for Chinook."* However, by Welch's own description there are big differences from the PSC method and huge discrepancies from hatchery program to hatchery program within the Columbia River basin. Welch states that these supplemental Columbia River CWT based SAR estimates were not expanded for incidental mortality or inter-dam loss, a departure for the method he applies for estimating SARs for the other Oregon, Washington, B.C. and Alaska indicator stocks. In addition, the supplemental Columbia River hatchery program CWT based SAR estimates that Welch inventories have inconsistent methods applied across these programs. In particular, Welch states in section 2.3 that; *'Hatcheries that do not tag 100% of smolts released may expand their estimates for the proportion tagged while others are estimated using only tagged fish.' See Table S1 for details.* Therefore, by Welch's own description, there are very different methodologies applied to estimating CWT-based SARSs across the regions and even within the Columbia River programs. It appears this fact alone would invalidate the conclusions of the range wide comparison on SARs, given that these discrepancies can impact SAR estimates and associated levels of uncertainty.

KRS: Because methodologies vary for estimating the ratio of adult returns to smolt releases does not *"...invalidate the conclusions of a range wide comparison"*. We used the data that we could reasonably find after verifying that there were no major biases. If the CWT data were as bad as Schaller et al. claim, we would not have obtained such high R^2 values in the regression of CWT-based SAR estimates on Schaller et al.'s *"highly precise"* PIT tag-based SAR estimates. So, *ipso facto*, the CWT data appear to be fairly good for comparing between regions despite their warts. (And, to drive the point home for the readers that have gotten this far, the really big deficiencies we found are in the PIT tag-based SAR estimates: failure to account for harvest and exclusion of variable amounts of the life history in the reach between the hatchery and the top-most dams.

As for the claim that "supplemental Columbia River CWT based SAR estimates *were not expanded for incidental mortality or inter-dam loss, a departure for the method he applies for estimating SARs for the other Oregon, Washington, B.C. and Alaska indicator stocks*", in our estimation the effect will be trivial within the comparisons and should not materially affect the conclusions. As with all other aspects of the paper, we have provided the raw data. Schaller et al. are welcome to demonstrate that their concern has substance.

4 - These previous issues we identify do not touch on the subject of how the CWT-based SARs have a high degree of uncertainty given the problems of high variability in catch and escapement sampling rates that generate extremely wide confidence bounds in the CWT based SAR estimates. Welch does not report any confidence bounds for his CWT based SAR estimates failing to consider the potentially large uncertainty in his methodology. Welch et al. also ignores this uncertainty when comparing SAR estimates across regions and therefore draws tenuous conclusions.

KRS: See the prior responses. Confidence bounds were calculated in the most robust way we know how to do: bootstrap resampling. In any case, this issue of the inherent uncertainty in the SAR estimates is a red herring. Because regional SARs for most other regions were generally lower than the Snake River (subyearlings) or similar (yearling) then expanding the width of the confidence intervals will just make the possibility of demonstrating any differences in SARs that actual supports what Schaller et al. believe even more statistically remote. What is needed is a demonstration of a reason why over time measures of central tendency (mean/median) for the SARs from most other regions have fallen from higher levels to approximate the Snake River values. So far we can't identify one—and neither have Schaller et al.

They state that SARs extending back to before 1978 show 3-fold decrease in SARs for hatchery populations. Snake and Upper Columbia rivers stream-type Chinook were in serious decline by early 1970s, well before 1978 regime shift]. Not clear what baseline they actually used for this. Selection of a base line needs to be clear so as to precisely test a posited hypothesis. Methods and results are organized around a vague set of questions without a specific approach to evaluate a well-defined question or hypothesis. For example, the authors describe how they '*collate Chinook SAR time series for the west coast of North America to document broad patterns in survival*'.

KRS: The key hypothesis we tested was whether SAR levels were closely similar between regions and particularly with respect to Snake River survival, as the abstract hints at: "*...the SARs of Snake River populations, often singled out as exemplars of poor survival, are unexceptional*". In the context of this hypothesis test, a SAR ratio significantly greater than one (equality) would have been evidence that other regions without dams have better survival. However, as the abstract went on to state: " *[the SARs of Snake River populations are] in fact higher than estimates reported from many other regions of the west coast lacking dams*". And as for the secondary issue (the 3-fold magnitude of the decline on the longer time series), this is readily apparent from Fig. 2 for longer time series (i.e., those that extend back to the 1970s). SARs are plotted in Fig. 2 using a $\log_4$ axis, so a 3-fold change in SARs is $\log_4(3)\approx0.8$ of one unit (space between tic marks).

Wild populations have higher SARs than hatchery. Limited CWT data for wild and no data from wild versus hatchery SARs from same population. Wild AK SARs lower than hatchery SARs but AK hatcheries release directly into ocean. Only CWT populations in 2-6% recovery range was UW experimental hatchery in Puget Sound & Chilliwack hatchery in Strait of Georgia.

KRS: This is a summary of some of the results from our paper. No response necessary.

3.2 Comparison between regions

Authors conclusion that ocean conditions drive these coastwide SAR patterns and that freshwater conditions may not be drivers of SARs, is questionable given all the methodological flaws described above; In addition, these conclusions are reached by the authors visual observation of patterns in their Figure 2. In order to support their conclusion a rigorous statistical analysis of these survival rate times series is warranted;

KRS: Perhaps Schaller et al. should read the text around Figs. 4 and 6 (last time we looked, bootstrap (Fig. 4) and regression (Fig. 6) both counted as "rigorous statistical analysis"). And, as we point out above, the claimed methodological flaws didn't prevent us from finding R2 values of ≥88% in 11 of 12 populations (82% for one more). For field data, these are remarkably high values. Schaller et al. are silent on (a) why such high consistency between PIT & CWT tagging methods occurs, and (b) why the departure from a 1:1 relationship are chiefly attributable to deficiencies in the PIT tag methodology (failure to account for harvest or above dame smolt & adult survival).

Authors (dubiously supported) conclusion that ocean conditions drive these coastwide SAR patterns, is contrary to the large body of published literature that concludes Chinook salmon population survival rates are most influenced during estuary and early ocean life stages (numerous references from our past pubs; Particularly Petrosky and Schaller 2010). Recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Nickelson 1986; Pearcy 1992; Mueter et al. 2002, 2005; Pyper et al.2005; Peterson et al. 2006).This early marine stage is a very vulnerable life stage for salmon because they make the transition from freshwater phase to a seawater phase involving numerous physiological changes while encountering marine predators. Therefore, especially recognizing the various dispersed ocean entry points for the salmon populations included in the Welch et al. paper, the influence of estuary and near shore ocean conditions would be highly variable (Peterman et al. 1998 shows strongest correlation of marine survival within about 500 km of ocean entry points), and would not support a common marine influence across such a wide geographic range of populations used in the Welch et al. paper.

KRS: It is useful to recall that "*survival rates are most influenced during estuary and early ocean life stages*" is *an assumption*. The hypothesis was put forward by the eminent Norwegian biologist Johann Hjort (Hjort, 1914). Testing Hjort's critical period theory requires (a) measuring smolt survival just after the end of the *"estuary and early ocean life stage"*, and (b) showing that it is highly correlated with survival at adult return. With the exception of Kintama's earlier POST telemetry studies, there is literally no data on the planet to back up the theory one way or the other

The point of our response here is simply a reminder that almost all critical period studies, much like the many papers Schaller et al. cite above, are correlation exercises and do not demonstrate cause and effect. (Incidentally, it is well-recognized that scientific studies not fitting with pre-expectation often get hostile reviews not levelled at statistical exercises fitting expectation. The dearth of papers not finding a statistical correlation supporting the critical period theory may just reflect the difficulty in getting negative results published).

The interested reader should examine the biomedical literature where there is now a concerted effort to move away from precisely the sort of correlation-based analyses that Schaller et al. cite. We think that the stakes are too high in the Columbia River to manage the fate of the hydropower system on the basis of statistical correlation and unvalidated assumptions, such as the one that the early marine phase is "critical". There is, for example, accumulating evidence that the dramatic increase in pinniped predation over the past few decades can potentially cause a great deal of mortality on returning adults. If all regions of the coast had similar increases in adult pinnipeds congregating in the lower reaches of rivers to intercept returning adults, this could be one way to achieve a pattern of decline in survival to similar levels in recent years. (We are not defending this as the primary mechanism driving the poor returns, merely using it as an illustrative of how the "salmon problem" does not have to be caused by a "critical period" in the early marine phase).

However, the only comparison tests the authors' implement is using a very short time series (recent 5 years) without taking into consideration the high level of uncertainty for CWT-based SARs. It is difficult to see how from a short 5-year time series analysis (that ignores the confidence intervals about SAR estimates) that one could seriously evaluate the influence of ocean conditions on west coast Chinook survival rate patterns. Finally, the authors claim 'they examined the CWT and PIT tag SAR data sets to evaluate the broader evidence for "delayed mortality," an important theory that argues that the greater dam passage experienced by Snake River stocks predisposes these populations to lower subsequent survival after migration out of the hydropower system than populations not migrating through the Snake River dams'. The authors present no formal evaluation or hypothesis test for delayed mortality and they dismiss the findings of numerous peer reviewed studies that found the operation and configuration of Columbia River hydrosystem impacts SARs and life cycle survival (delayed hydrosystem mortality) for Snake River stream-type Chinook populations. The results and conclusions of the Welch et al. paper are reached by the authors without any rigorous analyses of SAR estimates or synthesis of previous studies.

KRS: Schaller et al. are repeating the same claims they made earlier in this memo. See our earlier rebuttal of the claim that we did not do a "formal analysis" or "hypothesis test".

SARs from PIT tags

The authors summarize PIT-based SARs in the Columbia River stating that wild fish have generally higher survival and different regions have similar of lower SARs to Snake River. Exceptions are two Mid-Columbia River wild yearling populations (John Day & Yakima), which fall within 2-6% SAR target.

The authors state that both wild and hatchery subyearling SARs from the Mid-Columbia have SARs that fall well below Snake River SAR medians. In addition, the authors state that all other populations (including 3 hatchery Mid-Columbia yearling populaitons) have SARs which rarely or never exceed 2%.

Authors mischaracterize NPCC 2-6% SAR goals. The goals were established for stream-type wild Chinook, and also applied to wild steelhead. It's widely recognized in the Columbia Basin that the specific goal may not apply to subyearling Chinook because of the dramatically different life history strategy and is certainly not a goal to be applied to hatchery populations.

KRS: We simply show the 2-6% goals as bands on the SAR plots because it helps the reader assess what population groups might reach these targets (not many, obviously). In our view, it is just as reasonable to show those on the subyearling comparisons as it is to show them on the Spring Chinook survival values for other regions. For example, the simple fact that we plotted the 2-6% bands on the Spring Chinook SAR comparisons for say, Puget Sound SARs, does not mean that we are suggesting that these recovery goals should be applied to Puget Sound populations. Rather, we chose this presentation so that the reader could evaluate for themselves whether any other regions or population groups were achieving these ambitious goals. They are not, so it may be time to re-evaluate their current use in the Columbia.

3.3 Comparison of CWT and PIT-based SARs

The authors tried, but couldn't develop a relationship between PIT and CWT based SARs. They couldn't find much data from the same populations to compare CWT based to PIT based SARs, and all of these comparisons are from hatcheries. Where both SAR estimates were available, regression relationships were strong but biased. Subyearling CWT SARs were higher than subyearling PIT SARs (because harvest not captured in PIT SARs). Yearling CWT SARs were lower than PIT SARs. Correction factor appears infeasible. All of these comparisons lack rigor, because the authors ignored the confidence intervals for CWT based SARs vs CI for PIT tagged based SARs. Ignoring uncertainty for CWT based SARs (which tends to be relatively high) vs PIT based SARS (relatively low) and lack the small amount of comparison data, brings the authors slim findings into question.

KRS: Schaller et al. are repeating the same claims made earlier in this memo. See our earlier response. We find it remarkable that they repeat the assertion that we "couldn't develop a relationship" when our results using simple linear regressions had R^2 values almost always exceeding 88%.

DISCUSSION

4.1 SAR comparison

3rd paragraph: "North American decreases in survival have occurred despite governments' best attempts through harvest regulation, hatchery enhancement and habitat restoration. A major assumption is that freshwater habitat degradation ... make important contributions to the decreasing survival..." Welch et al. ignore the literature in Snake and Columbia that indicate both freshwater and ocean conditions are important drivers. They ignore the NPCC strategy of freshwater actions to ensure salmon can survive in face of variable ocean conditions.

KRS: We cited some of that literature, which is all based on statistical correlations between measures of freshwater & ocean indices and adult return rates (SARs). We have no disagreement that both ocean and freshwater conditions are important get adults back. Our interest is in the major drivers of current poor SARs. As we describe in a previous publication (Welch et al, 2011), events happening in the later ocean phase are ~27 times more influential on SAR than those in the freshwater and early marine phase.

In the last decade, a revolution has occurred in biomedical research that has now recognized that the correlation-based statistical methods research papers have used are subject to far too many problems (subconscious "cherry picking" of data, "p-hacking", and other sins). See (Horton, 2015) for a thoughtful, if despairing, commentary by the Editor of "The Lancet", which we quote in part here: "*The apparent endemicity of bad research behaviour is alarming. In their quest for telling a compelling story, scientists too often sculpt data to fit their preferred theory of the world. Or they retrofit hypotheses to fit their data.*").

8th paragraph: Delayed mortality paragraph: Welch et al. do cite the CSS chapter on delayed mortality & emphasize that direct tests of the theory have not found evidence to support it (citing their own [flawed] studies. They neglect to cite Haeseker's (2013) review comments and also neglect to mention the weight of evidence that actually does support delayed mortality. They further treat the John Day and Yakima wild yearling Chinook SARs as outliers, by stating that three PIT tagged hatchery mid-Columbia yearling populations and two (wild) upper Columbia populations have similar SARs to the Snake River populations (Figure 5). The flaw with this logic is two-fold: (1) hatchery yearling Chinook SARs are typically lower (sometimes dramatically) than wild due to a number of hatchery operational conditions and genetic differences, which can reduce fitness, and (2) upper Columbia wild yearling Chinook pass through similar number of dams as Snake River populations (the similarity in SARs would be expected due to presence of similar numbers of dams). In addition, mid-Columbia wild steelhead also exhibit higher SARs than counterparts in the Snake and upper Columbia (CSS 2019), mirroring the situation for wild yearling Chinook.

KRS: We responded (Rechisky, Welch, & Porter, 2013), to Haeseker's (2013) review of our "flawed" studies (Rechisky et al. 2009, 2013) and then followed them with another paper (Rechisky, Welch, Porter, Hess, & Narum, 2014) that addressed many of Haeseker's stated concerns but that reached the same conclusion (no evidence of reduced Snake River smolt survival due to extra dam passage).

In our response to Haeseker (Rechisky et al., 2013), we pointed out that our PNAS paper was a formal experimental test of treatment and control groups (Snake vs Yakima R smolts) and found no difference in survival to as far away as the northern tip of Vancouver Island, some 1,500 kms away and about 6 weeks after release. That study used carefully size-matched and timed release groups. Haeseker's criticism was that it wasn't actually the difference in the number of dams that caused the difference in survival, it was some subtle ecological difference between the smolts from the two river systems (perhaps size) that when combined with the difference in the number of dam passages precipitated the 3-fold difference in survival.

So here we can see the value of a rigorous experiment instead of correlation-based science-- the argument shifted to one of "*We are still right, it's just an unidentified ecological difference interacting with the amount of dam passage to cause the reduced survival of Snake River salmon*".

Forgive our cynicism here, but if regional biologists seriously thought that Haeseker's argument had merit they would have tried to identify what that mysterious ingredient was. But perhaps they were simply discouraged by our subsequent paper (Rechisky et al., 2014) where we tagged essentially all sizes of smolts simultaneously arriving at a dam and compared post-release survival using genetic techniques to identify how the Snake River smolts fared relative to the other groups. Again we found no evidence of reduced Snake River smolt survival due to extra dam passage, with fewer of Haeseker's stated concerns applicable. Oddly, that paper is studiously ignored in the Columbia, despite addressing many of the misgivings expressed by Haeseker towards using rigorous experimental tests.

In short, if the region still really thinks that delayed mortality is caused by the Snake River dams they should move to identify what the ecological difference was that combined with dam passage to cause the poor survival. Biologists instead continue to believe in an interesting theory. We think that by doing so they may be unwittingly dimming the prospects for real salmon conservation as ocean conditions worsen.

4.2.2 PIT tag-based estimates

Welch et al. statement about exclusion of survival from release to Lower Granite Dam can vary substantially cited (Faulkner et al. 2017). Note that SARs from upper dam to Columbia River mouth (including harvest & dam passage mortality) explained the majority (80%) of variation in life cycle survival rates of Snake River stream-type Chinook over a 70-year period (Petrosky et al. 2020). Whatever survival variation from rearing areas to the uppermost dam occurred in these years was much less influential.

Welch et al. statement that PIT-based SARs do not provide credible measure of SAR (because harvest is not included) is flat-out wrong. SARs can be measured at various locations, as is clearly pointed out in the CSS report which they cite. For wild yearling Chinook, the SAR with returns to Bonneville Dam include virtually all harvest impacts. Since ESA listing, no direct harvest occurs downstream of Bonneville Dam, and incidental catch and release mortality has been capped at about 2% (depending on projected run size). Moreover, incorporating the effects of stream-type Chinook harvest (and upstream passage mortality) into SAR analyses is straightforward and common in CSS Reports (Chapter 5) and peer- reviewed literature (e.g., Schaller et al. 2014; Petrosky et al. 2020).

KRS: Our point is that PIT-based SARs may not provide credible measures of survival, but rather adult returns from the fisheries (escapement). The distinction is important. We agree that PIT tag detectors at the dams likely provide complete detection of adults returning with PIT tags. However, the fisheries are harvesting a large and variable proportion of salmon that would otherwise survive to return. There are a wide range of populations whose SARs that CSS report, not just the Snake River Spring run. Those losses are unaccounted for because of the failure to design a PIT tag monitoring system for sport and commercial catches back when the PIT tag system was rolled out.

To repeat one of the main points of our paper, because the harvest levels we document are much larger than we had been led to believe, statistical analyses of SAR fluctuations actually measure the combination of dam and ocean-induced fluctuations in survival as well as the fluctuations induced by harvest. This on its own is troubling. However, the terms of the Pacific Salmon Treaty introduce a positive feedback system on those harvests that dampen (at best) or reverse (at worst) manipulations of the hydrosystem that might actually affect survival to adulthood for many of these populations.

Outside of salmon fisheries, we know of no fisheries where responsible adults would accept that analyzing the output from such a system was reliable. In short, the PIT tag situation in the Columbia, as we reported it in the paper (and expanded on this response) is likely not credible as currently used for most populations whose SARs are used as measures of survival. This may include the Snake River Spring Chinook, which we agree had the lowest harvest rates of those populations with harvest rate data that we could find. But the fluctuations in these harvest rates and their impact on SARs, even if "smaller" in absolute terms, may still be substantially larger than the direct effect of such dam manipulations as are currently underway, which are based on projection of SARs (not survival) under spill to levels far outside of previous experience.

4.3 Harvest and PIT-based SARs

Welch et al. statement about PIT-based SARs not accounting for stream-type Chinook river harvest is misleading (see previous comments). Harvest accounting for subyearling Chinook PIT-based SARs is more challenging than for yearlings. The authors apparently do not understand how PIT based SARs are used in the Columbia Basin, but uses (or misuses) them anyway.

The authors state that a challenge with using PIT-based SAR estimates to set quantitative recovery targets for Columbia Basin Chinook is that the fishery management strategy is divorced from the goals. This is false for stream-type Chinook. CSS analyses (Chapter 5) and Petrosky et al. (2020) demonstrated that pre-harvest SARs of 4% (the NPCC average SAR goal) for Snake River stream-type Chinook would result in about 70% of historical productivity. In addition, Lower Granite to Lower Granite SARs of less than 1% (after river harvest) have been shown to result in generational declines in abundance of Snake River wild stream-type Chinook and steelhead (CSS Chapter 5).

KRS: We can agree with Schaller et al. that the "pre-harvest" SARs of about 4% would be nice to return to. Where we differ is on the question of how much is realistically attainable given that almost nowhere else on the west coast of North America is reporting SARs that achieve those levels. As we showed in our 2020 paper and expanded on in our response to the FPC in this document, coastwide SAR levels have largely fallen to numerically comparable levels to the Snake River.

Conclusions

The authors statement in results section 3.1 '*Most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift..... show an approximate threefold decrease in SARs for hatchery populations (Figure 2).*', is the basis for the major conclusions. They claim '*The policy implications of Chinook salmon SARs falling to about 1/3rd of early levels and converging to similar levels nearly everywhere along the west coast of North America are profound.*' They draw from this statement to make the following conclusions:

1. fisheries community need to re-assess several core conservation assumptions;
2. if survival also falls by roughly the same amount in regions with nearly pristine freshwater habitats (SE Alaska, north-central British Columbia), it is difficult to argue for a major role of regional factors in causing the decline;

3. question the actual effectiveness of freshwater habitat restoration initiatives when northern populations with nearly pristine freshwater conditions have similar SARs;
4. Given the similarity of the decline in survival, the economics of hatchery Chinook production are likely similar in other regions;
5. It is unclear whether the quality of reported harvest rate estimates is good enough for past PIT-based SAR estimates to be reliably converted into useful survival estimates;

All of these speculative conclusions drawn by the authors are rooted in fundamental problems in the basic CWT data they relied upon, the poor documentation of the source of these data, and the inconsistent application of these data in their estimates and surveys for SAR estimates. The authors do not document how they generated consistent estimates for SARs within and across regions. In fact, the authors conclude that 'we encountered substantial challenges in fully understanding whether all components of adult returns were adequately included in many SAR time series. This appears to be a fundamental flaw in the coastwide CWT based SAR analysis. This problem only compounds when the authors ignore the uncertainty for these CWT based SARs, then they attempt to evaluate patterns of survival across regions, and then compare and make judgement about the efficacy of much more precise PIT based SARs. The authors make no attempt at formally evaluating the similarity or difference in patterns of SAR estimates across populations. In fact, no attempt is made to estimate the CIs for any of the SAR estimates. The authors simply draw the conclusions for their interpretation of a visual inspection of figure 2. The conclusions drawn from similarities and differences from figure 3 do not provide an evaluation of the pattern of SARs. Also, given the differences in life histories, hatchery vs wild, and within hatchery groups experimental versus production groups the SAR comparisons are dubious at best.

KRS: All the SARs data in the paper are summarized and sourced in Table S1. The full dataset is available for download from the Dryad repository.

The problem with documenting the majority of the SAR estimates is that they are unpublished. We specifically used the PSC's Chinook Technical Committee indicator stocks because they are likely the best available. We supplemented this dataset with other estimates only after verification from hatchery biologists that there was no known reason why the estimates were not representative. Error on the CWT SAR estimates is likely impossible to calculate, but this should not prevent us from using these data. It would be useful to better evaluate the methods used to calculate SARs, which is why we explicitly called for the funding agencies to do so: "*We call for a systematic review by funding agencies to assess consistency and comparability of the SAR data generated and to further assess the implications of survival falling to similar levels in most regions of the west coast*".

More broadly, despite the issues with fully documenting the coastwide survival monitoring programs, all regions have fallen to about the same level. Schaller et al. have pointed out that the monitoring programs are complex and not well documented (which we agree with), but they have no explanation for why the reported SARs would decrease to about the same level.

The authors conclusion that ocean conditions drive these coastwide SAR patterns and freshwater conditions may not be drivers of SARs, is questionable given all the methodological flaws described above. However, the authors dubiously supported conclusions are dismissive of the large body of published literature that conclude Chinook salmon population survival rates are most influenced during estuary and early ocean life stages (Petrosky and Schaller 2010). Recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Nickelson 1986; Pearcy 1992; Mueter et al. 2002, 2005; Pyper et al.2005; Peterson et al. 2006). This early marine stage is a very vulnerable life stage for salmon because they make the transition from freshwater phase to a seawater phase involving numerous physiological changes while encountering marine predators. Therefore, especially recognizing the various dispersed ocean entry points for the salmon populations included in the Welch et al. paper, the influence of estuary and near shore ocean conditions would be highly variable (literature e.g., Peterman et al. shows strongest correlation of marine survival within about 500 km of ocean entry points), and would not support a similar influence across such a wide geographic range.

KRS: We have already discussed these issues in this response. Succinctly put, (1) "correlation is not proof of causation," and (2) assuming that the early life history phase is the critical driver of recruitment is an unproven assumption. We need to move to higher scientific standards of evidence rather than to rely on beliefs.

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APPENDIX III- ANONYMOUS PEER-REVIEW COMMENTS ON "A SYNTHESIS OF THE COAST-WIDE DECLINE IN SURVIVAL OF WEST COAST CHINOOK SALMON"

Responses to 5 Reviewers and editor's comments from two rounds of reviews at Fish and Fisheries. (Our detailed responses describing how we modified the manuscript are also included).

From: Paul Hart <onbehalfof@manuscriptcentral.com>
Sent: Monday, May 11, 2020 6:43 AM
To: David Welch <David.Welch@Kintama.com>
Subject: Fish and Fisheries - Decision on Manuscript ID FaF-20-Mar-OA-084 [email ref: DL-SW-4-a]

11-May-2020

Dear Dr. Welch

I write to you regarding manuscript # FaF-20-Mar-OA-084 entitled "Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)" which you submitted to Fish and Fisheries.

Editor Comments to Author:

The three reviewers give a mixed assessment of your paper with one having only minor suggestions for change but the other two recommending major revision and resubmission. I have gone for the latter because it would be good to have expert opinion as to how you have coped with the reviewer comments. As a resubmission I will send your new version out to be reviewed again.

Although it has not caused me any trouble I would like to point out that both the websites you mention in your Cover Letter that include names of people you didn't want as reviewers, were closed to me. I was denied access to both sites.
Response: I must apologize for the trouble. It seems that these websites have been revamped and are now locked down—I no longer had access either.

If you choose to send the revised manuscript out for review once again, we can provide the list of people we would like to avoid as reviewers, but so long as the reviewers you select are from outside the Columbia River basin region we have no concerns. We are also happy with any of the reviewers we suggested from the original submission that were members of the ISAB/ISRP Columbia River review groups as they are charged with scientific oversight in the Columbia River basin but do not conduct primary research there, so we feel they can provide appropriate perspective and balance on some of our findings.

Reviewers' Comments to Author:

Reviewer: 1

Comments to the Author
This paper combines coastwide data on chinook ocean survival to present a comprehensive story of the historical changes that have been seen, and the result that will surprise many, that survival of Snake River fish is better or equivalent to most west coast chinook stocks.

The paper is clearly written and illustrations are well done and appropriate.

The authors have avoided discussing any causes of the decline in ocean survival which is probably a good idea as it is a totally different paper, but I think it would be worth mentioning the range of explanations that have been put forward.
Response: We added one paragraph in the Discussion, summarizing the potential causes of poor marine survival and listing the authors that identified these factors over the past decade. However, we do not want to get drawn into a debate about why survival is dropping in the ocean, because no one really knows—there is much speculation and some correlation-based analyses, but nothing definitive.

At this point we want to keep the primary focus on the fact that survival (SARs) has fallen everywhere and that this has not been recognized by the fisheries management and research communities, despite the fact that they have been generating more and more of these data sets over the past half-century. This is new information and we feel the community should focus on these results.

My only detailed comment is that lines 100-102 should mention the good performance of Alaskan sockeye fisheries, which are the most valuable salmon fisheries on the west coast
Response: We emphasized the major decline in *southern* populations of commercially important salmon species in our original manuscript because we want to focus on the broader issues and not get drawn into some of the exceptions. As we mention in the Introduction, the lower-valued species of Pacific salmon are doing well. (And, apart from crediting "climate change/global warming" right now I don't think anyone has any actual idea why Bristol Bay sockeye in the Bering Sea are doing so well).

Reviewer: 2

Comments to the Author
Review of Faf-20-Mar-OA-084

Welch et al. examine broad scale patterns in Chinook salmon survival (smolt-to-adult return rates: SARs) by collating data from multiple sources and regions along the Pacific coast of North America. The analysis synthesizes data from most regions where Chinook are monitored (excluding populations further west of SE Alaska), parses data into relevant life history strategies (sub-yearling vs. yearling) and hatchery vs. wild stocks (data more rare for these), and is transparent with sources of data.

With some exceptions, authors found similar and relatively poor SARs based on CWTs for hatchery stocks (both sub-yearling and yearlings) across regions, including those with relatively pristine freshwater conditions. For regions where the time-series of SARs combined across populations were long enough (extended back to 1970's), there was evidence for a synchronous 3-4 fold decline in SAR to approximately the same contemporary level (~1%).

Next, median regional SARs from 2010-2014 were referenced to the Snake River within the Columbia River basin since survival there is generally considered poor (although data suggest currently on the rise?) and SAR recovery targets are in place (2-6%). In general, standardized SARs were not statistically distinguishable from the Snake River (typical case for yearlings) or were lower than the Snake River (typical case for subyearlings).

Patterns in PIT-based estimates of SAR within the Columbia River basin generally aligned with CWT-based estimates, but were not directly transferable, and relationships between the two were population-specific and different between yearlings and subyearlings indicating that a general conversion was not possible. Authors point out that unlike CWT-based estimates, PIT-based estimates may not adequately account for harvest or other components of migration sequence which likely contribute to the lack of transferability.

Primary conclusions included (1) given similarity in regional SARs and seemingly congruent decline in SARs to similar contemporary levels, the notion that survival could be driven more by broader oceanic factors rather than local freshwater factors cannot be dismissed (I feel like relaxing language to something along these lines would help reduce knee jerk reactions and help stimulate conversation and advancement of knowledge)—in other words, actions (presumably small scale??) that try to alleviate ecological bottlenecks during freshwater life may not compensate for ocean conditions as they are generally perceived (or hoped) to do (Snake River dams are highlighted as key example), (2) more careful consideration of the role of harvest and migratory life-history in influencing SAR estimates (particularly PIT-based estimates) is needed to reduce potential bias and increase clarity in patterns of survival for conservation efforts, and (3) more rigorous technical standards are needed for measuring SARs.

Overall, I thought the paper was well written and that the authors effectively distill a large amount of information and present the key elements and patterns. I also do not find myself disagreeing with their conclusions. Given the scale of this assessment, perceptions that it challenges, and new actions that it calls for with the data to support, I feel it is suitable for Fish and Fisheries. However, I do have some suggestions that may help improve the manuscript and that authors and editors should consider:

First, the Abstract seems a little vague to me and primary conclusion (1) above is never explicitly stated and probably should.
Response: We extensively revised the abstract to better clarify the summary points that Reviewer #2 have outlined, and in fact incorporated Reviewer #2's phrasing: "*given similarity in regional SARs and seemingly congruent decline in SARs to similar contemporary levels, the notion that survival could be driven more by broader oceanic factors rather than local freshwater factors cannot be dismissed*" (slightly modified to limit the word count).

Next, I feel like authors could provide a bit better road map for readers by expanding the Introduction and better linking to the Discussion. Essentially including an additional paragraph at the end of the Introduction that makes it clear what is coming down the pipe. As written, all the reader knows is that authors are examining broad scale patterns in SAR, but don't really know what that entails and how it helps us evaluate the importance of ocean conditions vs. freshwater conditions (main conclusion is related to this)—something we don't know much about but is current focus of Introduction.
Response: This is an excellent point. We added a paragraph to the end of the Introduction to outline the methods, explain how our analyses provide evidence of the relative importance of oceanic versus freshwater conditions,

and to clarify the segue from the SARs compilation to the evaluation of the importance of harvest .

Another example is that the transition to PIT-based estimates of survival in the Columbia are never mentioned in the Introduction, but end up seemingly dominating the Results and Discussion. There needs to be a stronger link between what was explicitly examined in the analysis and how different Results regarding SAR methods/patterns would lead to one profound conclusion vs. another to better prime readers for why this assessment is needed and what it all means. If the Introduction could be modified to be a bit more hypothesis driven, maybe that would help?
Response: We have added this material into the Introduction, in order to frame the issues better.

Similarly, the Discussion reads much like repeated Results and most every Figure was cited again. I'm wondering if authors could rework some material that is currently in the Discussion and incorporate into the Results section. I happen to like Results sections that include more context/consistently remind readers as to the how and why, and feel that would be appropriate for a paper like this. The Discussion could then dive a bit deeper into the different profound conclusions. For example, what might be the "broader factors" driving survival? Do we need to ramp up monitoring of wild stocks? Maybe the real answers could be found in those stocks?
Response: We felt the need in the Discussion to reference back to the specific figures as we develop our observations and conclusions—there is a great deal of data boiled down into these figures and we feared losing the readers if they were unsure which data sets/analyses we were gauging our specific statements on.

We added a paragraph providing a literature review of the past decade of Chinook salmon studies (2010 to present) examining aspects of the survival conundrum, categorizing the papers by the mechanisms they propose. However, we don't want to go any further—all of these papers are either conjectural or, at best, correlational. Bluntly put, we don't want to stray into that particular morass when we don't have real data to allow us to discriminate what is going on…we feel it is important to keep the focus on the key points we have identified, not speculate on what is causing poor marine survival when we have no data to contribute.

(And as for the reviewer's point that maybe the "real answers" could be found by ramping up monitoring of wild stocks, this senior author is deeply cynical… he has watched the community start more and more monitoring programs without ever really looking at their data and asking why the survival estimates were so similar everywhere? It should not have taken my group, divorced from the monitoring programs, to point this out…. But it did. Starting more wild salmon monitoring programs will simply be a displacement activity that absolves major governmental organizations from responsibility for going out to sea and finding out what is really causing poor survival. But that is for a different paper).

The other major comment I have pertains to the selection of data. Authors mention excluding a large amount of data in this analysis in their conclusions. Given the call for a broad evaluation of SAR methods and development of more standardized methods for estimation, I feel presenting the rejected data is just as important as presenting the accepted data. The criteria for each is not very clear to me. Do the rejected data tell a different story, meaning that more digging and Discussion with folks on the

ground is needed? Do the accepted data represent and true random sample? Or is there some systematic bias involved? Maybe including rejected data on the map and in supplemental material would help improve transparency and allow us to gauge how representative selected data are?
Response: Including rejected data on the map is simply infeasible. We found in our efforts to find CWT-based SAR data for the Columbia River basin specifically that there are a number of regional databases, but in a number of cases the "SARs" that were calculated in those databases only included some components of adult returns (for example, only hatchery rack returns (the adults used to start the next generation of fish in the hatchery). In a number of cases we variously found that reported SARs did not include hatchery-origin adults spawning on the spawning grounds, counts were not expanded for sampling portions, data were coded as experimental or above dam numbers were not counted. In short, there seem to be very lax standards as to what was being collected & reported. However, we don't want to get into a battle over this—the major focus of the paper is on much more important scientific issues—so we have called for a major inter-agency review of the issues without getting too critical of specific groups. That review will presumably also want to expand our current analysis and make sure that other datasets of acceptable standards are consistent with our own findings. However, we have already done a huge amount of unanticipated work here assessing the quality of the data, and we simply need to publish now and move to the next stage.

Lastly, the standardization procedure authors used could be sensitive to the time-frame examined and I would like to see more rationale for the selection of 2010-2014. Regime shifts are mentioned, with the last one stated to occur in 1998. So, why not consider all data from that point, particularly if the major conclusion from this analysis is that broad scale drivers are more important than local drivers? Doesn't quite line up logically to me.
Response: We have modified the text to provide more rationale for the selection of the 2010-2014 period. We looked closely at Reviewer #2's suggestion but found that extending back over the entire post 1998 period included calendar years where some populations were just not available. We wanted to choose a time frame including the same populations and relatively constant environmental conditions. Unless the populations contributing to the analysis are stable over time, the resampling procedure can potentially include populations which might have different productivity characteristics, distorting the analysis in subtle ways. In addition, 2008 was recognized as a year of major global environmental change (see Arguez et al. (2020)) that was atypical and may have been a regime shift on the west coast of North America (we are still debating that as a community, because there are pros and cons). After 2014 the delays in getting data into the various government information systems meant that few populations were available—so we chose 2010-2014, a 5-year period. This rationale (and the reference to Arguez et al) is now presented.

LINE-BY-LINE COMMENTS:

Lines 360-361: Remind readers that time-series were then combined regionally to better set the stage for the following sections. **Response: We added the sentence "These populations were then aggregated by geographic area to compare regional SARs.".**

Lines 376-380: I would provide this general reminder at the start of the Results section. **Response: Moved.**

Lines 382-383: Two paragraphs above, the mid-Columbia is listed as showing declines in SAR?

Response: **We think it is clear from the text and Figure 2 that the major 4-fold decline is referencing those time series that extend back prior to 1978 but that there was some modest increase in numbers since the early 80s & 90s.** The two paragraphs up statement said (in part): ***"Most regions of west coast North America with CWT time series extending back prior to the 1978 regime shift show an approximate four-fold decrease in SARs for hatchery populations (Fig. 2). This applies to subyearling Chinook from … <u>and the mid-Columbia River</u>… average CWT-based SARs for all regions are now approximately 1% or less".*** Lines 382-383 that the reviewer is questioning says ***"…Chinook from all regions of the Columbia show some increase in CWT-based SARs since the 1980s and early 1990s".***

Lines 384-385: At least not yet. And, it was mentioned in Methods that SARs from Raymond are probably inflated when compared to those estimated more recently. Why doesn't that matter here? I think more explanation would be useful to improve transparency.

Response: We harbour some concerns that the original downstream smolt abundance estimates from Raymond's time may be distorted because of the technology of the day (possibly high doses of the anesthetic MS-222 and use of freeze branding to mark the fish, which could reduce smolt survival and thus <u>*understate*</u> the resulting SAR estimates). We had debated including this comment in the manuscript but decided against it because there appears to be no way to quantify these impacts (the original data sets that Raymond generated are apparently lost). In addition, the Raymond SARs data (even if underestimates), are the official recovery targets so, if anything, understate the true level of decline in survival.

We don't want to have this issue become a distraction from the main messages of the paper—and, in any event, we can't quantify our concerns—so would prefer to not get drawn into an unproductive side debate that cannot be resolved.

The other aspect which Reviewer #2 may actually be commenting on is from Line 252 of the original manuscript "… *(Raymond, 1988). These SAR estimates are inflated relative to the CWT-based estimates"*. However, we think that the manuscript actually makes clear that the PIT tag-based SARs are generated in essentially the same way as the Raymond estimates were (i.e., from dam to dam, not spawning ground to spawning ground). As we go to considerable lengths later in the manuscript to describe our attempts to achieve a consistent conversion factor between PIT & CWT-based SAR estimates (and fail for the reasons described), getting further into this rather murky issue here again seems unlikely to be productive.

Lines 397-404: I assume we should still be looking at Figure 3 here? Might be worth also highlighting any populations that fall well below where others cluster regionally if applicable. Also, on the log scale, some of the differences among medians observed could be quite large. Seems small changes in survival could result in much larger or much fewer adults returning. So, instead of saying that they simply cluster, give us more information by saying that they are variable but fall with XX-XX orders of magnitude of each other etc… Then highlight clear outliers.

Response: The reviewer raises a good point about several populations with unusually low SARs that fall well below the regional clusters. We originally opted not to belabor this point in the manuscript simply because the management response on the west coast of North America is all about trying to recover the SARs that were achieved 4-5 decades ago. The few populations we could identify that do achieve these recovery targets point to where to look if future research is to focus on this question. However, we did add a short sentence to the Discussion section pointing out that a number of populations with clearly lower SARs than typical for their geographic region could also be worthy targets for investigation: "*Similarly, a few populations with anomalously low SARs relative to regional medians also are evident (Fig. 3). If the underlying reasons for higher or lower survival can be identified it might be possible to improve hatchery productivity more broadly*" .

Line 406: Provide new section heading related to normalization and regional comparisons prior to this paragraph.
Response: Added the subheading "Comparison between regions".

Line 408: Not clear to me what is meant by "Interannual timing" here.
Response: Rephrased the paragraph to read: "*To compare the current status of regional CWT-based SARs we included the five most recent years of consistently available SAR data (2010-2014) in a resampling procedure to statistically quantify relative SARs. We chose this time period because there were a consistent number of populations contributing to each regional grouping used in the comparison period and it avoided including 2008, a year of unusually cold* conditions) Arguez et al. (2020))".

Lines 408-409: Briefly remind us why Snake River was chosen as baseline.
Response: Done.

Line 469-470: What are the profound conclusions here? Seems these should be outlined more explicitly in the first paragraph of Discussion to provide a better road map.
Response: We extensively re-wrote both the Discussion and Conclusions to better outline the major findings and the conclusions that stem from them.

Line 470-471: Rephrase to "How comparable are estimates of SAR's among agencies…"?
Response: Done.

Line 475: Shouldn't Figure 2 be referenced here? Overall, the extensive re-referencing of figures (aside from Figure 8) in the Discussion is odd and I don't think should be needed.
Response: The reviewer is correct, the reference should be to Fig. 2, not Fig. 1 (now corrected). We included the extensive referencing to figures to ensure that the readers do not get lost in what aspects of the analysis we were referring to. We can remove/reduce this if it doesn't fit with journal policy, but are inclined to keep the referencing to the figures as it currently is to minimize confusion.

Line 479: Be more explicit about what these "broad drivers" could be? What kind of spatial or temporal scale are we talking here? Rather than relying on citing other papers, give us the key elements in a review like this.
Response: Unfortunately, apart from likely occurring in the ocean, these "broad drivers" remain opaque. One objective for publishing this paper is to try to get governments to start taking the marine issues more seriously, rather than repeatedly falling back on doing more work on freshwater habitat issues (the current default). Straying into conjecture here about why marine

survival is so poor might be interesting but may shift the needed debate from whether our paper is correct in our current findings to squabbles over a side-issue—whether we have correctly identified the drivers of poor marine survival.

We did adopt a compromise here for the Discussion. We added one paragraph listing the possible mechanisms of poor Chinook marine survival, citing all of the papers we are aware of that touch on each proposed mechanism—a one paragraph mini-review of the literature, if you will. However, it is important to recognize that the cited papers are ALL either conjectural or correlational. There are no scientific papers that are actually testing mechanisms, which is what is really needed to move the field forward. (We are saving that topic for an entirely different paper!).

Line 482: Relative "shortness"? I'd rephrase.
Response: We delated "relative".

Line 684: Consider different word choice than "frustrated".
Response: Changed to "ineffective or misleading".

Line 703: I believe University of WA hatchery ended their Chinook program.
Response: Yes, but this is not relevant to our paper.

Figure 2: I don't see where hatchery vs. wild vs. mixed is being shown as indicated in the caption. I'm assuming that the individual data points on the different panels are coded with the different letters? Also, three regimes shifts are highlighted (1977, 1989, 1998) - what do these signify? Initial decline, low point, and some rebound, respectively? Don't recall these being defined in main body of text, but would be nice to describe these more explicitly to help with interpretation of results.
Response: The reviewer needs to zoom in to the individual panels under high magnification to see this—the data points are shown as H, W, & B (=both). We have re-phrased "*The major regime shifts of 1977, 1989, and 1998 are indicated by vertical dotted lines*" to read "*The timing of the major regime shifts starting in 1977, 1989, and 1998 are indicated by vertical dotted lines*".

Reviewer: 3

Comments to the Author
This manuscript has a lot of potential but it is extremely rough. The paper compiles existing tagging data needed to estimate changes in smolt survival to adulthood for Chinook salmon along the North American west coast. This topic will be interesting to lots of people but the manuscript is very poorly written. There is little coherence in the manuscript and the results are presented as a long list of specific examples, all of which seem to be exceptions to the general trend. This is only interesting to people who are intimately knowledgeable about these data. More effort is needed to improve the writing and provide a more accessible message with the data.
Response: This was a complex paper to write because it condenses a lot of data, has several related but disparate messages, and touches on controversial topics. Given that the first two reviewers thought that the paper was well-written and that Reviewer #3 hasn't provided much detail as to what might be improved, we would welcome the editor's input. We do note that we have extensively re-worked parts of the paper to respond to the specific comments from Reviewer #2 and we think that the new discussion and conclusions provide a readily understood summary of the major findings (and the exceptions, where they occur).

The core message that SAR has declined in most places along the west coast, in both heavily impacted and intact watersheds, across a broad swath of latitude, is an extremely important message. The current paper highlights this in the Abstract, but the paper then buries the result in a long list of exceptions to the rule.
Response: Although we have re-worked the discussion to better highlight the findings, we do wish to disagree with the reviewer here. If our results are to have credibility, we also need to demonstrate that we have carefully analyzed the data in a number of ways to see how robust this conclusion is. The delayed mortality theory (that passage through many dams subsequently reduces survival at sea) is a prominent theory that is very persistent. Despite making this aspect of the paper rather Columbia River-centric, we have taken the opportunity to review this theory in depth because the proponents missed the datasets (including their own!!) that did not support this theory. We are setting that shortcoming to rest.

The paper needs to be rewritten in a more streamlined and coherent fashion. It is currently a hodgepodge of results and observations and is difficult to follow. Those very familiar with the data might have a better time with it but this reads like a management technical report more than it does a coherent paper for the peer-reviewed literature.
Response: The Discussion & Conclusions have been extensively re-worked, and we think it now reads quite well. Suggestions from the editor would be most welcome, of course.

Technically, the paper seems to be reasonable, though I would have liked to see more effort put into statistically describing how the trends in SAR are shared among stocks and locations. The Dorner et al. paper shows one example of how to do this. A chronological clustering approach might as well. Again, statistically quantifying this shared trend would improve the quantitative nature of this paper.
Response: We considered a "chronological clustering approach" early on, but the reality is that the starting time of various populations' survival time series varies. Aggregating the data in the way that Reviewer #3 is suggesting risks introducing artifacts into the analysis where time series of regional SARs suddenly jump up or down as data for additional populations with unusually high or low productivity becomes available. It was for this reason that we chose the statistical approaches that we did. We would also like to point out that wherever possible we show the statistical confidence bounds on the data sets (Figs. 2, 4, 7) or use box & whisker plots (Figs. 3 & 5) to quantify the uncertainty for the readers.

Finally, it is important to point out that our statistical comparison of survival relative to the key Snake River stocks (variously listed as endangered or threatened under the US ESA) used the most rigorous modern statistical re-sampling methods we can identify… they are free from requiring us to make assumptions about the form of the underlying statistical distribution and let the data speak for themselves in the most relevant time frame—the most recent (Fig. 4), and in the supplementary information (Fig. S1) we have shown the results using all possible regions as the basis for comparison (to address the potential question about whether there is something unusual about the Snake River region—there is not).

One relevant paper that is worth looking at that provides an earlier analysis of recent changes in Chinook productivity is:

Ohlberger et al. Ecosphere 2016. Population coherence and environmental impacts across spatial scales: a case study of Chinook salmon.
Response: We missed this reference. We have added citations to this paper as well as a another by the same author to the revision.

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Dear Prof Hart—

Thank you for your comments, and the useful comments from the reviewers

I believe we have addressed all of them. Attached (below) is how we addressed each point raised.

Sincerely, David Welch

-----Original Message-----
From: Paul Hart <onbehalfof@manuscriptcentral.com>
Sent: Monday, July 20, 2020 2:35 AM
To: David Welch <David.Welch@Kintama.com>
Subject: Fish and Fisheries - Decision on Manuscript ID FaF-20-Jun-OA-162 [email ref: DL-SW-2-a]

20-Jul-2020

Dear Dr. Welch

Manuscript ID FaF-20-Jun-OA-162 entitled "Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)" which you submitted to Fish and Fisheries, has been reviewed. The comments of the reviewers are included at the bottom of this letter.

The reviewers have recommended some minor revisions to your manuscript. Therefore, I invite you to respond to the reviewers' comments and revise your manuscript.

Because we are trying to facilitate timely publication of manuscripts submitted to Fish and Fisheries, your revised manuscript should be uploaded as soon as possible. If you feel that you will be unable to submit your revision within two months please contact me to discuss the possibility of extending the revision time.

Once again, thank you for submitting your manuscript to Fish and Fisheries and I look forward to receiving your revision.

Sincerely

Paul Hart

Editor, Fish and Fisheries pbh@le.ac.uk

Editor Comments to Author:

The first reviewer also saw your original submission. The other two are new and have a fresh take on your paper but both agree that minor revisions are appropriate.

The second reviewer makes a very important point relating to the geographical scope of the paper. As it states in our Aims and Objectives "A paper in Fish and Fisheries must draw upon all key elements of the existing literature on a topic, normally have a broad geographic and/or taxonomic scope, and provide points of generic value, which make it compelling to a wide range of readers whatever their geographical location". To fulfil this objective it would be valuable if you could makes some comment about the SAR status in other parts of the chinook's distribution. Has any work in Japan been done on this? I don't expect a comprehensive survey of what's happening on the western side of the Pacific but it would be useful to readers who are not salmon specialists to be able to put your results into a wider context.
Response: You & the 2nd reviewer raise an interesting point—salmon survival rates in Asia. I checked with two of my very knowledgeable colleagues and neither are aware of any survival time series for Chinook from either Russia or Japan. Thus "high quality" survival data does not seem to exist. (Chinook are basically absent from Chinese or South Korean waters).

We therefore reviewed the historic pattern of Chinook productivity data for Asia (Russia and Japan) relative to North America (Canada & USA) using data from the NPAFC website (https://npafc.org/statistics/). Asian commercial catch and hatchery releases are both small, with Asian hatchery releases consistently <1% of the North Pacific hatchery release total for the species (thus explaining why SAR data is not available—it is much easier to measure survival for hatchery populations). The Asian commercial catch of Chinook averages just under 10% of the total North Pacific catch of Chinook in the 1970-2019 period.

I have thus inserted the following summary into the Discussion:

"Although survival data for Asian Chinook salmon populations appear to be lacking, Asian populations have had similarly large decreases in abundance relative to North America, suggesting that the drop in Chinook survival is not restricted to North American populations. The reported Asian commercial catch of Chinook averaged just under 10% of the total North Pacific Chinook catch for the 1970-2019 period (NPAFC, 2020). Russian catches for the most recent decade, 2010-2019, were only ¼ of the 1970-79 average. For Japan, catches in the 2010-2019 period were only 1/60th of the 1970s (NPAFC, 2020). Some of the decrease in Japanese catches is likely attributable to regulation changes, particularly the 1977 Law of the Sea Treaty which extended coastal state control out to 200 nautical miles (320 km), and resulted in the transfer of harvesting opportunities from Japan to other coastal states. However, the combined Asian catch still declined to only 17% (~1/6th) the level of the 1970s. Thus, although we only have survival data for North American populations, the decline in Chinook abundance due to decreased survival appears to be Pacific basin-wide".

Please also pay attention to the Instructions to Authors which gives details as to how the manuscript is laid out. At present it does not follow the instructions. If the paper is accepted you will have to make the necessary changes anyway so you might as well do it now.
Response: We reviewed the Author Guidelines from your website: https://onlinelibrary.wiley.com/page/journal/14672979/homepage/forauthors.html.

We are currently non-compliant in one area (odd bracketing for some of the references and some arcane inclusion of authors' initials in a very few of the text references). Unfortunately, this seems to be a bug in my referencing software (EndNote). It seems that the only way to fix this is to replace the dynamic links with pure text, but that will drop the reference from the reference list at the back. I expect that it is best for the copy editor to address this, as I have been unable to find a fix.

Reviewers' Comments to Author:

Reviewer: 1

Comments to the Author
I've carefully reviewed the re-submitted manuscript and response letter. The paper has really improved structurally in my opinion and I appreciate the authors willingness to incorporate numerous recommendations brought up during the first round of review. I also appreciated their thorough and detailed responses to my original comments. Between the substantive revisions that I see and thorough response letter, I have no additional concerns and satisfied with the paper as is.
Response: Thank you.

Reviewer: 2

Comments to the Author
Within the world of "salmonology", this paper will have considerable impact. Its key finding - that there have been fairly consistent region-wide reductions in ocean survival of Chinook salmon - has important policy implications as people consider where to invest in recovery. The authors specifically take aim at attempts to improve freshwater spawning and production, arguing that this may be fruitless if the major cause of declines is reduced ocean survival, including in areas where habitat remains relatively pristine. It is very valuable to have all of the data from such disparate sources assembled in one place. I give credit to the authors for the enormous amount of work that was required to assemble the data and analyze them, while dealing with numerous limitations of the methods that generate survival.

A key issue for this journal is whether this paper will be sufficiently understandable and interesting to a wide audience. It spends a lot of time in the weeds with the details of analyses, specifics of populations, etc. It has to do this, because these details really matter (and it would be good to ensure that the paper is reviewed by people with more experience than I have at analyses of datasets like this, to ensure that issues of comparability of data among sources and across time is adequate to support the authors' conclusions). But the editor should read the paper with an eye as to whether it aims broadly enough with its Intro, Discussion, and Conclusions to serve Fish and Fisheries' objectives.
Response: Addressed above in Response to Editor.

Line 126. "If survival across this vast swathe of relatively pristine territory is severe enough to seriously impact salmon productivity, then there is little hope that modifying freshwater habitat in more southern regions will support a newly productive environment for salmon." This seems logical, but I don't think most people involved in stream restoration are aiming for a "newly productive environment". They are aiming to increase the number of smolts that migrate to the sea, in the hopes that this will lead to stronger adult returns. If ocean survival is cut in half, then if twice as many smolts leave, that MIGHT mitigate the reduced ocean survival, though this depends crucially on the fitness of the smolts when they leave (e.g. reduced survival from hatcheries) and on negative density dependence, which could be severe if the ocean's carrying capacity is lower. All of this is just to say that the wording should be chosen carefully, in terms of objectives and caveats.

Response: If the freshwater habitat modifications won't produce a "newly (more) productive environment" that increases the number of smolts produced, then it is difficult to see how the people advocating for this work are going to generate more smolts to offset the decline in marine survival.

The reviewer's comment is a common response I have seen over my career, where freshwater habitat specialists call for more (freshwater) habitat work but then often fail to change smolt numbers… the habitat is "prettier" (or fits what human eyes see as "more natural", and thus beautiful) but this does not translate into more smolts out—which is the key. As a particularly important example of this, consider a 10 year Washington State study published this February using treatment and control groups to evaluate the improvements in smolt production resulting from a $1.5 Billion US habitat improvement effort. (See Krall, M., Clark, C., Roni, P., & Ross, K. (2019). Lessons Learned from Long-Term Effectiveness Monitoring of Instream Habitat Projects. North American Journal of Fisheries Management, 39(6), 1395-1411. doi:10.1002/nafm.10381).

The authors of that study convincingly demonstrated that there was essentially zero (no) difference in smolt numbers between the multiple replicated treatment/control comparisons conducted at any point in the decade-long monitoring program (Fig. 3 of that report, reproduced here). Yet they never concluded that the habitat restoration work was ineffective in increasing the number of smolts produced for any of the three species of salmonids monitored at any of the 4 time periods it was assessed (what their study demonstrated). Instead they concluded that the study must have been statistically underpowered, which was not true, as their own graph clearly demonstrated! (The differences in all cases were near zero, as opposed to large differences but with large variance).

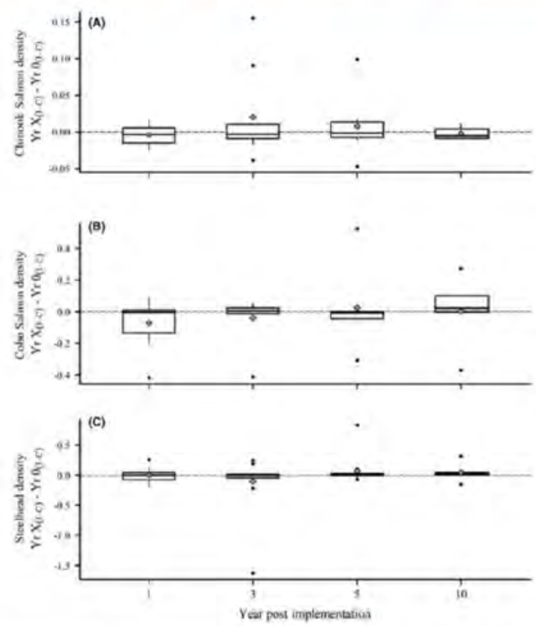


FIGURE 3. Boxplot of the mean difference in the impact (I) minus control (C) for each subsequent year of postproject monitoring (years 1, 3, 5, and 10) minus the impact minus control for densities of year 0 for **(A)** Chinook Salmon, **(B)** Coho Salmon, and **(C)** steelhead. The gray diamonds are the average difference in response between year 0 (impact minus control) and years 1, 3, 5, and 10 (impact minus control).

This is why our paper is important—we are showing that the marine survival declines are large and the same (or closely similar) for a wide range of populations and habitats—including essentially pristine (northern BC, SE

Alaska and (now) Russia). I don't think it is appropriate to hammer on this point that the reviewer makes further in the paper, but it is something I intend to pick up on in a separate paper dealing with the point that the effect of freshwater habitat improvements on smolt numbers is rarely measured, but where it has been there is little evidence that it has had the intended effect of increasing smolt numbers.

Line 142. "Although not explicitly stated, this seems to be the basis for setting the 2-6% rebuilding standard for the Columbia River." It's interesting that it's not obvious where this target came from, and the explanation doesn't mention 2%. It would be good if the authors could pin down the derivation of the targets, perhaps by contacting the authors of the report.
Response: We spent over a week researching precisely this issue in drafting the manuscript. It proved to be very confusing, with recent reports citing earlier reports (often by the same authors) as the justification. In the end, we drew a network diagram of all of the varying reports and their relevant citations before finally narrowing it down that they all led back to a single 1998 report on the issue (which we cite—the reviewer quotes our conclusion from that paper above). That paper (Marmorek et al 1998) does not explicitly state a rationale for choosing the definition of the 2-6% rebuilding target but seems instead to have chosen it because this survival level was what was measured (using different technology) in the 1960s and early 1970s. We found no reports that clearly laid out the justification.

Ultimately, we can't pin down the source—it seems that it transitioned from something that was loosely defined as a sensible aspiration, to something that was almost a legally prescribed definition. We deleted a long section we had written on this issue in an earlier draft of the paper because it added little to the main thrust and we don't want to belabor what is essentially a side issue in the current manuscript,

Line 146. "The SAR is the three-fold product of freshwater smolt survival during downstream migration multiplied by the marine survival experienced over two to three years in the ocean, and multiplied by adult freshwater survival during the upstream migration to the final census point." It would be good to state explicitly how fishing mortality fits in here. When I think of "returns" I usually take this to mean not including fishing mortality, i.e. returns are the num number of fish that return to the coast, and then may or may not be caught. This seems to be the correct interpretation based on Line 244, but readers shouldn't have to wait that long to find out.
Response: We added the following text to the Introduction: *"Survival should include animals removed by the fisheries; however, as we show later, harvest is not included in PIT tag-based survival estimates, which has significant implications".*

Line 179. "Attempts to improve SARs by addressing region-specific issues such as freshwater habitat degradation or salmon aquaculture in coastal zones are therefore unlikely to be successful." Don't you mean "hatcheries", not "aquaculture"? Aquaculture is fish farming; no intentional releases and nothing to do with attempts to improve fish survival. And again, smolt-to-adult returns may not be improved by addressing habitat degradation, but the total number of smolts that leave may be improved.
Response: Salmon aquaculture (fish farming) has been implicated by many as a possible reason for the decline in wild salmon stocks, particularly in British Columbia. We simply want to flag the point that neither dams nor

salmon farms are likely a big driver if regions lacking either industry (Northern BC, SE Alaska) have the same survival issues.

Line 220. Typo. "is to note that that after log-transformation the mean…"
Response: Corrected.

Line 221. Something missing here "We therefore use the simpler terminology both for clarity and because. Furthermore, the median is invariant under log-transformation, which is not true for the mean. Pacific Salmon Commission (CWT)".
Corrected: *"We therefore use the simpler terminology both for clarity and because the median is invariant under log-transformation, which is not true for the mean".*

Line 274. "should include hatchery rack returns," What is a hatchery rack return?
Response: Clarified

Fig. 2 is difficult to read. Consider splitting it in half and present 2 panels one below the other. There is no logical reason to run them all out in a single horizontal row. The caption says "Annual SAR estimates for Hatchery (H), Wild (W), and mixed hatchery-wild data sources (B) are shown…". I don't see those symbols / distinctions among data sources in this figure.
Response: As discussed previously with the editor, the on-line version of the figure allows the reader to zoom in and see the requisite detail. (We added this statement to the figure caption). Additionally, the published version of the figure will be substantially larger than the one used for review. We chose the horizontal row format to allow easy comparison of the magnitude of the decline for the same life history type (yearling/subyearling) across regions.

Fig. 3. At first I missed the legend to distinguish whether populations are wild, hatchery or mixture. Why do some population names include additional symbols for these distinctions, but others not?
Response: Economy of space. We restricted the number of letters in the abbreviated names to reduce the space taken by the axis labels but still allow them to be informative. Symbols to distinguish wild/hatchery/mixed stocks are only included in this figure where necessary to distinguish populations that would otherwise have the same name. The origins for all populations are in Table S1.

Reviewer: 3

Comments to the Author
Title: Review of the Coast-wide Decline in Survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha)
Authors: DW Welch, AD Porter, EL Rechisky Manuscript ID: FaF-20-Jun-OA-162

Summary: In this manuscript the authors present an analysis and review of patterns and trends in the survival of Chinook salmon stocks from southeastern Alaska to California. To accomplish this, they collected the historical smolt and return data for 123 stocks that are tagged as juveniles or smolt using either coded-wire (CWT) or passive integrated transponder tags (PIT). Survival was estimated as the smolt-to-adult return (SAR) rate, where return included both harvest and escapement information. While there is are comprehensive programs to sample harvest for CWT across this stretch of coast, no such program exists for PIT leading to SAR estimates that are concordant but biased compared with CWT-based estimates. The authors find that survivals have generally declined across stocks and almost all are below the rebuilding targets (2-6%) set for Columbia River stocks. Based on the observation that declines are consistent across a geographical scale where freshwater habitats range from highly compromised to almost pristine, the authors propose that the main causes are to be found in the marine environment.

Assessment: This manuscript will be interesting to a variety of audiences and will contribute to the ongoing conversation around the current demographic patterns and trends in this species in specific and all Pacific salmon species in general. The concept that one or more critical periods exist in the marine portion of the Chinook salmon life history has been discussed for decades, but the collation of data and presentation of a widespread pattern across this species adds to the discussion. Likewise, the discussion and demonstration that there are significant differences in data depending on the technology and design of application. Sometimes a great technology can't make up for lack of information. I appreciate the time and attention paid to the style and grammar used, which helped with reading and comprehension.

Recommendation: Publish with minor edits

Comments:
1. Line 130 - This is the first use of SAR and a definition is not supplied until Line 145
Response: We added "*(smolt-to-adult return, or survival)***" to Line 130.**

2. Line 170 - From the text (e.g. Line 734) the changes referred to at this point happened two decades ago, in 1999. The treaty has been renegotiated twice in that period. This needs clarification.
Response: We have clarified that the change we are referring to occurred in 1999 (rather than more recent negotiations). Beyond this, we don't want to divert focus to a history of the Pacific Salmon treaty because Chinook salmon harvest remains "abundance-based" since 1999. All of the battles over further negotiations may be very real to those who live through the multiple meetings each year, but these changes are irrelevant to our big point—that the "abundance-based" management system mandated by the treaty operates to remove much of the variability in adult returns that those working in freshwater are attributing to changes in hydropower dam operations. The two groups are disconnected and working in isolation.

3. Line 182 - Why is the call to funding agencies and not management agencies or trans-jurisdictional management organizations?
Response: Because the funding agencies can drive change. It is the management agencies that have spent the funding agencies' money without ever picking up on the critical issues we have outlined. They should have done so years ago.

4. Line 221 - The end of this sentence is missing.
Response: Apologies. Fixed as follows: *"We therefore use the simpler terminology both for clarity and because the median is invariant under log-transformation, which is not true for the mean".*

5. Line 225 - "coastwide" is not and appropriate descriptor. The Treaty only covers fisheries from Cape Suckling, Alaska to Cape Falcon, Oregon.

Response: We have adopted the reviewer's definition: *"The PSC is a bilateral treaty organization between the US and Canada coordinating coastwide management of Pacific salmon from Cape Falcon, Oregon, north to Cape Suckling, Alaska."*.

6. Line 312 - This statemen is true, but could be better worded since the point being made concerns the measurement of the "return", a term that is hidden in the acronym, SAR. The finer point here may not be clear to a reader that is not familiar with salmon management. See Line 635.
Response: We have elected to leave the existing wording ("*PIT tag-based SARs do not incorporate losses due to harvest (McCann et al., 2018, p. 95) because the commercial and sport catch is not monitored for PIT tags.*") as it currently is. We feel the importance of the failure to account for harvest (catch) is best clearly laid out once, later in the paper where we outline the magnitude of the harvest variations, rather than lightly raised in multiple places.

7. Line 341 - "essentially immune" may be too strong as there can be fishery removals at remote marine locations in the Gulf of Alaska and southern Bering Sea and many yearling stocks are subject to a period of harvest in nearshore fisheries.
Response: Reworded to incorporate this point.

8. Lines 350 to 354 - Limiting the years to 2010-2014 is explained, but the rationale is not clear. Not including through 2008 because it was unusually cold while not acknowledging the unusual warmth that these boodyears experienced in the marine environment during 2014 and 2015 seems inconsistent.
Response: We added the parenthetical clause *"(2014 being the last year with essentially complete data available for all populations)"*.

9. Line 360 - It would help to incorporate the description of this analysis in Lines 444-446 into the description here. The inclusion of SAR_SNAK,j in the equation was confusing until I was reminded that every region was normalized to the Snake River.
Response: We inserted *"relative to the Snake River"* **into the sentence to make this clearer.**

10. Line 551 ff - Consider including Howard et al. 2016 and/or Murphy et al. 2017 to the lists for growth and ocean conditions to extend the range of observations
Response: We added both.

11. Line 558 - Consider including Seitz et al., 2019 for marine predation
Response: Added.

12. Line 607 - This statement is backwards according to the equation at Line 235
Response: Fixed.

13. The style and format of the intext citations varies widely and was actually quite distracting. For example in the paragraph beginning at Line 551.
Response: We agree. We finally (partially) fixed this, which was an obscure bug in how our bibliographic software (EndNote) formats references. (Some remain to be fixed by the copy editor because EndNote still "corrects" some references to a format inconsistent with the journal's guidelines).

14. Citation at line 1135 is missing information and difficult to locate. Suggest adding the following information: "Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative retrieved from http://www.aykssi.org/aykssi-chinook-salmon-research-action-plan-2013/"

Response: We updated the reference information.

15. Figure 2 was too small to be informative.

Response: The published version of Figure 2 will be larger than the version available during review. As my email to the editor indicates, the figure was designed to support ample magnification to allow inspection of individual panels—the detail is there, so long as the reader zooms in using the on-line version and the figure is kept in its native TIF format. We can change the orientation and split up the rows or columns, but the reader then loses the ability to see the bigger picture and compare across regions. We would welcome editorial advice here, but for now have not made any changes (we have tried many, many variants already).

We have added the following text to the figure caption, as it is clear the reviewers did not try to zoom in on the details: *"(The on-line version of the figure supports substantial magnification to examine the details of each panel).".*

APPENDIX IV. CORRESPONDENCE BETWEEN KINTAMA RESEARCH SERVICES AND THE PACIFIC SALMON COMMISSION'S CHINOOK TECHNICAL COMMITTEE

Note that this Appendix contains the main correspondence between the KRS and the CTC about our requests for clarification on issues raised in FPC Memo 53-20. Some replication of questions has been removed. Additional clarifications by KRS that were not sent to the CTC follow some of the issues.

TO: David Welch, Aswea Porter, Erin Rechisky, Kintama Research
FROM: Antonio Velez-Espino, John Carlile, Jon Carey, Chinook Technical Committee Co-Chairs
DATE: January 4, 2021
SUBJECT: Request for CTC Clarification
CC: Jessica Gill, CTC Coordinator

On December 14, 2020, John Carlile and Antonio Velez-Espino received an email requesting clarification on data used in a recent publication (*A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (Oncorhynchus tshawytscha, Salmonidae)* published in Fish and Fisheries, October 2020). The responses to the clarification questions are below in blue.

1. Could you please advise which of you was contacted by the Fish Passage Center, so that I can attribute any CTC responses to an individual?

   A: Both Antonio Velez-Espino and John Carlile were contacted by the FPC. The entire CTC participated in the discussion and preparation of response to the FPC.

2. Is it true that "*the CTC does not compute SARs in any of their analyses and no such database exists*"?

   A: True. The CTC uses and maintains various data sources that contain the information necessary to calculate SARs as they are defined in the paper, but they were not developed for this purpose.

   a. Gayle Brown of the CTC provided us with the data used in our paper well prior to her retirement in July. (As the Acknowledgement section of our paper states, we also had discussions with Kristen Ryding). According to our understanding, the column labelled "TotalCWTSR" is the SAR (smolt to adult return) rate as we defined it in our paper. Is this incorrect?

      A: We were able to very closely replicate the SAR values used in the paper with outputs from our CWT-based annual Exploitation Rate Analysis (ERA), but cannot be certain which file specifically was provided by Gayle and what level of post-processing it contained. Would you be willing to send us the data set that you were provided? KRS: We have responded and provide this to the CTC as requested.

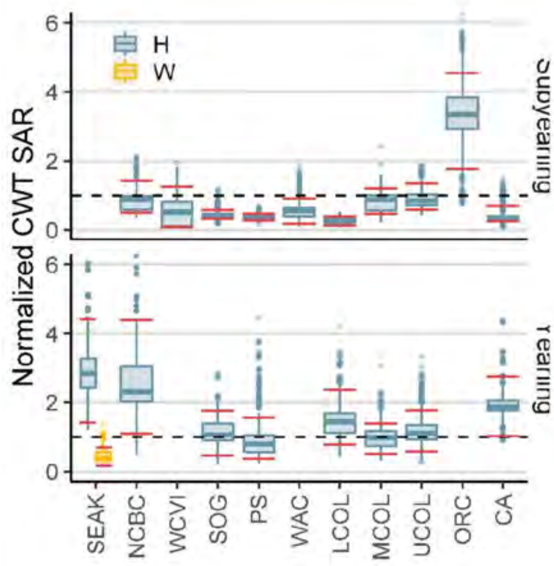
b. Is it true that the CTC does not maintain a database? We would appreciate it if you could shed some light on what the FPC is claiming, as we are at a loss as to how "*the CTC does not maintain a database*" and yet carry out your functions. (Perhaps all the FPC are implying is that the data are held in Excel spreadsheets, as we received it from Gayle, rather than a formal database?).

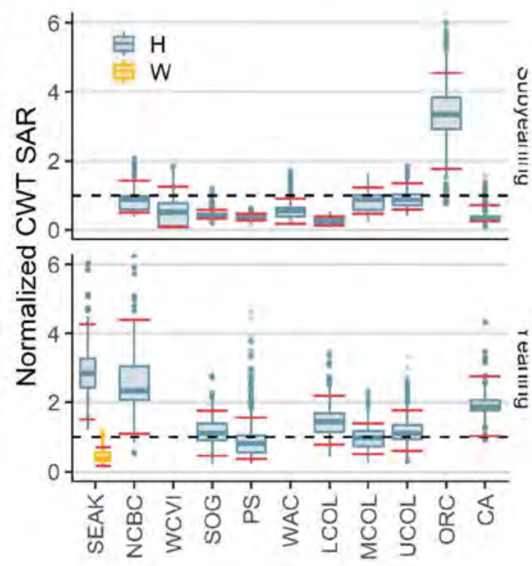
A: The CTC maintains numerous databases, but there is no "SAR database" or one that "provides several measures of SAR," as the paper indicates, as the CTC does not compute SARs in any of their analyses.

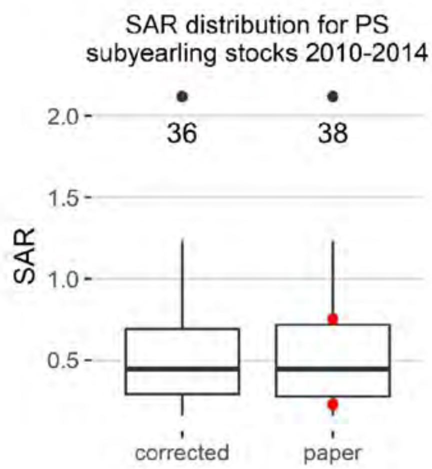
3. In our comparison of Chinook SARs for the three populations NSF, SKF, and SQP, we allocated them to subyearling or yearling categories based on actual smolt age at release (not the life history type). ("*Furthermore, the CTC chairperson advised that the authors assigned incorrect smolt-ages for three stocks (NSF, SKF and SQP)*"). Were we mistaken in doing so, or is the issue the FPC is identifying that yearling smolt populations may not actually leave the river and migrate to sea in the year of their release?

A: In the SAR_Data.csv supplemental data file provided with the paper, for the three stocks mentioned (Nooksack spring subyearling, Skagit spring subyearling, Squaxin Pens), while the smolt age appears to be correctly identified, it appears that the SAR values are associated with the incorrect smolt years (offset by +1 for Nooksack and Skagit and -1 for Squaxin). For example, the SAR value of 0.1106 for Nooksack spring subyearling that is associated with smolt year 1990 is based on releases from the 1988 brood year, which were released in 1989, not 1990.

KRS: The CTC's statement is correct and an error in the dataset we received made it into the published paper. When we corrected the error, two datapoints were removed from the 2010-2014 dataset for Puget Sound subyearlings. Fortunately, this change does not affect the conclusions. We have reproduced here three figures: the original Figure 4 from the published paper (left), the revised Figure 4 with corrected data (right), and the distribution of the SAR data in Puget Sound before and after the correction (below). In this last figure, the two data points that were removed are overplotted in red.







4. Could you clarify what concerns you had with our paper? ("*The CTC expressed serious concerns with how the CTC data were characterized in the Welch et al. (2020) paper*").

A: Chiefly, the CTC is concerned with how the CTC data are characterized in your paper. In many places the paper implies that the SAR values being used are a formal CTC product, which is untrue (i.e., "*The PSC database provides several measures of SAR. We used their estimates calculated as…*"). The paper references a CTC SAR database, however, as previously noted, the CTC does not compute SARs in any of their analyses and no such database exists. No current CTC members were afforded the opportunity to review the analyses prior to the paper's publication.

KRS: We did think these were formal products of the CTC. It appears this was not true; however, the SARs values were at least calculated using vetted CTC data with the formula provided in the paper. No current members of the CTC reviewed the paper, but the Canadian co-chair of the CTC provided us with the estimates and met with us to discuss. Further clarification on this point is included in the CTC's response dated Jan 18, 2021.

5. What, in your interpretation, does the FPC mean when they state "*the CTC does not use their CWT recovery data to calculate SARs*"? As we defined them in our paper (see the equation at the bottom of p. 3), the "TotalCWTSR" is a measure of the sum of all adults age 2+ divided by the release numbers with older ages uninflated for potential mortality between age 2 and older ages of return. As we are using the CTC's calculated number, by definition the CWT recovery data have been used to calculate the SAR.

   A: We use CWT data to calculate maturation rates, distribution of mortalities, survival rates from release to age 2 (subyearling) or age 3 (yearling), brood-year and calendar-year exploitation rates.

   KRS: Further clarification on this point is included in the CTC's response dated Jan 18, 2021.

Questions from Kintama Research posed January 7, 2021. The Chinook Technical Committee responded January 18, 2021.

1. What is the definition of a "*formal CTC product*"?

   CTC Response: We would consider a "formal CTC product" to be something that is annually calculated and reported on as part of our annual analyses. Generally these are stock and fishery data critical to implementation of the Pacific Salmon Treaty.

2. In your follow-on response (#5), you state "*We use CWT data to calculate maturation rates, distribution of mortalities, survival rates from release to age 2 (subyearling) or age 3 (yearling), brood-year and calendar-year exploitation rates*". Yet in response #4 you state "*the CTC does not compute SARs in any of their analyses and no such database exists*", but then state that you use the data to calculate "*survival rates from release to age 2 or age 3*" (Response #5). I'm not sure if this is a matter of semantics or something more fundamental, which is why I am trying to be as careful as possible here. We calculated the SARs used in our paper from the data Gayle Brown provided and you seem to make the same calculation as well. Can you clarify whether you have a concern with the scientific quality of what we have done or is your concern with our (apparently) implying that we employed a "formal product" of the CTC? (And any clarification of what a "formal product" is would be helpful).

CTC Response: There are key differences between the survival rates calculated by the CTC and the smolt-to-adult return values calculated in your paper. The difference is more than semantics and has to do with the value used in the numerator. The CTC calculates survival from release to age 2 or 3, where the numerator is the cohort size of age 2 or 3 fish (depending on life history type) prior to recruitment into fisheries (section 2.1.3 of TCCHINOOK (19)-02). The smolt-to-adult return values calculated in your paper provide a different metric where the numerator includes the sum of escapement and fishery mortalities for fish of all ages. This results in SAR estimates that are confounded by variability in fishing levels, because a pre-terminal fishery mortality, particularly one of a younger aged fish, is not equivalent on a one-to-one basis with a fish in escapement. Depending on the age of the fish, it is possible that if it were not caught, it would remain in the ocean and die of natural causes, never making it back to its natal stream.

KRS: We agree with the CTC's description of the difference. The CTC's "cohort size" measure is the estimated number of age 2 (fall) or 3 (spring) Chinook alive in each year prior to the start of the fisheries. This is calculated using cohort (VPA) analysis. The CTC is estimating the abundance of young Chinook in the ocean prior to the fisheries starting, not what would survive to return as adults. The latter value is what is relevant for our study.

The smolt-to-adult return values we used in our paper (Column TotalCWTSR in the CTC datafile we received from Dr. Gayle Brown, the former CTC Co-Chair) used as the measure of adult abundance catch at all ages plus adult escapement. This is most similar to what is used in the CWT-based SAR estimates we obtained for populations within the Columbia River basin. (In other words, the scientific question we are interested in is not how many salmon were alive in the ocean prior to becoming vulnerable to the fisheries, but how many survive to return to the river—or (presumably) would have if there were no fisheries).

In the figure to the right, we have compared the calculated survival estimates used in our published paper with what is obtained using the PSC's Chinook Technical Committee estimate TotalCWTSR. (In both cases the number of released smolts, the denominator, is the same). The relationship has a slope of 2.5, so the CTC estimates that 2.5-times as many salmon are alive prior to the start of the fisheries as are caught or return to the river as adults.

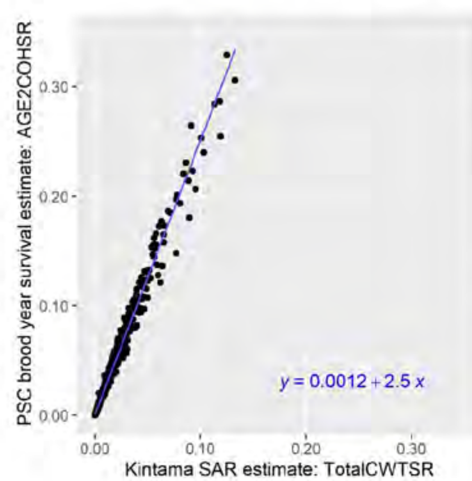


Figure 1. Comparison of survival estimates using CTC data for all stocks and all years (yearlings and subyearlings combined; incomplete brood years removed).

Put the other way, 40% of the pre-fishery abundance (=1/2.5) is caught or returns to the river, so 60% die from other causes. The exact value of the slope will depend upon the maturity schedule applied (i.e., the proportion of salmon remaining to older ages in the ocean and being exposed to more natural mortality), the natural mortality rate, the fishing mortality rate (F), and the incidental rate of fishing mortality on "shakers" (sub-legal Chinook that are caught and released but die as a result; treated in this way as a component of M). This 40:60 ratio seems plausible to us, but obviously will vary somewhat with the values the CTC chose to use.

In summary, there is a strong relationship between the two measurements. The primary issue concerns what is the appropriate abundance level to use in the numerator of CWT-based SAR estimates to compare with the Columbia's SAR values (and especially the values for Snake River populations). The PSC's CTC "formal product", AGE2COHSURV, over-estimates the number of adults returning to the Columbia River because it is the estimated abundance of immature fish in the ocean prior to the start of fisheries. The TotalCWTSR estimate we used in our paper is closer to what various hatcheries within the Columbia River basin calculate in their CWT-based SAR estimates: the sum of harvest(s), hatchery rack returns, and the spawning ground escapements.

APPENDIX V- LETTER TO MICHELLE DEHART (FPC) FORMALLY REQUESTING THAT THE FPC PROVIDE US WITH THE CSS'S SAR ESTIMATES INCLUDING SMOLT SURVIVAL ABOVE THE TOPMOST DAM.

Kintama Research Services Ltd
4737 Vista View Cres
Nanaimo, B.C. Canada V9V 1N8
T: (250) 739-9044

KINTAMA

Technology that Provides Answers

Revenue Canada Business Number: 85245 0519 RT0001
DUNS: 247365385

18 Sept 2019

Re: Provision of CSS SARs data

Dear Ms DeHart:

As you will be aware, the FPC's published CSS studies report annual survival primarily from the topmost dam back to the topmost dam. This excludes smolt survival in the migration segment from hatchery release or upstream tagging site to the topmost dam for most populations (and particularly the Snake River). Over the past several years Kintama has requested three or four separate times via Dr Christine Petersen (our BPA Contracting Officer) that the FPC provide smolt to adult survival data (SARs) for the entire life history.

To date there has been no provision of this survival data, although your staff indicated several times that they will look into the request.

The FPC criticized a recent manuscript of ours partly because of the apples to oranges nature of the comparison of SARs calculated using PIT tags in the Columbia River basin and CWTs used elsewhere on the west coast of North America. This is problematic for my group because although you have criticized this difference, it is the mainly the lack of data from the CSS on upstream survival that is one of two major causes of discrepancy between the CWT and PIT tagging methods. (The other being lack of harvest data in PIT tag SAR estimates). As a result it is the PIT tag estimates that are anomalous because of the exclusion of upstream smolt and adult survival.

Your staff suggested to Dr Petersen that our request would be a lot of work. It is unclear why this would be so troublesome. We had initially planned to simply do the extractions ourselves, but found that there is insufficient detail in the CSS reports for us to know exactly what tagging groups the CSS use and exclude in creating their SAR estimates. As a result, if we simply do the SAR estimation ourselves the criticism may then simply shift that we have failed to exactly replicate what tagging groups your group uses.

As a result, I am requesting that the FPC provides the SAR data directly, using the data filters you use for the CSS report. Specifically, we are looking for SARs estimates that span the complete migration history from smolt release (from the hatcheries or traps) back to the hatchery or spawning grounds as adults for all the populations that have 'Overall' SARS reported in the CSS annual reports (Appendix B in the 2016 version, specifically Tables B1-B49, B51-100, B103-105). The data we need are for hatchery and wild steelhead, and yearling and subyearling hatchery and wild Chinook from the Snake and upper and mid Columbia rivers.

Kintama Research Services Ltd., 4737 Vista View Cr, Nanaimo, B.C. Canada, Tel: (250) 7239-9044 • e-mail: david.welch@kintama.com

– 2/2 – 18 Sept 2019

The SARS currently reported in the CSS reports are from dam to dam so tributary mortality above the dams is excluded for both smolts and returning adults. Our goal here is to capture and credit to freshwater as much of the survival losses as is practicable. If the FPC only has survivals from smolt release until adult return to the most upriver dam (i.e. excluding mortalities of returning adults from the top dam to hatchery &/or spawning ground), we will use those instead.

We note that the FPC has some limited portions of the data we are seeking publically available on their website, but it would be much cleaner for our analysis to have the entire dataset from one source. We will also need a citation for the data source so that we can publish it (a "personal communication" from you or a senior member of your staff will be fine if necessary).

This request is being sent via email and registered letter.

Sincerely,

David Welch, Ph.D.

KINTAMA

President, Kintama Research Services Ltd. david.welch@kintama.com

c.c. Dr Christine Petersen, BPA

Kintama Research Services Ltd., Nanaimo, B.C. Canada
Tel: (250) 729-2600 x223 • e-mail: david.welch@kintama.com

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From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: April 3, 2020 1:56 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Fish Passage Center email...

Oh, sorry for slow response.

Yes – Michele asked for the contract details although I don't recall if there was a new letter or email asking for it, beyond the public email. My coworker Katie McDonald dug around and found the email where she had sent over a legally truncated version of the contract that omitted your personal info and also one or two work elements that weren't pertinent to what she was asking for. This had been sent January the year before and we had held a meeting with an attorney about it.

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, April 1, 2020 3:37 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Fish Passage Center email...

Christine—

Attached is the email Michelle de Hart sent out to various organizations after I formally requested she provide the data we needed. In it Michelle says that she will respond to Kintama, which we never received… she wrote to the agencies, but never back to Kintama. (*"The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables."*).

Do you know whether Michelle wrote back to BPA asking for the contract details? She certainly has never responded to me at all.

David

David Welch

From:	Petersen,Christine H (BPA) - EWP-4 [chpetersen@bpa.gov]
Sent:	Wednesday, October 02, 2019 9:12 AM
To:	David Welch
Subject:	FW: Kintama Letter
Attachments:	KintamaLetter-091919.pdf

Hi David

This letter may warrant no response, and may be the documentation needed to show we don't have access to hatchery to hatchery PIT based SARs. A little weird to CC all the agencies. I will talk with Jody Lando or maybe Ben Z tomorrow.

Christine

Sent from Workspace ONE Boxer

---------- Forwarded message ----------
From: Michele Dehart mdehart@fpc.org>
Date: Oct 1, 2019 3:50 PM
Subject: [EXTERNAL]
FW: Kintama Letter To:
adam.j.storch@state.or.us,Erick.S.VanDyke@coho2.dfw.state.or.us,tucker.a.jones@state.or.us, lort@critfc.org,l otr@critfc.org,LESR@critfc.org,'Christine Golightly' <GOLC@critfc.org>,ED.Bowles@state.or.us,lance Hebdon <lance.hebdon@idfg.idaho.gov>, tim.copeland@idfg.idaho.gov, Daniel.Rawding@dfw.wa.gov, tweitwmt@dfw.wa.gov, Michael.Garrity@dfw.wa.gov, Steve_Haeseker@fws.gov, David Swank <david_swank@fws.gov>, ritche.graves@noaa.gov, jayh@nezperce.org, zpenney@critfc.org
Cc: Jerry McCann <jmccann@fpc.org>, Brandon Chockley <bchockley@fpc.org>, Erin Cooper <ecooper@fpc.org>, Gabriel Scheer <gscheer@fpc.org>, Bobby Hsu <bobbyhsu@fpc.org>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>

Hello:

This is just a heads up, to pass along a recent certified letter received by the Fish Passage Center from David Welch, Kintama Research Services. This letter is related an article by Welch et al, developed under contract with BPA, submitted for publication in the online journal PLOS. The article titled, "The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow moving catastrophe or deeper failure?". The article was posted on a biological sciences archive page, for non-peer reviewed articles, called bioRxiv. The analyses developed under BPA contract was attached to recommendations by Welch to the NW Power Planning Council amendment process.

The BPA COTR on this contract is Christine Petersen and Welch has copied her on this letter. Some of the statements by Welch in this letter, do not comport with the documentation of emails from Christine Petersen, BPA, to the Fish Passage Center in 2017, in which Ms. Petersen states that BPA is interested in SARs from release to uppermost dam for the 2017 Biological Assessment. SARs from point of release to upper most dam, are not a component of CSS analyses or study design. The FPC does not generate these SARs and Ms. Petersen was advised accordingly in 2017 and advised that this request would represent a significant amount of new work. When the FPC was asked to review the Welch analyses, 2019, the BPA contract, including deliverables and work elements was requested, to understand the hypotheses that BPA contracted Kintama to pursue. The Kintama contract, work elements, deliverables, was not provided.

(**KRS Comment:** Our registered letter to Ms Dehart made the point that the CSS actually does calculate the above-dam survival because they needed this value in order to remove this value from their calculation of survival from release to adult return (SAR). In any event, we never received any response to our request (despite Ms Dehart contacting these individuals and stating that she would respond to us). The email exchange that we had with Dr Petersen is attached. Although we do not explicitly state it in this particular email exchange that we have no objection to the FPC being made privy to the details of our contract, we did so in other correspondence).

The FPC provides all data and analyses completed in FPC, CSS and SMP projects to the public. SARs from point of release, traps, etc…are not generated as part of these projects. The FPC will respond to the Welch letter and will once again request the BPA/Kintama contract work elements and deliverables.

(**KRS Comment:** Actually, this statement is incorrect, and the distinction is important. We found it was not possible to recreate the CSS' SAR estimates because the tag release groups they chose to include or exclude from their analyses is unavailable. The FPC often criticize other groups' results by arguing that the fish used in those analyses were "unrepresentative". However, because the FPC/CSS do not make the details available for how their own analyses are produced, it is not possible to actually determine whether the underlying details are reasonable. More transparency seems called for, as well as an end to claims that data are unrepresentative" without actually showing that (a) this is true and (b) that the suggested distortion is meaningful.

Fortunately, it was during the process of trying to establish whether we could actually recreate the CSS analysis after we were stonewalled in our direct request that we discovered that harvest levels were large and variable, not small and negligible as the FPC assumed. Given that this error alone likely invalidates much of the FPC's past SAR analyses, this point may now simply be moot).

From: David Welch

Sent: Wed Feb 03 15:17:26 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: ISAB

Importance: Normal

Thanks, Christine-

Erin was asked to present the work at the Quantitative Ecology seminar series at UBC today (her old alma mater). Carl Walters gave the intro and gave a very fulsome description of Erin, which was nice to hear. Erin also gave a great talk!

Our presentation to the ISAB on Friday benefits from that dry run, but of course will be different because we have to dig into a lot of the mud that Michelle & company have tried to smear us with while remaining professional and on point to the bigger issues. I don't think that will be difficult because the FPC (& to a much lesser extent Schaller et al) have made themselves look rather foolish by slamming us for failings that we can easily show aren't even remotely true, but the broader issue is to try to crack open the door so we can have a serious discussion of whether or not the Columbia's goals can even be achieved by just trying to do evermore work in freshwater… time will tell!

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: February 3, 2021 1:00 PM

To: David Welch <David.Welch@Kintama.com>
Subject: ISAB

Hi David,

Thanks for forwarding your responses. I have only started reading it, but I forwarded the material to coworkers. Kristen Jule found the call-in information and passed this around. It looks good.

Christine

This is an interesting trial balloon, if you contemplate the costs, the information being used to forecast the outcome of taking this action, and whatnot.

From: NewsData LLC <newsdata@newsdata.com>
Sent: Tuesday, February 2, 2021 5:01 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: [EXTERNAL] Simpson Floats Massive Snake River Dam Breaching Proposal -- Clearing Up News Bulletin Feb. 2, 2021

A Clearing Up News Bulletin

Clearing Up flag

Feb. 2, 2021

Simpson Floats Massive Snake River Dam Breaching Proposal

For more details, visit the Clearing Up website.

From: Petersen,Christine H (BPA) - EWP-4

Sent: Thu Feb 04 11:36:35 2021

To: David Welch

Subject: FW: NWRP Press Statement on Rep. Simpson Proposal

Importance: Normal

Hi,

Kristen and Jody passed on the ISAB link and your materials around our department and quite a few expect to call in.

Good luck with your presentation tomorrow.

Christine

From: Jule,Kristen R (BPA) - EWP-4 <krjule@bpa.gov>
Sent: Thursday, February 4, 2021 8:38 AM
To: ADL_EWP_ALL <ADL_EWP_ALL@BPASite1.bpa.gov>
Subject: FW: NWRP Press Statement on Rep. Simpson Proposal

FYI

Sent: Wednesday, February 3, 2021 9:54 PM
To: Kurt Miller <kurt@nwriverpartners.org>
Subject: [EXTERNAL] NWRP Press Statement on Rep. Simpson Proposal

A close up of a logo Description automatically generated

PRESS STATEMENT

Northwest RiverPartners Considers US Rep. Simpson Proposal to Overhaul the Region's Energy Infrastructure; Urges Caution and a More Circumspect Approach

Advocacy Group Advises Further Examination of Critical Issues Impacting NW Communities

US Rep. Mike Simpson (R - Idaho) has started discussions about a multi-billion-dollar proposal that could dramatically change the way electricity is provided and goods are delivered across the Pacific Northwest. The sheer magnitude of the plan and its timing, amid a federal stimulus push, has captured the region's attention. Behind the plan is Rep. Simpson's hope to put an end to the decades-long legal battle over salmon restoration and the lower Snake River dams.

The proposal, which continues to evolve, would create a $32 billion Columbia Basin Fund with many objectives, but the primary aim is to finance the breaching of the lower Snake River dams and to replace them with alternative forms of clean energy and batteries. Because the dams enable other critical benefits, such as transportation and irrigation, the fund would also attempt to compensate the many communities, farms, and businesses that depend on the dams as a mainstay for their livelihoods.

We are encouraged that the scale of the plan's budget reflects the tremendous value that the lower Snake River dams bring to the region. That long-debated topic is effectively put to rest by the proposal's significant price tag.

Like Rep. Simpson, we also have a vision for regional collaboration that moves the Northwest beyond the courtroom and towards partnership. This collaboration is in the best interest of recovering threatened and endangered salmon populations while we work to achieve a clean and equitable energy future for all of our residents. We appreciate that the Simpson plan clearly reflects extensive input of tribal nations and hundreds of stakeholder groups.

At the same time, Northwest RiverPartners has long-opposed breaching the lower Snake River dams. We truly believe that carbon-free hydroelectricity is an important part of the solution to the salmon crisis. It is also a critical part of providing affordable, clean electricity to the region's vulnerable communities.

While we remain open-minded about the Simpson proposal, there are several key issues in the plan that need to be addressed before we can consider it a fair and equitable solution for our Northwest communities.

First, we believe the case for breaching to save salmon lacks scientific rigor. Given the Pacific Coast-wide declines in salmon survival in both dammed and undammed rivers, it is hard to make the case that breaching dams with advanced fish passage technology will reverse this disturbing trend.

In addition, a growing body of science suggests warming, acidifying oceans are the driving factor behind worldwide declines in marine fish populations, including salmon. Breaching the lower Snake River dams does nothing to address this issue.

In fact, the Simpson proposal *substantially increases* the region's C02 output by eliminating low-carbon barging and shifting transported goods to semi-trucks and rail. This shift could result in hundreds of thousands of additional tons of C02 in our atmosphere each year.

If sustainable salmon populations don't return to the Snake River, US taxpayers will have footed the bill to the tune of tens of billions of dollars to end up with a larger carbon footprint than we have today.

We are also concerned by the speculative nature of the plan's energy replacement component. Hydropower and pumped storage dams are proven technologies that we can depend on, but long-duration utility-scale batteries and small modular nuclear reactors are still very much in the exploratory stage. We welcome the advancement of these technologies, but the region's electric customers should not be made reliant on technological breakthroughs to keep the lights on.

We also urge a more circumspect approach to the topic of litigation. The Simpson plan includes a 35-year moratorium on salmon-related lawsuits against dam operators, but with the multitude of laws and regulations governing waterways, we are worried the plan may fall short. We are particularly concerned that state jurisdiction under the Clean Water Act provides an open door for additional legal actions. As it stands, the proposed moratorium seems ripe for a legal challenge and warrants additional safeguards.

Many families in the Northwest rely on dam-dependent employment, whether they are seasonal farm workers or riverboat operators. Any plan around dam removal must consider how we specifically support these families. As we've learned throughout the pandemic, a check from the government cannot make up for the loss of one's career. We must ensure the transition of livelihoods for those who rely on the lower Snake River dams.

We believe Rep. Simpson's plan has the best of intentions, and it deserves to be vetted among Northwest stakeholder groups. However, considering the extremely high stakes involved, we cannot afford to ignore the need for a much more thorough analysis of what the plan can actually deliver and the deep impact it may have on our diverse Northwest communities.

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About Northwest RiverPartners

Northwest RiverPartners (NWRP) is a not-for-profit, member-driven organization. We represent not-for-profit, community-owned utilities across Washington, Oregon, Idaho, Montana, Wyoming, and Nevada. We also proudly represent farmers, ports, and businesses across the region that support clean energy and low-carbon transportation.

NWRP is focused on raising awareness about how the Northwest's hydropower system betters communities and the natural environment, and we encourage science-based solutions that help hydropower and salmon coexist and thrive. http://nwriverpartners.org

From: David Welch

Sent: Tue Feb 09 13:55:47 2021

To: Petersen,Christine H (BPA) - EWP-4

Cc: Erin Rechisky

Subject: [EXTERNAL] Time for a call?

Importance: Normal

Hi Christine—

I think I saw you were logged in for the ISAB review last Friday, but I wasn't sure… I was trying to keep my focus on the presentation. However, I do recall seeing that Jody Lando was logged in, as was Howard Schaller, but I didn't see Michelle Dehart or any of the other people from the FPC, although I am sure they were in attendance. (Perhaps they were anonymously logged in?).

I thought the presentation went well, but I would be interested in hearing the views of you & your colleagues. Also, now that the review is past and (I assume) found no devastating error in what we have done despite the FPC's (b)(5) [redacted] (b)(5) [redacted] Given Representative Simpson's recent trial balloon about spending $35B to compensate for taking out the Snake River dams, it might not be a bad idea to move to (b)(5) [redacted] it was interesting to me that the ISAB actually raised our 2008 paper during the discussion.

[redacted]

I can outline more on this when we can talk—my week is fairly open.

Regards, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: David Welch

Sent: Wed Feb 10 16:55:25 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: NPAFC Newsletter Issue No. 49 is Now Available!

Importance: Normal

Thanks, Christine.

(b)(6) [redacted]

Let's try for 11:30 am tomorrow. I can set up a Teams or Zoom call if you like or we can just do the regular phone call approach.

I haven't heard much of anything about broader coverage. I CCed my original response to Bill Crampton and KC Mehaffey, but the email to Crampton at the Columbia Basin Bulleting bounced back. Perhaps Mehaffey will write something?

(b)(5) [redacted]

[redacted]

Much to talk about!

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: February 10, 2021 4:39 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: FW: NPAFC Newsletter Issue No. 49 is Now Available!

Hi,

Those of us who watched your presentation each thought it was very well done. We also greatly appreciated how you took the extra time to thoroughly respond to the FPC and Schaller comments. It was helpful to have both a public presentation that dozens of people called into (although that probably raises the pressure on the presenters a little bit) and the dialog that you were able to have at the end. We look forward to the ISAB response and subsequent discussions.

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(b)(5) [redacted]

After the newspaper articles, and also the ISAB presentation and their eventual review on the subject, I hope that you have received additional attention and feedback for your very timely study. In some of the online comments that I have seen, it seems like people have definitely heard and absorbed it (even if they only saw the news release and didn't download the paper) because I have seen references to concerns over declines, and comparable survival rates in Canada.

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Christine

From: Doumbia,Julie A (BPA) - PEH-6 <jadoumbia@bpa.gov>
Sent: Wednesday, February 10, 2021 12:32 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: FW: [EXTERNAL] NPAFC Newsletter Issue No. 49 is Now Available!

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Sent: Wednesday, February 10, 2021 12:23 PM
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Sent: Wed Feb 10 16:59:21 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: NPAFC Newsletter Issue No. 49 is Now Available!

Importance: Normal

(b)(5) [redacted]

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: February 10, 2021 4:39 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
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From: Petersen,Christine H (BPA) - EWP-4

Sent: Thu Feb 11 08:51:49 2021

To: David Welch

Subject: RE: NPAFC Newsletter Issue No. 49 is Now Available!

Importance: Normal

Hi,

Should we do a regular phone call?

My work phone number is (971)266-7553

Christine

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, February 10, 2021 4:55 PM
To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
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From: David Welch

Sent: Thu Feb 11 10:19:38 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] RE: NPAFC Newsletter Issue No. 49 is Now Available!

Importance: Normal

Hi Christine—Confirming that I will call your office phone number at 11:30.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: February 11, 2021 8:52 AM
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From: David Welch

Sent: Thu Feb 11 11:07:20 2021

To: Ben Zelinsky

Subject: [EXTERNAL] Time for a call?

Importance: Normal

Hi Ben-

No particular rush, but I would value having a call to get your views on where BPA Is going? (see below).

(b)(5) [redacted]

(b)(5) [redacted]

[redacted]

Thanks in advance for your perspective.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
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To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
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From: David Welch

Sent: Thu Feb 11 13:14:02 2021

To: Petersen,Christine H (BPA) - EWP-4

Subject: [EXTERNAL] Ranking of the Fish & Fisheries paper...

Importance: Normal

Hi Christine-

Nice talking with you. This is the impact tracking website Altmetrics that I mentioned: https://wiley.altmetric.com/details/93472538#score

It is a bit obscure where the relative impact ranking info sits on this website, so I have pasted in below a screenshot I took of the impact back in early January when I realized that this info was available. The numbers have changed very little since then (our impact ranking is currently in the top 68,274/16,726,235 or 0.4 percentile of all 16+ million scientific papers they have tracked to date). Click on the "Attention Score in Context" link to bring up the current data.

Regards, David Welch

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) [redacted]

Our new paper looking at coastwide survival of Chinook salmon has just been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

From: David Welch

Sent: Thu Feb 11 13:17:50 2021

To: Zelinsky,Benjamin D (BPA) - E-4

Subject: [EXTERNAL] RE: Time for a call?

Importance: Normal

Thanks, Ben—

I appreciate you taking the time. I think you can use Zoom?

I will send you a link for a call next Tuesday at 10:30. If Zoom won't work, Teams or Skype are fine as well—just choose what does work for you. (Sonia tells me that some of the US federal agencies are still not allowed to use Zoom).

Regards, David

From: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Sent: February 11, 2021 12:07 PM

To: David Welch <David.Welch@Kintama.com>
Subject: RE: Time for a call?

Yes – of course David.

Those are fair questions to ask and I'd be happy to share my perspective.

Tuesday the 16th between 10:30 and 1 are open. Friday the 19th after 11 works too.

Would either of those work?

Looking forward to it.

Ben

From: David Welch <David.Welch@Kintama.com>
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No particular rush, but I would value having a call to get your views on where BPA Is going? (see below).

(b)(5) [redacted]

Thanks in advance for your perspective.

David

From: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Sent: February 10, 2021 4:39 PM
To: David Welch <David.Welch@Kintama.com>; Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: FW: NPAFC Newsletter Issue No. 49 is Now Available!

Hi,

Those of us who watched your presentation each thought it was very well done. We also greatly appreciated how you took the extra time to thoroughly respond to the FPC and Schaller comments. It was helpful to have both a public presentation that dozens of people called into (although that probably raises the pressure on the presenters a little bit) and the dialog that you were able to have at the end. We look forward to the ISAB response and subsequent discussions.

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Christine

From: Doumbia,Julie A (BPA) - PEH-6 <jadoumbia@bpa.gov>
Sent: Wednesday, February 10, 2021 12:32 PM

To: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>
Subject: FW: [EXTERNAL] NPAFC Newsletter Issue No. 49 is Now Available!

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From: NPAFC Secretariat <secretariat@npafc.org>
Sent: Wednesday, February 10, 2021 12:23 PM
To: NPAFC Public Distribution List <secretariat@npafc.org>
Subject: [EXTERNAL] NPAFC Newsletter Issue No. 49 is Now Available!

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North Pacific Anadromous Fish Commission

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- **Recipe: Salmon Tartare Kimbap**
- **Upcoming Events**

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From: David Welch

Sent: Thu Feb 11 13:18:06 2021

To: Renner,Marcella P (BPA) - E-4

Subject: [EXTERNAL] David Welch's Zoom Meeting

Importance: Normal

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/78335207597?pwd=djJ5aW5TdnlKWUFuY2lITkcwNmk2Zz09

Meeting ID: 783 3520 7597

Passcode: aRK1UB

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Thu Feb 11 13:30:25 2021

To: David Welch

Subject: RE: Time for a call?

Importance: Normal

Perfect!

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, February 11, 2021 1:18 PM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] RE: Time for a call?

Thanks, Ben—

I appreciate you taking the time. I think you can use Zoom?

I will send you a link for a call next Tuesday at 10:30. If Zoom won't work, Teams or Skype are fine as well—just choose what does work for you. (Sonia tells me that some of the US federal agencies are still not allowed to use Zoom).

Regards, David

From: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Sent: February 11, 2021 12:07 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: Time for a call?

Yes – of course David.

Those are fair questions to ask and I'd be happy to share my perspective.

Tuesday the 16th between 10:30 and 1 are open. Friday the 19th after 11 works too.

Would either of those work?

Looking forward to it.

Ben

From: David Welch <David.Welch@Kintama.com>
Sent: Thursday, February 11, 2021 11:07 AM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] Time for a call?

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To unsubscribe from our newsletter, please reply to this e-mail with the word "unsubscribe" in the subject.

From: David Welch

Sent: Thu Feb 11 14:22:38 2021

To: Ben Zelinsky

Subject: David Welch's Zoom Meeting

Importance: Normal

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https://us04web.zoom.us/j/78335207597?pwd=djJ5aW5TdnlKWUFuY2lITkcwNmk2Zz09

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(b)(5) [redacted]

Thanks in advance for your perspective.

From: David Welch

Sent: Tue Feb 16 10:31:16 2021

To: Ben Zelinsky

Subject: [EXTERNAL] Please join Zoom meeting in progress

Importance: Normal

Join Zoom Meeting
https://us04web.zoom.us/j/78335207597?pwd=djJ5aW5TdnlKWUFuY2lITkcwNmk2Zz09

Meeting ID: 783 3520 7597
Passcode: aRK1UB

David Welch, Kintama Research
Tel: [redacted]

From: David Welch

Sent: Tue Feb 16 14:00:19 2021

To: Ben Zelinsky

Subject: [EXTERNAL] CSAS (Integrated Biological Status of S BC Chinook-2016 042).pdf

Importance: Normal

Attachments: CSAS (Integrated Biological Status of S BC Chinook-2016 042).pdf; Neilson & Taylor (EA-Thompson & Chilcotin SteelheadTrout-COSEWIC Feb 2018).pdf

Ben-

Thanks for your time. I mentioned that I would send you the report on the status of Chinook in the Fraser River.

To save some time, I pasted into the bottom of this email the status of southern BC Chinook stocks ***as of 2016***. (See the attached file for the officially accepted report, as well as a separate file petition for an emergency listing of Upper Fraser steelhead from 2018).

(b)(5)

[redacted]

[redacted]

[redacted]

David

Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Advisory Report 2016/042

INTEGRATED BIOLOGICAL STATUS OF SOUTHERN BRITISH COLUMBIA CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) UNDER THE WILD SALMON POLICY

Chinook Salmon adult spawning phase. (Photo credit: Fisheries and Oceans Canada.)

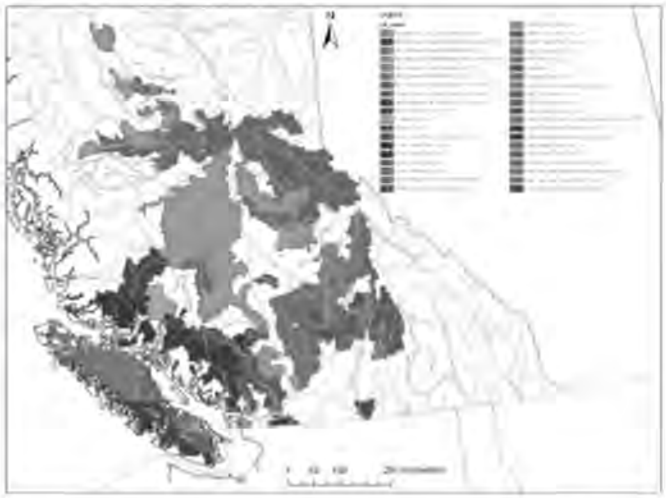

Figure 1. Map of southern BC showing the Chinook Conservation Units.

Context:

Canada's Wild Salmon Policy's (WSP) identifies six strategies for implementation. Strategy 1 is "Standardized monitoring of wild salmon status" and requires biological status assessments for all Pacific salmon conservation units (CUs). To conduct WSP status assessments, a toolkit comprised of a number of classes of indicators and metrics for status evaluation was completed in 2009. However, since a number of metrics can be used to evaluate biological status, it is possible that each metric can indicate a different status (Red, Amber, or Green). Therefore, status integration, which includes synthesis of CU status information across metrics into one or more status zones, and the provision of expert commentaries on the information used to assess status, is a useful final step in the status designation process. This report presents the application of WSP status integration conducted in a CSAS workshop. This workshop builds upon a previous application of WSP status integration techniques conducted for Fraser Sockeye CUs.

This Science Advisory Report is from the February 4-6, 2014 Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule](#) as they become available.

August 2016

Canada

SUMMARY

- A workshop entitled “Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status” was conducted to determine an integrated Wild Salmon Policy (WSP) status for each of the 35 southern BC Chinook Salmon Conservation Units (CU). The status integration method used was similar to that applied to Fraser Sockeye (Grant & Pestal 2013). A characteristic of southern BC Chinook Salmon CUs that is distinct from the Sockeye Salmon CUs assessed so far is the significant presence of hatchery-origin fish in addition to wild-origin fish in many of the CU area/watersheds.
- For this workshop, multi-page standardized data summaries were produced for each southern BC Chinook Salmon CU. The data used to generate these summaries had been previously reviewed through two Regional Peer Review processes.
- Participants were asked to determine a single WSP status zone from Red (poor status) to Amber (cautious status) to Green (healthy status) for the CU based on a combination of the information from the individual status metrics.
- Status evaluations were completed and consensus reached on an integrated WSP status designation for 15 of the 35 CUs. Of these, 11 were assigned a Red status, one was assigned a Red/Amber status, one was assigned an Amber status and two were assigned a Green status. For another nine of the 35 CUs, an integrated status evaluation was not possible based on the information presented at the workshop. For these CUs, the status designation is “data deficient” and this designation is not expected to change until more information becomes available. For the remaining 11 of the 35 CUs, status evaluations were not completed. Instead, the status of these CUs was classified as “to be determined”. These CUs are a component of units where the enhanced sites are predominant; consensus was not reached on how to derive a WSP status assessment for such units.
- In addition to providing final integrated status for each CU, the expert interpretation of the data summaries was documented in status commentaries. These commentaries provide the details underlying the final integrated status decisions. Status zones on their own do not provide an indication of which factors drive their designation, which would influence subsequent WSP strategies. The commentaries are an important source of information to inform management considerations.
- The designation of seven Fraser River CUs as Red and two others with a status of Amber is especially noteworthy. A review of all Chinook populations in BC carried out more than 30 years ago found compelling evidence of substantial declines in abundance in all geographic regions, except within the Fraser River watershed. The last 12 to 15 years have been a period during which most groups of Chinook within the Fraser River have declined in numbers, and the outlook for Chinook outside of the Fraser River has generally not shown sustained improvement since the earlier review.
- Integrated WSP status designations could not be developed for 20 of the 35 southern BC Chinook CUs based on the information and methods available to the workshop participants, which is very concerning. This highlights the need for additional work relating to information collection and assembly and for the development of a suitable method for status assessment when there is a significant contribution to recruitment and spawner abundance from enhanced sites.
- A proposal on the frequency of status re-assessments was agreed to: DFO staff should recalculate the individual status metrics annually, update the standardized data summaries,

and check for any substantial changes. If results from individual metrics indicate a change that could affect the overall status for the CU, a meeting would be convened to address the affected CUs only. A full re-assessment of all CUs would take place every four years.

INTRODUCTION

The goal of the Wild Salmon Policy (WSP) is to "restore and maintain healthy salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity" (DFO 2005). In order to achieve this goal, the WSP outlines a number of strategies, including Strategy 1 (Standardized Monitoring of Wild Salmon Status), which is the subject of this Science Advisory Report (SAR). Action Steps for Strategy 1 include:

1. identification of CUs;
2. development of criteria to assess CUs and identification of benchmarks to represent biological status; and,
3. monitoring and assessment of CU status.

Work on these action steps has progressed since the WSP was published in 2005, with the following peer-reviewed milestones:

- method for the identification of Pacific salmon CUs (Holtby & Ciruna 2007);
- method for the assessment of Pacific salmon biological status under the WSP (Holt *et al.* 2009);
- technical background for WSP status assessments (Holt 2009; Porszt 2009; Holt 2010; Holt & Bradford 2011; Porszt *et al.* 2012);
- integration techniques for WSP status assessments of salmon CUs (Grant & Pestal 2013);
- revision of southern BC Chinook Conservation Unit assignments (DFO 2013).

Four classes of indicators have been recommended to evaluate WSP status of wild Pacific salmon: abundance, trends in abundance, distribution, and fishing mortality (Holt *et al.* 2009). Within each class of indicator, one or more metrics can be used for status assessments, and, for each metric, a lower benchmark and upper benchmark delineate the Red to Amber and Amber to Green status zones, respectively (Table 1). These biological benchmarks are specifically used for status assessments, and are not prescriptive for specific management actions. They are also designed to be more conservative than the criteria established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), as required by the WSP.

Table 1. The three zones of biological status defined in the WSP (Grant & Pestal 2013).

Status	Definition
Red	"... established at a level of abundance high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC"
Amber	"While a CU in the Amber zone should be at low risk of loss, there will be a degree of lost production. Still, this situation may result when CUs share risk factors with other, more productive units"
Green	"identif[ies] whether harvests are greater than the level expected to provide on an average annual basis, the maximum annual catch for a CU, given existing conditions…there would not be a high probability of losing the CU"

Since CU status evaluations can include more than one metric, it is possible that different metrics could each indicate a different WSP status zone from Red (poor status) to Green (healthy status). For example, the WSP recent trend in abundance metric could suggest a CU's status is poor, while conversely, the long-term trend metric could indicate the same CU's status is healthy. In cases where metric information is contradictory, provision of this metric-specific status information alone does not provide complete scientific advice to fisheries management. Instead, a final step that synthesizes all metric and status-related information into an integrated status for each CU, and provides expert commentary on this information, is necessary as inputs into subsequent implementation of WSP Strategy 4 (Integrated Strategic Planning) to prioritize assessment activities and management actions (Table 2. Guidance in the WSP on assessment actions and management considerations for CUs in each of three status zones (Grant & Pestal 2013).Table 2).

Table 2. Guidance in the WSP on assessment actions and management considerations for CUs in each of three status zones (Grant & Pestal 2013).

Status	Assessment Actions	Management Considerations
Red	"… a detailed analytical assessment will normally be triggered to examine impacts on the CU of fishing, habitat degradation, and other human factors, and evaluate restoration potential", "… detailed stock assessments will identify the reasons for the change in status". "CUs in the Red zone … will be identified as management priorities … the protection and restoration of these CUs will be primary drivers for harvest, habitat, and enhancement planning."	"Biological considerations will be the primary driver for the management of CUs with Red status". "The presence of a CU in the Red zone will initiate immediate consideration of ways to protect the fish, increase their abundance, and reduce the potential risk of loss".
Amber	"… a detailed analytical assessment may be required to input into Strategies 2 & 3.."	"Decisions about the conservation of CUs in the Amber zone will involve broader considerations of biological, social, and economic issues"; "involves a comparison of the benefits from restoring production versus the costs arising from limitations imposed on the use of other CUs to achieve that restoration"; "implies caution in the management of the CU"
Green	" a detailed analytical assessment of its biological status will not usually be needed"	"Social and economic considerations will tend to be the primary drivers for the management of CUs in the green zone, though ecosystem or other non-consumptive values could also be considered".

For Pacific Salmon CUs, WSP biological status integration methods have previously been developed and applied to Sockeye Salmon assessments (Grant & Pestal 2013). However, a characteristic of southern BC Chinook Salmon CUs that is distinct from the Sockeye Salmon CUs assessed so far is that many areas support substantial numbers of hatchery-origin fish in addition to wild-origin fish. Therefore, the guidelines developed for Sockeye Salmon are only partially applicable to the southern BC Chinook Salmon situation. In order to explore the applicability of the status integration techniques developed previously, and to provide WSP status assessments, a CSAS workshop entitled "Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status" was conducted to achieve these goals. This SAR summarizes the results from this CSAS workshop.

The objectives of the workshop were to:

1. Determine an integrated WSP status for each southern BC Chinook Salmon CU;
2. Indicate the effect on the status assessments of including, or excluding, enhanced Chinook Salmon contributions;
3. Provide advice on data and methods required for assessing the status of any CUs that are currently data deficient;
4. Include information specific to each CU on fishing mortality, where possible;
5. Provide advice on the appropriate frequency of status re-assessment, changes to monitoring variables that could invoke early re-assessment, and the appropriate timing for assessment relative to data availability; and
6. Identify and recommend data management approaches required to support recommended changes to re-assessment of CUs.

ASSESSMENT

Data

For this workshop, multi-page standardized data summaries were produced for each southern BC Chinook Salmon CU. The data used to generate these summaries had been previously reviewed through two CSAS Regional Peer Review processes[1,2]. These data summaries included the following:

- time series plots of spawner abundances (either relative indices or absolute abundances, where available);
- a table of absolute abundances relative to COSEWIC criteria D1 for small populations;
- a summary of overall data quality (as a percentage of spawner abundance);
- a summary of the categorization of enhancement activity level by census site[3];

---

[1]Brown, G.S., Baillie, S.J., Thiess, M.E., Bailey, R.E., Candy, J.R., Parken, C.K., and Willis, D.M. 2014. Pre-COSEWIC Review of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Conservation Units: Part I, Background. CSAS Working Paper 2012/P62. In revision.

[2] Brown, G.S., Baillie, S.J., Bailey, R.E., Candy, J.R., Holt, C.A, Parken, C.K., Pestal, G.P., Thiess, M.E., and Willis, D.M. 2014. Pre-COSEWIC Review of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Conservation Units, Part II: Data, Analysis and Synthesis. CSAS Working Paper 2012/13 P23. In revision.

[3] The concepts of a "Total Unit" (TU) and an Enhancement Unit (EU) were introduced at the workshop. A Total Unit can be comprised of two components: the CU and an associated EU. The CU includes only census sites with low or unknown enhancement level activity in an attempt to be consistent with the WSP focus on 'wild salmon'. The EU contains only census sites with moderate or high enhancement level activity. Although these concepts were introduced at the workshop, they were not endorsed by the participants and therefore are not considered to form a viable conceptual approach to this issue.

- a stacked bar plot illustrating the distribution of spawner abundance across sites within the CU;
- a whisker plot illustrating short term trends by census site within the CU;
- a table of spawner abundance by census site within the CU;
- status information for up to three WSP metrics: one metric for abundance relative to biological benchmarks, one metric for extent of decline in abundance, and two related metrics for short-term trend in abundance;
- where available, supplementary time series plots of natural log-transformed spawner abundance, generational average of spawner abundance, CWT indicator spawner abundance, total return, productivity (recruits/spawner by brood year), hatchery releases from within and outside the CU, exploitation rates and marine survival;
- retrospective (historical) time series of status for each WSP metric relative to established benchmarks (Holt *et al.* 2009).

Methods

Workshop participants were invited to attend based on their experience with different aspects of salmon assessment and included DFO staff from Science, Ecosystems Management and Fisheries Management sectors and external participants from First Nations organizations, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia. Participants were requested to join one of four pre-workshop seminars in order to review the data summary layout and to provide feedback to organizers on the workshop format. At the workshop, participants were assigned to one of six groups, each comprised of six or seven individuals. Their group assignment remained the same for the duration of the workshop. Individuals were assigned in order to provide a varied mix of views and expertise within each group.

Each of the 35 CUs (and their associated enhanced sites where applicable) was designated as an individual case study. The identity of the CU represented by a case study was not revealed to the participants during the initial assessment sessions. This “blind” approach was similar to that employed by Grant & Pestal (2013) during the Fraser Sockeye workshop. The 35 case studies were presented in seven sets over the first two days of the workshop. Participant groups were given 15 minutes, 30 minutes, one hour or 1.5 hours, depending on the set size and complexity, to discuss each set in a breakout session. At the end of each breakout session, back in a full participant plenary session, groups compared results and discussed their reasoning for their final integrated status designations. All of the 35 CUs were evaluated by at least some of the groups, and each group evaluated a representative number of CU types (different metrics and statuses). Late on the second day, the CU identity of each case study was revealed to the participants. The third day of the workshop was a full day of plenary discussion to reconcile group integrated status results allowing for use of knowledge of the identity of each CU.

Results

Final Integrated Status

By the end of the workshop, participants completed status evaluations and reached consensus on an integrated WSP status designation for 15 of the 35 CUs (Table 3 and Figure 2). The 15 southern BC Chinook CUs are ordered in Table 3 using their final integrated status, with CUs designated Red (poorest status) located at the top of the table to CUs designated Green (best status) at the bottom. Thirteen out of the 15 CUs were reconciled between groups in the post-reveal plenary session to a single WSP status zone. There was one CU where final integrated statuses included two status zones. The Lower Fraser River_FA_0.3 (CK-03) CU's integrated Green status was flagged as provisional by participants. Following the example of the Fraser Sockeye WSP status assessments (Grant & Pestal 2013), when some participants held divergent views, the status assignment was classified as "provisional". In this case, the short-term decline observed in recent years, despite decreasing exploitation rate, resulted in a provisional status designation to highlight the need for monitoring the trend.

For another nine of the 35 CUs, an integrated status evaluation was not possible based on the information presented at the workshop. For these CUs, the status designation is "data deficient" (DD). When preparing the data summaries, the workshop organizers identified five CUs as obviously data deficient (Table 3, Cases 31 to 35). The workshop participants supported this initial assessment and also designated an additional four CUs as data deficient. For all nine of these CUs, the status designation is not expected to change until more information is available.

South Thompson-Bessette Creek_SU_1.2 (CK-16) and Okanagan_1.x (CK-01) were designated as Red status. However, there was some concern expressed by the participants that the definition of these CUs might not be valid. The status of these CUs should be re-evaluated following a review of their CU definitions.

The remaining 11 of the 35 CUs (Table 4) presented a substantial challenge for the participants and ultimately, status evaluations could not be completed for them. Instead, the status of these CUs was classified as "to be determined" (TBD). These CUs are geographically proximate to predominantly enhanced sites, or data exist only for the enhanced sites geographically proximate to the CU (e.g. a CU may exist but no wild census sites have data of sufficient quality for assessment at this time). Consensus was not reached on how to derive a WSP status assessment for such combined wild and enhanced site units, or the CUs that spawn in the same area. A method to consider enhanced contribution by redefining the wild site versus enhanced site classification in the data summaries was proposed by the workshop organizers. However; there was consensus that a review of the proposed method was not within the scope of the workshop and should be the subject of a future review. Although there are no status evaluations provided for these 11 CUs, unlike the situation with the data deficient CUs, an integrated WSP status could be determined in some cases once a suitable method is developed to assess the status of enhanced sites and how they should be considered in status assessments of the CU.

Status Commentaries

In addition to documenting a final integrated status designation for each CU, the expert interpretation of the data summaries was recorded as status commentaries (Appendix B of the Research Document resulting from the workshop). These commentaries provide the details underlying the final integrated status decisions, which varied even amongst CUs with identical status designations. These details will be important when the results from Strategy 1 (Standardized Monitoring of Wild Salmon Status) are linked to Strategy 4 (Integrated Strategic Planning). Status zones on their own do not provide an indication of which factors drive their designation, which would influence subsequent WSP strategies. The commentaries are an important source of information to inform management considerations.

Table 3. Summary of completed integrated status evaluations for Southern BC Chinook Salmon CUs.

Integrated status evaluation completed at workshop

Integrated Status	Case #	CU ID	CU Name	Area
RED	1	CK-10	Middle Fraser River_SP_1.3	Fraser
RED	4	CK-18	North Thompson_SP_1.3	Fraser
RED	6	CK-19	North Thompson_SU_1.3	Fraser
RED	11	CK-09	Middle Fraser River-Portage_FA_1.3	Fraser
RED	24	CK-17	Lower Thompson_SP_1.2	Fraser
RED	25	CK-31	West Vancouver Island-South_FA_0.x	WCVI
RED	26	CK-12	Upper Fraser River_SP_1.3	Fraser
RED	29	CK-29	East Vancouver Island-North_FA_0.x	Inner SC
RED	30	CK-32	West Vancouver Island-Nootka & Kyuquot_FA_0.x	WCVI
RED*	3	CK-16	South Thompson-Bessette Creek_SU_1.2	Fraser
RED*	5	CK-01	Okanagan_1.x	Columbia
RED / AMBER	27	CK-14	South Thompson_SU_1.3	Fraser
AMBER	12	CK-11	Middle Fraser River_SU_1.3	Fraser
GREEN(p)	9	CK-03	Lower Fraser River_FA_0.3	Fraser
GREEN	2	CK-13	South Thompson_SU_0.3	Fraser

Integrated status evaluation not possible based on information presented at workshop

Integrated Status	Case #	CU ID	CU Name	Area
DD	7	CK-82	Upper Adams River_SU_x.x	Fraser
DD	8	CK-06	Lower Fraser River_SU_1.3	Fraser
DD	10	CK-05	Lower Fraser River-Upper Pitt_SU_1.3	Fraser
DD	28	CK-28	Southern Mainland-Southern Fjords_FA_0.x	Inner SC
DD	31	CK-08	Middle Fraser-Fraser Canyon_SP_1.3	Fraser
DD	32	CK-20	Southern Mainland-Georgia Strait_FA_0.x	Inner SC
DD	33	CK-34	Homathko_SU_x.x	Inner SC
DD	34	CK-23	East Vancouver Island-Nanaimo_SP_1.x	Inner SC
DD	35	CK-35	Klinaklini_SU_1.3	Inner SC

"(p)" means provisional, and identifies cases where some participants held divergent views.
"*" means that CU definition should be reviewed.

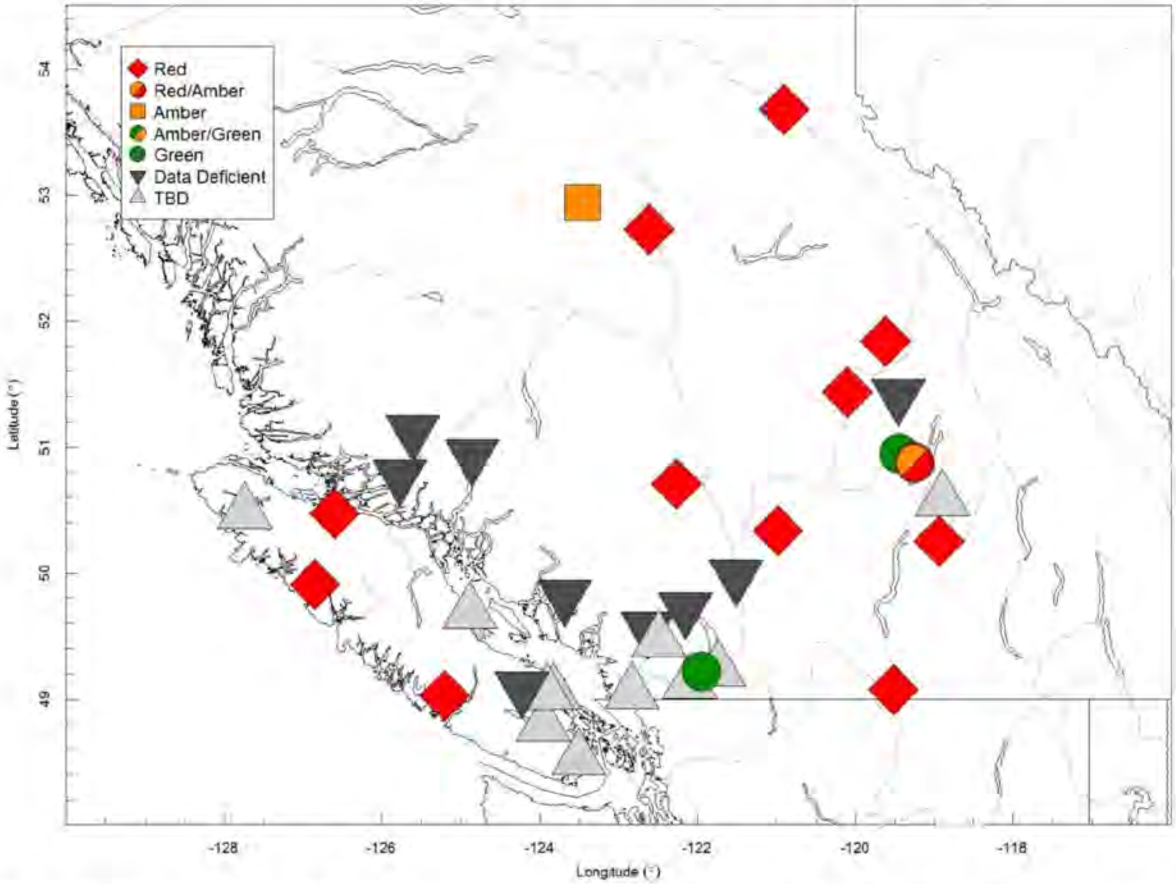

Figure 2. Map of southern BC summarizing workshop consensus on biological status of southern BC Chinook Salmon CUs.

Status Integration Approaches

The workshop organizers had prepared an initial set of guidelines for status integration (see Appendix E of the Proceedings resulting from the workshop). These guidelines were largely based on the recommendations in Grant and Pestal (2013). After the groups had completed several evaluations they reported that they were adopting patterns in their approach to status integration. Based on the feedback from participants, the guidelines were revised and are reported in Section 3 of the Research Document resulting from the workshop. In addition, the status deliberation notes and plenary discussions exposed some common themes to status integration approaches that were not explicitly endorsed as guidelines by the participants. These are also documented in Section 3 of the Research Document resulting from the workshop.

Table 4. Summary of incomplete integrated status evaluations for Southern BC Chinook Salmon CUs.

Integrated status evaluation not attempted at workshop due to unresolved methods

Integrated Status	Case #	CU ID	CU Name	Area
TBD**	13	CK-04	Lower Fraser River_SP_1.3	Fraser
TBD	14	CK-21	East Vancouver Island-Goldstream_FA_0.x	Inner SC
TBD	15	CK-33	West Vancouver Island-North_FA_0.x	WCVI
TBD	16	CK-22	East Vancouver Island-Cowichan & Koksilah_FA_0.x	Inner SC
TBD	17	CK-02	Boundary Bay_FA_0.3	Inner SC
TBD	18	CK-07	Maria Slough_SU_0.3	Fraser
TBD	19	CK-25	East Vancouver Island-Nanaimo & Chemainus_FA_0.x	Inner SC
TBD	20	CK-15	Shuswap River_SU_0.3	Fraser
TBD	21	CK-83	East Vancouver Island-Georgia Strait_SU_0.3	Inner SC
TBD	22	CK-27	East Vancouver Island-Qualicum & Puntledge_FA_0.x	Inner SC
TBD	23	CK-9008	Fraser-Harrison fall transplant_FA_0.3	Fraser

"**" means that CU status should be re-evaluated after review of enhancement level definition.

Sources of Uncertainty

- The standardized data summaries were prepared based on data that had been previously reviewed[1,2], however, these summaries are based largely on spawner data with a substantial but unquantified level of uncertainty.
- A period of apparent abundance increases occurred during the 1990s and early 2000s when major improvements were made in many BC escapement programs. These escapement estimation improvements typically resulted in immediate and noticeably higher annual estimates relative to earlier estimates. This suggests that apparent improvements in abundance could be related more to changes in survey and estimation methods than to genuine biological changes.
- Some of the abundance time series represent relative rather than absolute abundances. Relative abundances likely under-estimate true abundance (by unknown and variable amounts), so an indication of red zone status in relation to the WSP metric on absolute abundance may not be accurate.
- Some of the individual metrics display a pattern of changing status from one year to the next (e.g. red status one year followed by green status the next year and then returning to red). In this situation, the metric is not conveying meaningful results for determining integrated status and would typically be disregarded or given less weight in status deliberations.
- Information on the contribution of enhanced fish to the abundance of fish observed at "wild" sites is often limited; and as such, the actual wild contribution (which is key to the WSP CU definition) is often unknown. For the purposes of these status assessments, observations at wild sites are assumed to be comprised entirely of wild fish.
- The status evaluations developed at this workshop ultimately relied on the expert opinions of the participants and as such, are subject to the experience and opinions of the individuals involved. Because many of the evaluations are more subjective than objective, the

repeatability of these findings is uncertain. The status commentaries in Appendix B of the Research Document resulting from the workshop identify cases where participants were especially confident in their assessment, as well as cases where the status designations were particularly uncertain, which may be useful in developing approaches to quantifying this uncertainty in the future.

CONCLUSIONS AND ADVICE

Southern BC Chinook CUs Integrated Status

Integrated status designations were developed for 15 of the 35 southern BC Chinook CUs, and status commentaries were provided for all 35 CUs. In some cases, the commentaries provide more useful advice for management considerations than would be indicated by the mapping of the status zone to the management considerations in Table 2. These results address two of the six objectives for the workshop: "determine an integrated WSP status for each southern BC Chinook Salmon CU", and "include information specific to each CU on fishing mortality, where possible".

The majority of CUs for which an integrated status was developed occurred within the Fraser River watershed (11 of 15). This reflects the reduced prevalence of enhancement as a management intervention in that region. While seven of the Fraser River CUs were designated as Red, all four of the CUs that were assessed from other regions were also designated as Red. All adult and juvenile life history patterns known in southern BC Chinook are represented in the group of 11 Red status CUs. This suggests that declines in abundance shown by these CUs cover a broad geographic area and are not specific to any particular group of Chinook Salmon.

The designation of seven Fraser River CUs as Red and two others with a status of Amber is especially noteworthy. A review of all Chinook populations in BC carried out by Healey (1982) more than 30 years ago found compelling evidence of substantial declines in abundance in all geographic regions, except within the Fraser River watershed. Riddell *et al.* (2013) suggested that spawner abundances in most southern BC areas may have increased for a period in the 1990s and early 2000s. However, these apparent improvements in abundance could be related more to changes in survey and estimation methods than to genuine biological changes. Regardless of whether real abundance increases occurred in the 1990s, the last 12 to 15 years have been a period during which most groups of Chinook within the Fraser River have declined in numbers. The outlook for Chinook Salmon outside of the Fraser River has generally not shown sustained improvement since Healey's (1982) review.

Recommendations

- Integrated status designations could not be developed for 20 of the 35 southern BC Chinook CUs based on the information and methods available to the workshop participants. This represents the majority of the southern BC Chinook CUs, or approximately 21% of the surveyed aggregate abundance, which is a concern. This highlights the need for additional work and relates to the objectives: "provide advice on data and methods required for assessing the status of any Conservation Units that are currently data deficient", and "identify and recommend data management approaches required to support recommended changes to re-assessment of CUs".
- In some cases, additional information relating to the data deficient CUs is in the possession of the Department, but has not yet been incorporated into the regional escapement data holdings where it would be accessible to analysts. If this information were incorporated, it is possible that some of the CUs would no longer be data deficient and status designations could be developed. This information includes escapement survey records held by local

offices in paper and electronic formats that have not been a priority for further analysis to date. The work necessary to locate and incorporate this information into the regional escapement data holdings could provide significant benefits for future status assessments.

- The workshop participants identified an issue where a Chinook population is known anecdotally to exist, but there are no escapement surveys recorded in the regional escapement data holdings. Examples of this are information from local traditional knowledge, data from non-DFO programs such as fish habitat surveys initiated for forestry purposes, and data from juvenile salmon surveys. Since the regional adult escapement data holdings provided the source information for initial CU definition, the absence of survey records meant that these populations were not included in the CU definitions. Thus it is possible that there are additional Chinook CUs yet to be defined. These would likely form additional CUs for the data deficient category. This issue could be addressed by incorporating the information on un-surveyed but known Chinook populations into the regional escapement data holdings as placeholder records.
- The amount of data filtered out due to data quality concerns prior to status assessments raises questions regarding the utility of temporally extensive, low-quality surveys and their role in the stock assessment program should be reviewed. If such data are not useful for status assessment, then they are of little value other than indicating fish presence which has proved useful only in identifying spawning sites for potential grouping within a CU.
- Aside from the data deficiency issue, the other issue which prevented integrated status designations relates to the workshop objective: "indicate the effect on the status assessments of including and excluding enhanced Chinook Salmon, where applicable". This was the only objective of the workshop that was not successfully addressed. The participants attempted to address this objective but the consensus was that given the methods and guidelines available to them, status designation was not possible for CUs that had a substantial contribution from enhanced sites. To resolve this issue for future assessments would require a specific project to develop a suitable method for status assessment for sites (or groups of sites) with significant enhancement contribution. In addition, guidance would need to be developed for considering the interaction between the CU and an associated enhanced contribution in the status assessment of the CU. The resulting proposed method and guidelines should then be subject to peer review. Once this work is complete, the southern BC Chinook CUs currently categorized with a status of To Be Determined should be re-assessed.

Status Integration Process

Again, similar to the approach taken for Fraser Sockeye Salmon CUs (Grant & Pestal 2013), expert opinion on status integration and associated commentaries were elicited through a combination of smaller breakout groups and full participant plenary sessions. The advantage of this approach was that it permitted independent small-group evaluation of a range of integration approaches and integrated status designations, which could then be consolidated in a plenary session with all participants. Although not highlighted in the results presented here, more often than not, the individual group results showed a similar status designation for a CU and the status reconciliation during the plenary session was rapid and not controversial. This provides some confidence that the integration process is more objective than subjective, and is repeatable.

Integration Guidelines

Now that two of these larger integration workshops have occurred, and a variety of CUs have been examined, it might be possible to prepare a more comprehensive set of integration guidelines for formal peer-review. Once accepted, these guidelines could allow for the completion of a preliminary status integration report for a collection of CUs by a small expert team. This report would then become the working paper to be reviewed via the more typical CSAS Regional Peer Review process. If this work were undertaken it would help to address the concern that the workshop format for WSP status assessment is onerous and is limiting the opportunity for status assessments.

Frequency of Re-Assessment

A key workshop objective was to "provide advice on the appropriate frequency of status re-assessment, changes in monitoring variables that could invoke early re-assessment, and appropriate timing for assessment relative to data availability". The following proposal on the frequency of status re-assessments was agreed on by participants in plenary session.

- DFO staff should recalculate the individual status metrics annually, update the standardized data summaries, and check for any substantial changes.
- A meeting would not be required to re-assess status of CUs unless results from individual metrics indicated a change that could affect the overall status for the CU.
- A shorter (and perhaps smaller) meeting would be convened to address the affected CUs only.
- A full re-assessment of all CUs would take place every four years (representing approximately once per generation for most Chinook CUs).
- Full re-assessment meetings would include representation from DFO and stakeholders, but could be shorter than the current workshop; the meeting could review a status assessment working paper, and could possibly be vetted through a CSAS Science Response process instead of a Regional Peer Review process.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 4-6, 2014 Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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MPO. 2016. État biologique intégré du saumon quinnat (oncorhynchus tshawytscha) du sud de la Colombie-Britannique en vertu de la politique concernant le saumon sauvage. Secr. can. de consult. sci. du MPO, Avis sci. 2016/042.

Technical Summaries and Supporting Information for Emergency Assessments

Steelhead Trout
Oncorhynchus mykiss

(Thompson River and Chilcotin River populations)

John Neilson, Co-chair, Marine Fishes Subcommittee, COSEWIC
Eric Taylor, Chair, COSEWIC

February 2018

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

ASSESSMENT SUMMARY

Assessment Summary – February 2018

Common name
Steelhead Trout (Thompson River population)

Scientific name
Oncorhynchus mykiss

Status
Endangered

Reason for designation
This wildlife species faces a number of threats, including declining habitat quality both in marine and freshwater environments, and bycatch mortality from Pacific salmon fisheries. The number of spawning fish was variable with little trend prior to 2000. Since then, the population has declined dramatically (79%) over the last three generations and it is now the lowest on record. The 177 mature fish observed in the most recent survey are only about 9.5% of the pre-2000 mean. If the current rate of decline persists for another three generations, the number of spawning fish will decline to 37, which is 2.0% of the pre-2000 abundance.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in an emergency assessment conducted on January 10, 2018.

Assessment Summary – February 2018

Common name
Steelhead Trout (Chilcotin River population)

Scientific name
Oncorhynchus mykiss

Status
Endangered

Reason for designation
This wildlife species faces a number of threats, including declining habitat quality both in marine and freshwater environments, and bycatch mortality from Pacific salmon fisheries. The population has declined dramatically (81%) over the last three generations and it is now the lowest on record. The number of spawning fish was high and variable with little trend prior to 2000. The 58 mature fish observed in the most recent survey are only 5% of the pre-2000 mean. If the current rate of decline persists for another three generations, the number of spawning fish will decline to 11, which is 0.9% of the pre-2000 abundance.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in an emergency assessment conducted on January 10, 2018.

EXECUTIVE SUMMARY

In British Columbia, *Oncorhynchus mykiss* occurs as two evolutionary lineages, commonly referred to as “coastal” and “interior” *O. mykiss*. Both lineages of *O. mykiss* are found in freshwater-resident and anadromous (sea run) populations or life-history types, known as Rainbow Trout and Steelhead Trout, respectively. Interior *O. mykiss* are found in the Thompson-Chilcotin rivers (part of the Fraser River drainage). There is some interbreeding between freshwater-resident and anadromous individuals and freshwater-resident individuals may produce anadromous offspring and vice versa.

The anadromy of Steelhead Trout and their older age (and larger size) at maturity are significant aspects of their life history that set them apart from freshwater-resident Rainbow Trout. Thompson and Chilcotin Steelhead Trout are likely to have evolved from fish isolated in the Columbia refugium during the last glaciation while other Canadian Steelhead Trout may have arisen from the Haida Gwaii refugium. Based on genetic data, Steelhead Trout in the Thompson and Chilcotin rivers are discrete from all other Canadian Steelhead Trout, and also differ from each other. Thus, the interior Fraser River Steelhead Trout satisfy COSEWIC criteria to be assessed as two separate designatable units (DUs) or populations: Thompson River population and Chilcotin River population.

Thompson and Chilcotin Steelhead Trout have been the subject of considerable recent public concern, including the submission of an application for an Emergency Assessment in January 2016. Such input heightened concern for Thompson and Chilcotin Steelhead Trout already held by COSEWIC, and a status report was expected to be initiated in 2018. The most recent information on returns of adult fish, however, indicates that the situation is worsening and constituted an emergency. This resulted in an additional application for an Emergency Assessment submitted in November 2017.

The number of mature fish that have returned to fresh water from the sea in the fall of 2017, and that will spawn in the spring of 2018, are 177 and 58 for the Thompson and Chilcotin rivers, respectively. The average annual number of mature individuals returning to the Thompson and Chilcotin rivers in the last three years (2016-2018) is the lowest in a time series that began in 1978. The decline of mature individuals in the Thompson River over the last three generations (15 years) is 79%, and the decline of the Chilcotin River Steelhead Trout over three generations (18 years) is 81%. Bycatch mortality in commercial Pacific salmon fisheries and declines in marine and freshwater habitat quality are the key factors driving the declines.

The Emergency Assessment was conducted on January 10, 2018. The participants in the Emergency Assessment considered these data, and concluded that the status both of the Thompson River and Chilcotin River DUs of Steelhead Trout is Endangered and constitutes an emergency situation. This report documents the background material used during the Emergency Assessment and the conclusions reached.

Introduction

In response to record low returns of Thompson/Chilcotin Steelhead Trout and public concerns over their conservation status, COSEWIC conducted an Emergency Assessment (EA) of those wildlife species on January 10, 2018. There were 31 participants in the EA and their names and affiliations are listed in Appendix One. This report provides a summary of the information reviewed by participants, and the conclusions of the EA. Pending the decision regarding COSEWIC's recommendation that an Emergency Order be made (see below), a full COSEWIC status report will be produced on an expedited basis, and within one year of an Emergency Order being made as per the *Species at Risk Act* (s30.1).

Taxonomic Structure and Designatable Units

The taxon *Oncorhynchus mykiss* exhibits two broad life-history types: a lake- and stream-resident form known as Rainbow Trout and an anadromous (sea run) form known as Steelhead Trout (McPhail 2007). Depending on the geographic context (e.g., distance from the sea, presence of migration barriers, presence of lakes within a watershed), one or both forms may occur in a single watershed and even in the same tributary within a watershed. Again, depending on geographic context, the forms may exist separately, co-exist at the same place and time as juveniles and spawning adults, or their ranges may be adjacent to one another (McPhail 2007). Predictably, there is also a variable degree of demographic and genetic interaction between the forms where they co-exist. In some instances, there is little detectable genetic differentiation between the forms and in other instances they may represent genetically-distinct populations (Docker and Heath 2003; McMillan *et al.* 2007; Pearse *et al.* 2009). Furthermore, there is evidence that in some systems, Steelhead Trout may be produced from Rainbow Trout mothers and some Steelhead Trout offspring may remain permanently in fresh water (termed "residuals"), especially when they experience faster growth as juveniles, e.g. as often occurs in hatchery-supplemented populations (Viola and Schuck 1995; Zimmerman and Reeves 2000; Thrower *et al.* 2004). These variable relationships between Steelhead and Rainbow Trout are also found in other salmonid species such as *O. nerka* where there are freshwater-resident ("Kokanee") and anadromous forms ("Sockeye Salmon") and *Salmo salar* (with freshwater "Ouananiche" and anadromous "Atlantic Salmon" forms). In the context of Thompson and Chilcotin rivers' Steelhead Trout, there is no information on the genetic relationship between the two life-history forms. There is some evidence that Steelhead Trout in these systems may be produced from Rainbow Trout mothers (R. Bison, BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development, Kamloops, BC, pers. comm.), but the spatial and temporal extent of this phenomenon is not well understood. Accordingly, and consistent with recent status assessments both for Atlantic Salmon (COSEWIC 2010) and Sockeye Salmon (COSEWIC 2018), this assessment of interior Fraser River *O. mykiss* concerns only Steelhead Trout. The COSEWIC approach is also consistent with that of USA fisheries management agencies; here, anadromous and freshwater-resident forms of *O. mykiss* are assessed separately (Hard *et al.* 2015).

Steelhead Trout in the Thompson River and Chilcotin River are discrete from other Canadian Steelhead Trout based on genetic data, and also differ from each other. Thompson and Chilcotin Steelhead Trout likely evolved from fish isolated in the Columbia refugium during the last glaciation while other Canadian Steelhead Trout may have arisen from the Haida Gwaii refugium. After reviewing available information on Designatable Units (DU) for Thompson/Chilcotin Steelhead Trout and applying the COSEWIC criteria of discreteness and significance, EA participants agreed that Thompson and Chilcotin Steelhead Trout should be assessed as two DUs separate from all other BC Steelhead Trout populations: Thompson River DU and Chilcotin River DU (see Appendix Two for additional details).

Available Information for the Assessment

Annual monitoring information is available from a test fishery conducted in the Fraser River about 60 km upstream from the ocean (near Albion, BC). The fishing gear used is conventional salmon gillnets. A large mesh gillnet (8 inch) and a slightly smaller mesh gillnet (6.75 inch) are used on alternate days and on consistent tide stages during the early and peak time of Interior Fraser Steelhead Trout migration at that site. During the latter stage of the migration, only the smaller mesh gillnet is used on a daily basis. The catch statistic used in the forecasting of spawning (breeding) fish abundance is simply the number of Steelhead Trout caught per day.

For some of the tributaries of the Thompson and Chilcotin rivers where Steelhead Trout spawn, instream counts and estimates are also conducted. For the Thompson River tributaries, automated fish counters are used in the Deadman and Bonaparte rivers and periodic boat-based visual counts are used in a major tributary of the Nicola River watershed. These visual counts are combined in a maximum likelihood estimate model with observer efficiency, timing and spatial distribution estimates from external tagging and radio tagging to estimate abundance of Steelhead Trout in the Nicola River watershed, which includes estimates for the Coldwater River, Spius Creek and the lower Nicola River (Bison and Phelps 2017). For the Chilko River (a tributary of the Chilcotin River), periodic visual (helicopter based) counts are conducted over a distance of 24 km (i.e., from Brittany Creek confluence with the Chilko River up to Chilko Lake; Bison and Phelps 2017).

Catch (and release) in the sport fishery is estimated by random stratified on-the-ground angler surveys, where about one-third of the total effort is surveyed (Bison and Phelps 2017). A secondary estimate is based on an annual post-season angler questionnaire survey conducted province-wide by Fish & Wildlife Branch (Bison and Phelps 2017).

Bycatch in the commercial Pacific salmon fisheries is estimated indirectly, using trends and level of encounter rates and fishing mortality rates are estimated with the use of a simulation model (Bison 2016).

The trends in annual abundances of spawning fish for major tributaries of the Thompson and Chilcotin River DUs both show dramatic declines since the early 2000s (Figures 1 and 2). The rates of decline over three generations are 79% and 81% for the Thompson and Chilcotin DUs, respectively.

For the Thompson River DU, if the current rate of decline persists for another three generations, the number of spawning fish will decline to 37, which is 2% of the pre-2000 abundance. For the Chilcotin River DU, if the current rate of decline persists for another three generations, the number of spawning fish will decline to 11, which is about 0.9% of the pre-2000 abundance.

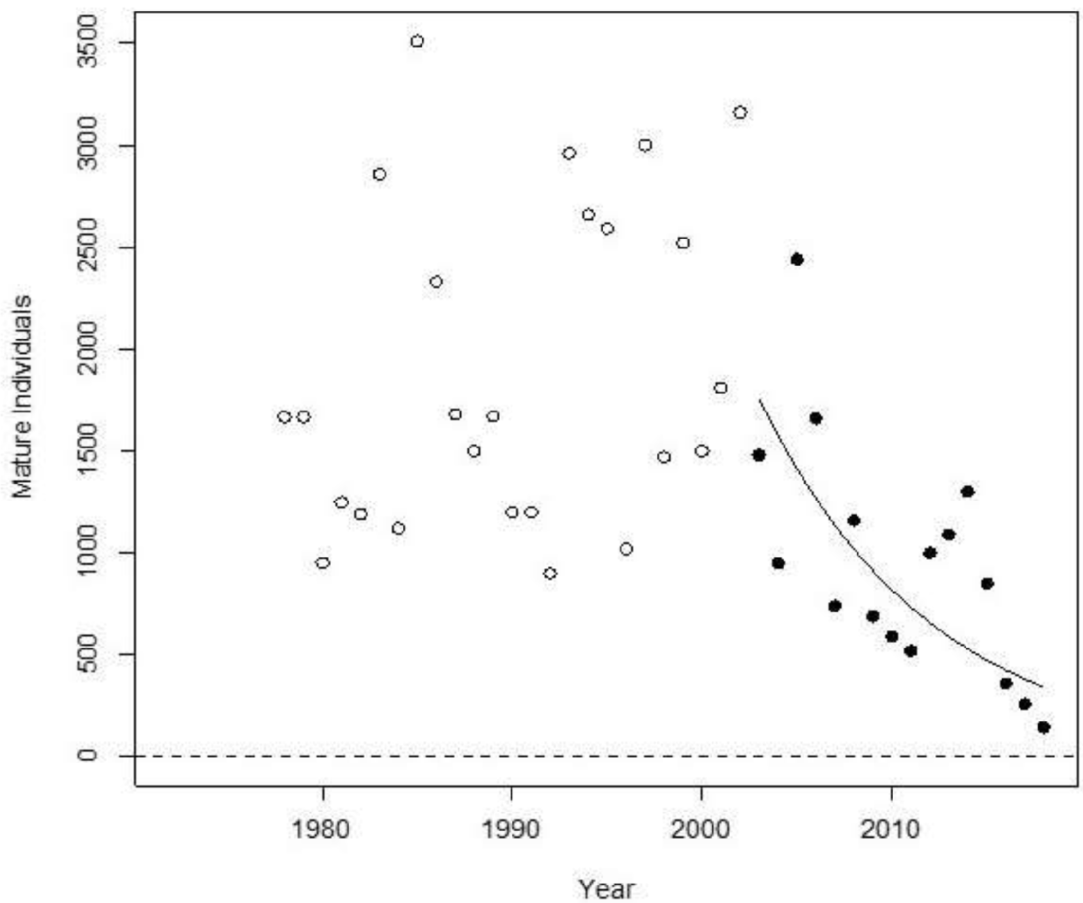

Figure 1. Trend in the number of mature individuals in the Thompson River Steelhead Trout DU, 1978-2018, and the fitted log-linear regression through the last 3 generations (5 year generation time). The solid data points were used in the decline estimate of 79%. Data obtained from R. Bison, November 6, 2017. Note that fish entering fresh water in the fall of 2017 will spawn in the spring of 2018.

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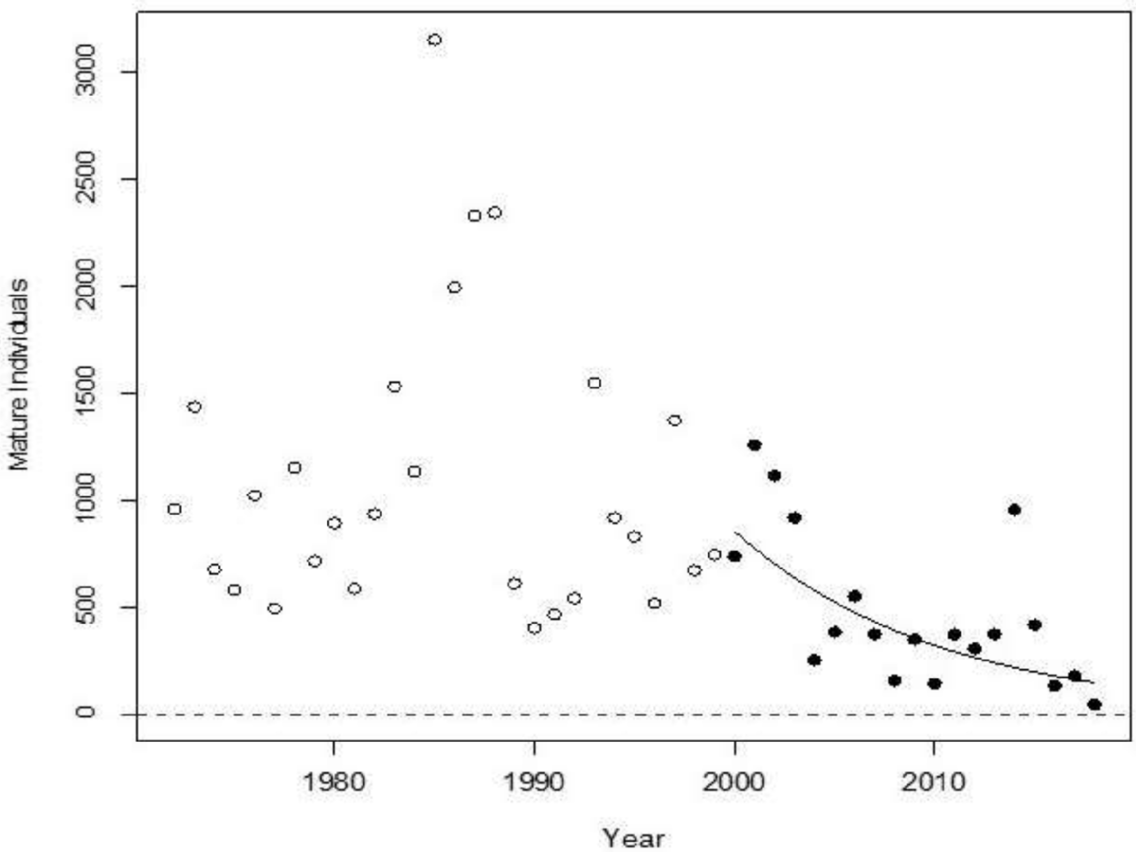

Figure 2. Trend in the number of mature individuals in the Chilcotin River Steelhead Trout DU, 1972-2018, and the fitted log-linear regression through the last three generations (6 year generation time). The solid data points were used in the decline estimate of 81%. Data obtained from R. Bison, November 6, 2017. Note that fish entering fresh water in the fall of 2017 will spawn in the spring of 2018.

Threats

Reduced marine survival of Steelhead Trout is considered to be a key factor driving population declines since the early 1990s (Kendall *et al*. 2017). Similar poor ocean survival-based declines have been reported in recent COSEWIC reports for Sockeye Salmon and Coho Salmon (*O. kisutch*). Although relationships between marine temperature and survival have been identified, the underlying causal mechanisms driving the relationships are poorly understood for Steelhead Trout. Ocean temperatures have warmed an average of 0.5°C over the past two decades and have likely contributed to declining survival of Steelhead Trout as has been suggested for Sockeye Salmon (Hinch and Martins 2011). Ocean temperatures in the Gulf of Alaska where Steelhead Trout spend much of their marine life are predicted to increase 1-2°C by the 2040s (Abdul-Aziz *et al*. 2011). Berejikian *et al*. (2016) suggested that predation by Harbour Seals (*Phoca vitulina*) contributed to mortality of migrating juvenile Steelhead Trout off Washington State, and they hypothesized that documented changes in the Puget Sound ecosystem may currently put Steelhead Trout at greater risk of predation by Harbour Seals and possibly other predators.

Bycatch of returning mature fish in purse seine and gillnet fisheries directed at Pacific salmon is a better-quantified threat compared with marine survival. There are no directed commercial fisheries for Steelhead Trout in BC and the sport fishery operates on a catch-and-release basis with closures if in-season abundance estimates are below pre-determined limits. The estimated mortality rate from all bycatch in commercial fisheries is in the range of 15-25% annually (Bison 2016). This alone could explain a large proportion of the observed decline in mature individuals.

While it is generally considered that the quality of freshwater habitat is declining, the severity of the freshwater habitat-based threats in the Thompson and Chilcotin rivers is not well understood.

Assessment Results

The EA concluded that for the Thompson River DU, a designation of Endangered applies (Endangered A2bd+4bd; C2a(i); D1 – see Technical Summary 1). For the Chilcotin River DU, the EA also concluded that Endangered applies (Endangered A2bd+4bd; C2a(i,ii); D1 – see Technical Summary 2).

The EA also used RAMAS Red List V3.0 (http://www.ramas.com/redlist) software for a rapid assessment using International Union for the Conservation of Nature (IUCN) criteria. For both DUs, the RAMAS procedure using the most recent spawning adult abundance estimates from the Province of BC and the decline rates used in this report indicated a "**Critically Endangered**" IUCN status.

Rescue Effect

As noted earlier, freshwater-resident Rainbow Trout may produce offspring that become anadromous (e.g., Zimmerman and Reeves 2000). The same literature, however, also indicates that the phenomenon is a watershed-specific characteristic, and the extent to which this occurs within the Thompson and Chilcotin watersheds is not well known. Regardless, given the observed declines (Figure 1 and Figure 2), there is no evidence that any potential contribution of resident Rainbow Trout is mitigating the recent precipitous decline in Steelhead Trout or that it might do so in the future.

Acknowledgements

The authors thank the many COSEWIC members and members of the Marine Fishes Species Specialist subcommittee who contributed to this report. Alan Sinclair, John Reynolds, John Post, Greg Wilson, and Robert Bison (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development) led the preparation of material supporting the Emergency Assessment. They also thank all in the COSEWIC secretariat who have contributed to this urgent matter.

TECHNICAL SUMMARY 1
Steelhead Trout (Thompson River population)

Oncorhynchus mykiss

Steelhead Trout (Thompson River population)

Truite arc-en-ciel anadrome (Population de la rivière Thompson)

Range of occurrence in Canada (province/territory/ocean): British Columbia (Thompson River), Pacific Ocean

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used).	5 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	71% decline in last 2 generations
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	79% decline in last 3 generations
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	If the current rate of decline persists for another 3 generations, the number of spawning fish will decline to 37, which is 2.0% of the pre-2000 abundance.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	79% decline inferred over this time period assuming the same decline rate as in the last 3 generations
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Partially if bycatch fishing mortality is reduced. b. Bycatch mortality well understood but declines in marine and freshwater environments less so. c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	> 20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value.)	< 500 km²

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	NA
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	NA
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, there is an inferred decline in habitat quality.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Thompson River, includes spawning in the following tributaries: Deadman, Bonaparte, Coldwater rivers and Spius Creek and Nicola River in most recent survey year (2017).	177 (the average of last 3 years is 255)
Total	177

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not calculated

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? No. This population faces a number of threats in the marine and freshwater environments, many of which are similar to Sockeye Salmon in the Fraser River drainage and Coho Salmon in the Interior Fraser River. Fishery removals for the interior Fraser River Steelhead Trout vary from 15-25% per year, depending on the abundance of Pacific salmon targeted in commercial fisheries.

i.
ii.

What additional limiting factors are relevant?

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Thompson Steelhead Trout are endemic to this watershed and rescue is not possible from other Steelhead Trout populations. Rescue from non-anadromous trout within this watershed is unlikely.
Is immigration known or possible?	NA
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA
Are conditions deteriorating in Canada?[+]	NA
Are conditions for the source (i.e., outside) population deteriorating?[+]	NA
Is the Canadian population considered to be a sink?[+]	NA
Is rescue from outside populations likely?	NA

Data Sensitive Species

Is this a data sensitive species?	No

Current Status

COSEWIC: Not previously assessed

Recommended Status and Reasons for Designation:

Recommended Status:	**Alpha-numeric codes:**
Endangered	A2bd+4bd; C2a(i); D1

Reasons for designation:

This wildlife species faces a number of threats, including declining habitat quality both in marine and freshwater environments, and bycatch mortality from Pacific salmon fisheries. The number of spawning fish was variable with little trend prior to 2000. Since then, the population has declined dramatically (79%) over the last three generations and it is now the lowest on record. The 177 mature fish observed in the most recent survey are only about 9.5% of the pre-2000 mean. If the current rate of decline persists for another three generations, the number of spawning fish will decline to 37, which is 2.0% of the pre-2000 abundance.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bd+4bd. The number of mature individuals has declined by 79% over the past 3 generations and it is inferred that this decline will continue into the future.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion. IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, but the population is not severely fragmented, the criterion for restricted number of locations does not apply and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i). The number of mature individuals for all subpopulations is 177 in the most recent survey year, and no subpopulation is estimated to have more than 250 individuals.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 because the number of mature individuals in the last survey year is 177 (most recent 3 year average is 255).
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY 2
Steelhead Trout (Chilcotin River population)

Oncorhynchus mykiss

Steelhead Trout (Chilcotin River population)

Truite arc-en-ciel anadrome (Population de la rivière Chilcotin)

Range of occurrence in Canada (province/territory/ocean): British Columbia (Chilcotin River), Pacific Ocean

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used).	6 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	59% decline in last 2 generations
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	81% decline in last 3 generations
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	If the current rate of decline persists for another 3 generations, the number of spawning fish would decline to 11, or about 0.9% of the pre-2000 abundance.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	81% decline inferred over three generations assuming the same decline rate as in the last 3 generations
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Partially if bycatch fishing mortality is reduced. b. Bycatch mortality well understood but declines in marine and freshwater environments less so. c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	> 20,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	< 500 km²

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	NA
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*	NA
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, there is an inferred decline in habitat quality.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Chilcotin River, including the following spawning tributaries: Taseko, Chilko and Little Chilcotin rivers in the most recent survey year (2017)	58 (average of last 3 years is 120)
Total	58

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not calculated

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? No. This population faces a number of threats in the marine and freshwater environments, many of which are similar to Sockeye Salmon in the Fraser River drainage and Coho Salmon in the Interior Fraser River. Fishery removals for the interior Fraser Steelhead Trout vary from 15-25% per year, depending on the abundance of salmon targeted in commercial fisheries.

i.
ii.

What additional limiting factors are relevant?

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Chilcotin Steelhead Trout are endemic to this watershed and rescue is not possible from other Steelhead Trout populations. Rescue from non-anadromous trout within this watershed is unlikely.
Is immigration known or possible?	NA
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA
Are conditions deteriorating in Canada?[+]	NA
Are conditions for the source (i.e., outside) population deteriorating?[+]	NA
Is the Canadian population considered to be a sink?[+]	NA
Is rescue from outside populations likely?	NA

Data Sensitive Species

Is this a data sensitive species?	No

Current Status

COSEWIC: Not previously assessed

Recommended Status and Reasons for Designation:

Recommended Status:	**Alpha-numeric codes:**
Endangered	A2bd+4bd; C2a(i,ii); D1

Reasons for designation:
This wildlife species faces a number of threats, including declining habitat quality both in marine and freshwater environments, and bycatch mortality from Pacific salmon fisheries. The population has declined dramatically (81%) over the last three generations and it is now the lowest on record. The number of spawning fish was high and variable with little trend prior to 2000. The 58 mature fish observed in the most recent survey are only 5% of the pre-2000 mean. If the current rate of decline persists for another three generations, the number of spawning fish will decline to 11, which is 0.9% of the pre-2000 abundance.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2bd+4bd. The number of mature individuals has declined by 81% over the past 3 generations and it is inferred that this decline will continue into the near future.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion. IAO meets criterion for Endangered and the quality of the freshwater and marine habitats is declining, but the population is not severely fragmented, the criterion of restricted number of locations does not apply and there are no extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i,ii). The number of mature individuals is 58 in the most recent survey year, there has been a 59% decline in the number of mature individuals over the last 2 generations, no subpopulation has more than 250 individuals, and one subpopulation has more than 95% of all mature individuals.
Criterion D (Very Small or Restricted Population): Meets Endangered D1 because the number of mature individuals is less than 250 (most recent year is 58, with an average of 120 over the most recent three years).
Criterion E (Quantitative Analysis): Not done

APPENDIX ONE

Thompson/Chilcotin Steelhead Trout Emergency Assessment Participants
January 10, 2018

Participant	Role
Eric Taylor	COSEWIC Chair
John Neilson	Co-chair Marine Fishes
Dwayne Lepitzki	Co-chair Molluscs
Dave Fraser	Jurisdiction - BC
Greg Wilson	Jurisdiction - BC
Syd Cannings	Jurisdiction – CWS
Jennifer Shaw	Jurisdiction - DFO
Simon Nadeau	Jurisdiction - DFO
Robert Bison	British Columbia government area fishery specialist
John Post	Co-chair Freshwater Fishes
John Reynolds	Non-government Science member
Alan Sinclair	EA SSC special member or observer
Arne Mooers	Non-government Science member
Donna Hurlburt	Co-chair ATK
Roger Gallant	Co-chair ATK
Paul Grant	Co-chair Arthropods
Ross Claytor	Co-chair Marine Fishes
Aaron McNeil	Marine Fishes SSC member
Bruce Atkinson	Marine Fishes SSC member
Craig Purchase	Marine Fishes SSC member
David Hardie	Marine Fishes SSC member
Ian Fleming	Marine Fishes SSC member
Laura Weir	Marine Fishes SSC member
Margaret Treble	Marine Fishes SSC member
Nancy Shackell	Marine Fishes SSC member
Peter Westley	Marine Fishes SSC member
Carrie Holt	Marine Fishes SSC member
Marc Trudel	Marine Fishes SSC member
Bev McBride	Secretariat
Karen Timm	Secretariat
Lisa Twolan	Secretariat

APPENDIX TWO

Thompson River and Chilcotin River Steelhead Trout DU structure

British Columbia contains myriad populations of Steelhead Trout (anadromous *Oncorhynchus mykiss*) from south coastal areas to northwestern British Columbia with perhaps 1,200 or more watersheds potentially supporting Steelhead Trout populations (Fig. A1). The Thompson and Chilcotin rivers' Steelhead Trout (TCS) constitute two designatable units (DUs) within this assemblage as they satisfy both the discrete and significance criteria for recognizing DUs (COSEWIC 2016).

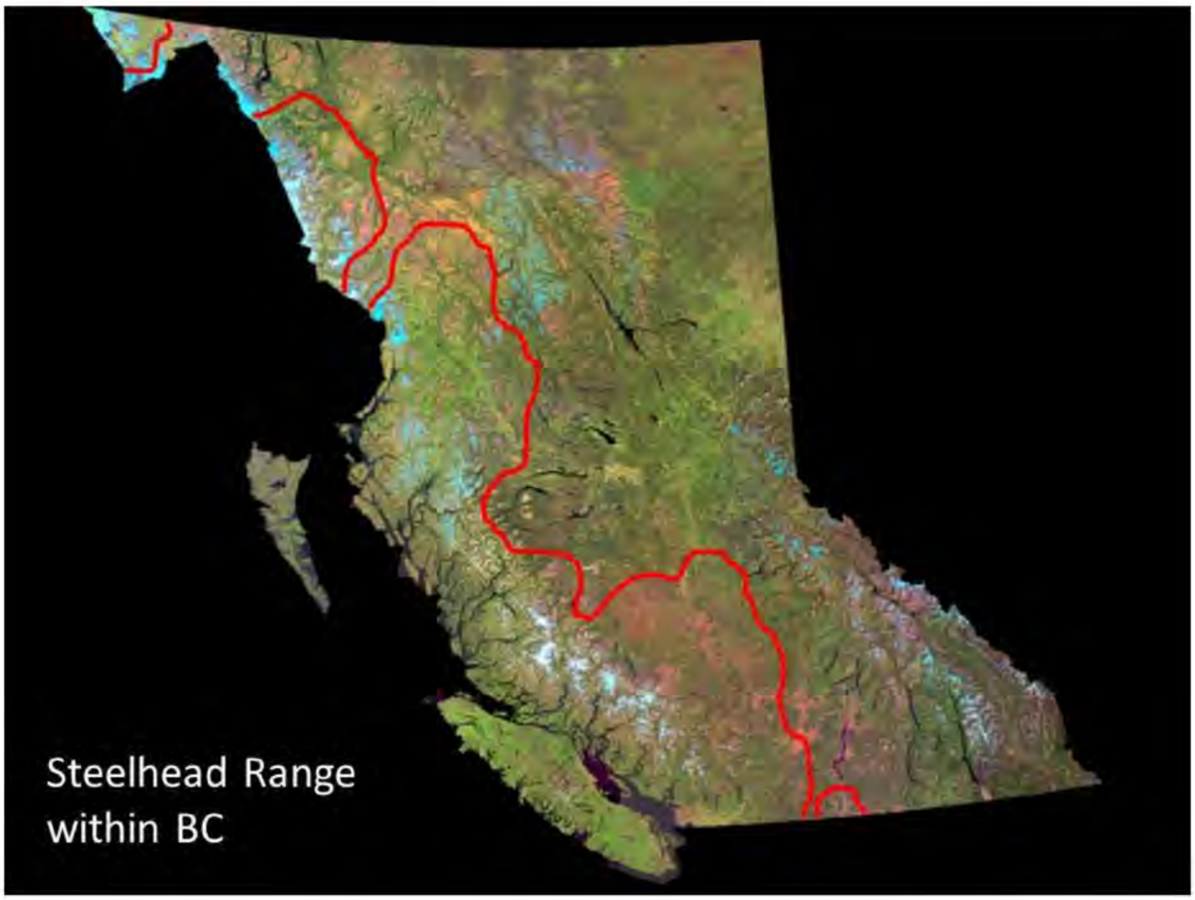

Figure A1. Approximate range of Steelhead Trout in BC (left of red line including all coastal islands). Figure provided by G. Wilson, BC Ministry of Environment.

(a) Separation of Thompson and Chilcotin Steelhead Trout (TCS) from other BC Steelhead Trout

Discreteness:

The TCS spawn within tributaries of the Thompson and Chilcotin rivers of the Fraser River drainage and thus are spatially discrete from other Steelhead Trout populations in BC. Given the well-documented homing to natal streams for spawning of most anadromous salmonids like Steelhead Trout, there is a high degree of spatial genetic population structure in interior Fraser River Steelhead Trout. For instance, Beacham *et al.* (2004) used 14 microsatellite DNA loci and demonstrated that TCS, and a group of Steelhead Trout from the mid-Fraser River (MFS; Stein, Nahatlatch, and Bridge rivers), formed a well-defined cluster of populations (75% bootstrap support, Fig. 2 in Beacham *et al.* 2004) distinct from 46 other populations from northwestern BC to US portions of the upper Columbia River. In fact, the TCS (and MFS) were more similar genetically to Steelhead Trout from the upper Columbia River than they were to Steelhead Trout from the lower Fraser River (e.g., Chilliwack and Coquihalla rivers, Fig. 2 of Beacham *et al.* 2004). Furthermore, the TCS are part of the admixed south coast/interior phylogenetic group as inferred from mtDNA that is unique in BC (Fig. 9, 10 in McCusker *et al.* 2000; Fig. A2, A3). In addition, the Thompson River component of the TCS are discrete from the MFS as well as from the Chilcotin River Steelhead Trout (CRS) when assayed using these same microsatellite loci (98% bootstrap support). Allele frequency tests based on the microsatellite DNA data of Beacham *et al.* (2004) and four polymorphic allozyme loci studied by Parkinson (1984, Table 1), however, both indicate that the Chilcotin River Steelhead Trout are also significantly distinct from all three MFS samples (all $P < 0.001$, E. Taylor, University of British Columbia, Vancouver, unpublished results). In the case of the allozyme loci, most of the differentiation is attributable to differences between the Chilcotin River and the Stein/ Nahatlatch River samples, but one locus (AGP) also distinguished Chilcotin River fish from Bridge River fish (randomization test $P = 0.0003$). These two samples were also significantly distinct when combining probabilities across all four loci (Fisher's combined probability test, $P < 0.001$, E. Taylor, University of British Columbia, Vancouver, unpublished analysis). The Bridge River fish are also the most similar of the MFS samples to CRS in terms of microsatellite loci. The proportion of total variation in microsatellite allele frequencies attributable to differences between Bridge River fish and CRS (F_{ST}) is 2.5% ($P < 0.002$) whereas it is between 5.6% and 8.8% between Nahatlatch and Stein rivers and CRS, respectively (both $P < 0.002$, T.D. Beacham, DFO, Nanaimo, BC, pers. comm. Jan. 12, 2017 based on data in Beacham *et al.* 2004). Although the degree of differentiation is variable, the TCS are, demonstrably discrete from all other BC Steelhead Trout, and the Thompson and Chilcotin rivers' populations are discrete from each other (see below).

Significance:

The genetic data cited above also point to the significance of the TCS as a discrete assemblage of Steelhead Trout. The microsatellite and mtDNA data both suggest that the TCS have had a unique glacial and postglacial history in BC in that they share a close affinity with Steelhead Trout from the south coast (mtDNA) as well as from the upper

Columbia River (microsatellites). This suggests that the TCS may result from a double invasion of the current waterscape from two glacial refugia – again, a situation that appears to be unique within the evolutionary legacy of BC Steelhead Trout (Fig. 9 in McCusker *et al.* 2000; Fig. A2, A3).

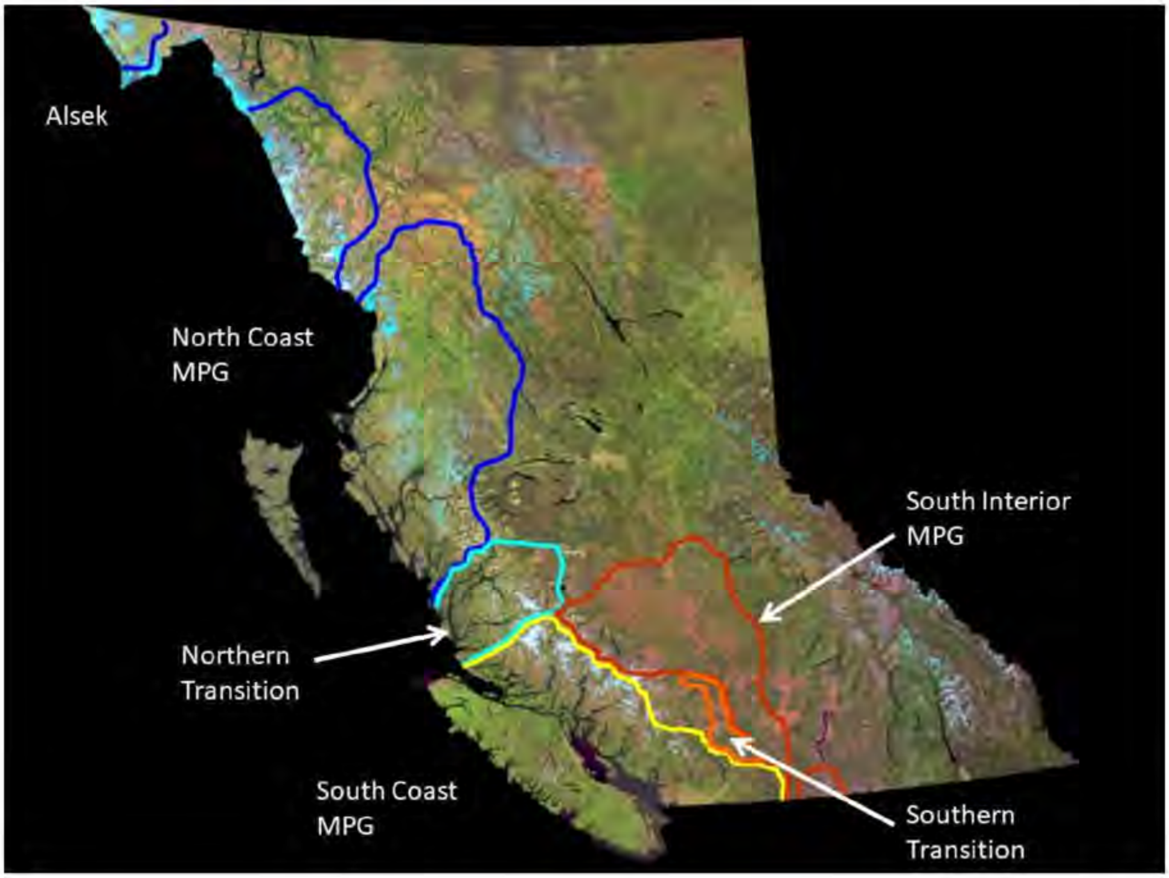

Figure A2. Distribution of major phylogenetic groups (MPG) of *Oncorhynchus mykiss* in BC (based on McCusker *et al.* 2000). Figure provided by G. Wilson, BC Ministry of Environment.

Further evidence for the evolutionary significance of the discreteness of TCS from other Steelhead Trout comes from the studies of allozyme differentiation and its apparent association with swimming stamina. The TCS, represented by samples from the Thompson River, have higher frequencies of lactate dehydrogenase phenotypes that are associated with substantially greater prolonged swimming performance compared to fish from the lower Fraser River (Tsuyuki and Williscroft 1977). Such physiological differences are also apparent between coastal and interior populations of Coho Salmon (Taylor and McPhail 1985) and point to the actual and potential adaptive characteristics of salmonid fishes with long upstream migrations in the Fraser River. Other differences between TCS and south coast Steelhead Trout include their fall-season run timing and the immature state of gonads during migration – a phenomenon known as "premature migration". By contrast, south coast Steelhead Trout typically migrate through the lower Fraser River after TCS and with gonads in more advanced states of maturity. The premature migration phenotype appears to have a relatively simple genetic basis, to be under strong positive selection, and is considered critical for the persistence of Steelhead Trout biodiversity in other portions of its range (Prince *et al.* 2017). The TCS also differ in several aspects of migration timing, speed, age at maturation, and smolt age from fish in the lower and middle Fraser River. These differences are especially evident between the Chilcotin River fish and all others and likely reflect adaptations to the longer and more arduous migrations of these fish and the distinct climates that they live in (see below).

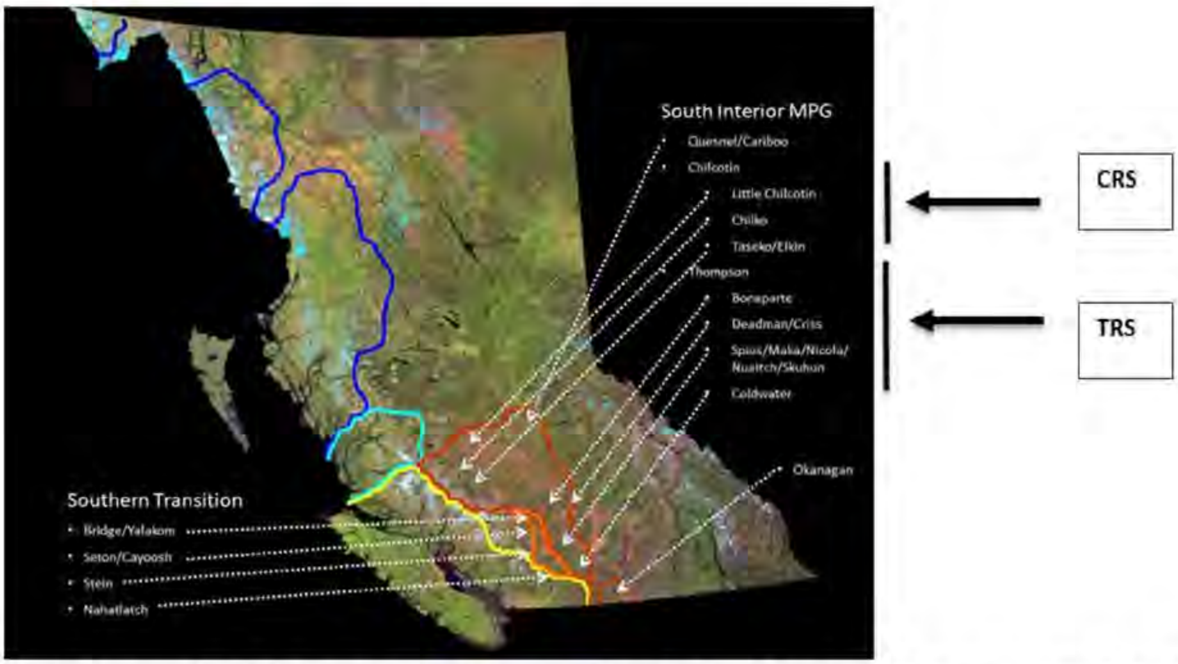

Figure A3. Location of Chilcotin River (CRS) and Thompson River Steelhead Trout (TRS; black arrows) within BC and major phylogenetic groupings (see Figure A2). Figure provided by G. Wilson, BC Ministry of Environment.

Given all the above, TCS satisfy both the discrete and significance criteria for their recognition as at least one distinct DU within *O. mykiss*. Further, it is proposed that TCS be subdivided into two DUs distinct from one another: Thompson River Steelhead Trout (TRS) and Chilcotin River Steelhead Trout (CRS).

(a) Separation between TRS and CRS

Discreteness:

As discussed above the genetic data of Beacham *et al.* (2004) clearly (i.e., with 98% bootstrap support) identified TRS as a genetic cluster distinct from other Steelhead Trout including the CRS. Genetic distance (F_{ST}) between TRS and CRS at microsatellite loci accounted for between 6.2% and 8.3% of the total variation when assaying those two samples (all P < 0.001, pers. comm. from T.D. Beacham, DFO, Nanaimo, BC Jan. 12, 2017 based on data in Beacham *et al.* 2004). Parkinson's (1984) data also showed that CRS had multilocus genotypes across four allozyme loci (SOD, LDH, MDH, and AGP) that were distinct from samples of Thompson, and MFS rivers' Steelhead Trout (see above). The TRS and CRS are also spatially discrete (see below) and phenotypically discrete from each other, most notably in terms of adult age at maturation, migration timing and behaviour, and smolt age (discussed below under significance).

Significance:

The TRS and CRS differ in several aspects of migration timing, speed, and behaviour that can be plausibly interpreted as adaptations to the different locations of their spawning areas. In general, genetic mixture and telemetry studies indicate that the CRS enter the Fraser River earlier, migrate upriver faster, and exhibit less "milling" behaviour than TRS (i.e., "milling" is a behaviour where fish remain relatively stationary in certain areas *en route* to the spawning or overwintering areas). For instance, Bison (unpublished data) reported a mean difference in the date of migration past river km 235 (near the Nahatlatch River) of 13.8 days (i.e., these fish arrived on average almost 14 days *earlier* than the date averaged across all populations) for CRS compared to 0.2 to -4.3 days for the TRS (and -1.6 to -8.3 days for the later-arriving MFS fish, respectively, N = 49 fish radio-tagged from all areas). These differences likely result from selection for earlier and more direct migration in CRS because they have to surpass three major migration hurdles prior to the onset of winter (two in the lower Fraser River canyon at river kms 185 and 210, and one at Bridge River rapids at river km 340). By contrast, TRS need only surpass two hurdles in the lower Fraser River canyon. Further, CRS have further to travel to their overwintering sites which are at least as far upstream as river km 522 in the Chilcotin River and river km 510 in the Fraser River (~100 km upstream of the Chilcotin-Fraser confluence; Renn *et al.* 2001). By contrast, TRS overwinter only as far upstream as the outlet of Kamloops Lake at river km 375 from where the Fraser River enters the Strait of Georgia (note: the latest-arriving Nahatlatch River fish travel only 238 km from the mouth of the Fraser River). Finally, TRS and CRS differ from each other both in smolt age and adult age of return to fresh water; the majority of TRS smolts are age two years when they migrate to sea (93%), while the majority of CRS smolts are age three years (83%, Bison 2012). The older age at smolting of CRS drives their older adult age at return. The age at first spawning is typically five years (more rarely six or seven) for TRS, but age six years (rarely seven or eight) for CRS (N = 14 - 215 fish annually over 40 years of monitoring, Bison 2012). The older age of smolting and adult maturation in CRS are likely adaptations to the longer and/or more arduous migrations experienced by these fish (see above). Finally, the TRS and CRS are found in different biogeoclimatic zones of BC; the TRS are found primarily in the Interior Douglas Fir Zone whereas the CRS are found across a mix of several smaller zones. The former is considered more of a semi-desert region with generally higher mean annual air temperature (see Fig. A4). The higher temperature may result in greater growth opportunity for TRS smolts and, in part, explain their younger average age at smolting relative to CRS. Several studies have provided evidence of divergence in thermal tolerance physiology in *O. mykiss* from non-BC populations along a similar desert-montane environmental gradient (Rodnick *et al.* 2004; Narum *et al.* 2010, 2013) and it is plausible that similar differences exist between TRS and CRS.

Summary:

The TRS and CRS should be assessed as two distinct DUs.

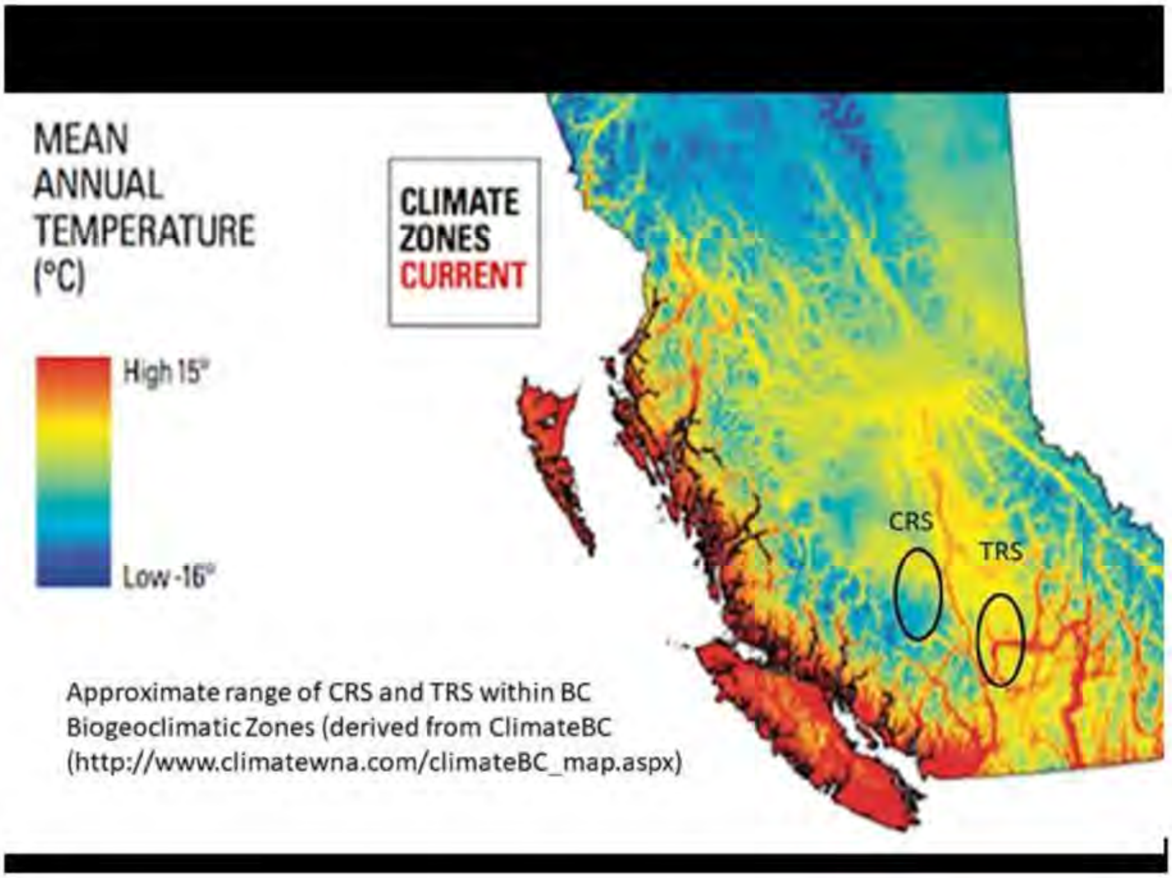

Figure A4. Approximate locations of populations of Chilcotin River Steelhead Trout (CRS) and Thompson River Steelhead Trout (TRS) within the context of climate zones of BC as measured by mean annual air temperature (climate map from ClimateBC 2017).

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From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Tue Feb 16 14:33:51 2021

To: David Welch

Subject: RE: CSAS (Integrated Biological Status of S BC Chinook-2016 042).pdf

Importance: Normal

Thanks David

It was good to catch up for a minute. I'll take a look and will consider how incorporate these into our thinking.

All the best.

Ben

From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, February 16, 2021 2:00 PM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] CSAS (Integrated Biological Status of S BC Chinook-2016 042).pdf

Ben-

Thanks for your time. I mentioned that I would send you the report on the status of Chinook in the Fraser River.

To save some time, I pasted into the bottom of this email the status of southern BC Chinook stocks ***as of 2016***. (See the attached file for the officially accepted report, as well as a separate file petition for an emergency listing of Upper Fraser steelhead from 2018).

(b)(5) [redacted]

(b)(5) [redacted]

David

From: David Welch

Sent: Fri Feb 19 15:41:12 2021

To: Ben Zelinsky

Subject: [EXTERNAL] BPA budget for survival rate paper

Importance: Normal

Ben—

I forgot to mention this before we hung up the other day, but we originally had a SOW in BPA's PICES system for
(b)(5) [redacted]

(b)(5) [redacted]

We budgeted this at $115K US. To remind BPA senior staff about what was to be accomplished I have taken a stab at writing a short summary blurb on this based on what was already in our PICES proposal. My hope is that BPA can support this work in the current calendar year both because it gives us an initial resolution to the question outlined, but also because the data can be fed into the costing of a subsequent proposal to directly measure TDG impacts on smolt survival in the lower river and the coastal ocean.

Regards, David

David Welch

(m) +[redacted]

[redacted]

(b)(5)
[redacted]

From: Erin Rechisky
Sent: Wednesday, September 2, 2020 6:34 PM
To: David Welch <David.Welch@Kintama.com>
Subject: RE: BPA budget for survival rate paper

Years ago, it was three papers, but one of those was a comparison of freshwater survival in large rivers which was included in the SAR paper....and then removed, right?

I'll have to go back to 2017 budgets. I'll have to ask Shaun to send more files.

Erin

From: David Welch <David.Welch@Kintama.com>
Sent: September 2, 2020 6:19 PM
To: Erin Rechisky <Erin.Rechisky@Kintama.com>
Subject: RE: BPA budget for survival rate paper

Thank you. If you have it , let me know the value of the other piece (can't even recall what that was to be right now!).

From: Erin Rechisky <Erin.Rechisky@Kintama.com>
Sent: Wednesday, September 02, 2020 5:22 PM
To: David Welch <David.Welch@Kintama.com>
Subject: BPA budget for survival rate paper

Hi David,

I had Shaun send me files. I see that we budgeted $115k for the survival rate paper. I think we did use some of this in the past since you, and maybe Aswea, were working on it a year and bit ago.

I think it's safe to stick with $115k for an approximation.

Erin

From: Monroy Flores,Luisa F (BPA) - EWB-4

Sent: Fri Feb 19 16:44:04 2021

Subject: Announcement Posted: Fish and Wildlife Administrator, GS-0480-09 FPL 12, EWM

Importance: Normal

Hello,

The GS-09 Fish and Wildlife Administrator position just opened in the Montana/Idaho Implementation (EWM) org. Below are the details for this job announcement.

Announcement: DOE-BPA-21-14400-RG

Position Title: Fish and Wildlife Administrator **(Recent Graduate), GS-0480-09 FPL 12, (EWM) – Portland, OR**

Opening Date: 02/19/2021

Closing Date: 02/28/2021

USA Jobs Link: https://www.usajobs.gov/GetJob/ViewDetails/592824100

Individuals that are eligible to apply are:

- Recent Graduates - Individuals who have graduated from an accredited educational institute or certificate program within the last 2 years or 6 years for Veterans.

- The public – U.S citizens, nationals or those who owe allegiance to the U.S

Please forward to anyone who may be interested.

Thank you,

Luisa Monroy Flores

Program Analyst | Business Operations Support EWB-4

Bonneville Power Administration
bpa.gov | P 503-230-5888 | E lfmonroyflores@bpa.gov

Facebook-Icon_31x31_v3Flickr-Icon_31x31Instagram-Icon_31x31LinkedIn-Icon_31x31Twitter_31x31YouTube_31x31

From: Pisces

Sent: Thu Feb 25 14:22:52 2021

To: Pisces

Subject: Pisces Web Release Tonight - New Default Dashboard

Importance: Normal

Good afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

The biggest update this month is the switch from the old dashboard to the new dashboard as your default setting on your home page. When you first log in to the system, you will see a welcome message explaining the new functionality. If you are interested in learning more, you can find a help document here.

The following is a list of updates that will be included in the release:

- Displaying new dashboard for all users

- New Dashboard: Improve lock/unlock UI/UX
- Add contract hyperlinks and budget categories to BiOp Annual Report
- Add planned values to BiOp Annual Report
- Capture changes to WE budgets for CCR SOW Review

Important bug fixes include:

- Alerts in old and new Dashboards are not the same
- No default Alerts widget created when user switched to using the new Dashboard for the first time
- Add Contact(s): It's unclear who makes the default list of names
- The default width setting of some grids do not persist
- Amendment and Change Request Summary dialog does not show expected data

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact

the Pisces team at pisces@bpa.gov

As always…

· For system access or bugs in Pisces Web – email support@cbfish.org

· For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Vendor MTC Team

Sent: Wed Mar 10 19:28:58 2021

To: David Welch

Cc: Petersen,Christine H (BPA) - EWP-4; Eisenach,Greg A (BPA) - NSTS-4400-LL; Vendor MTC Team

Subject: RE: Inquiry: from Bonneville Power Administration (BPA) | RE: 2020 Kintama Research Services LTD - Contract 81498 | Invoice # 2020-03

Importance: Normal

Certainly, I called the toll free number: +1-866-546-8262…perhaps this is why. On any account, if the toll free number is not a valid number, I will update our vendor profile as needed.

I sincerely appreciate the prompt response.

I hope your evening is enjoyable.

Stay healthy and be safe. Kandy

Kandace Hunter

Supply System Data Specialist | Technology Services Support

Supply Chain Services | Bonneville Power Administration

Vendor Mtc. Team Phone: 360-418-2800; leave message

Calls returned same day or next business day

Emails: klbarritt@bpa.gov | vendormaintenance@bpa.gov

From: David Welch <David.Welch@Kintama.com>
Sent: Wednesday, March 10, 2021 6:55 PM
To: Vendor MTC Team <vendormaintenance@bpa.gov>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Eisenach,Greg A (BPA) - NSTS-4400-LL <gaeisenach@bpa.gov>
Subject: [EXTERNAL] RE: Inquiry: from Bonneville Power Administration (BPA) | RE: 2020 Kintama Research Services LTD - Contract 81498 | Invoice # 2020-03

Good evening, Candace

Odd—I just checked my cell and landline and I do not have a voice mail message from you. I wonder if you could check your records and advise me what number you were calling? (A few years ago the company moved premises within our city but crossed some invisible line, requiring us to use a new phone number—perhaps you were calling an old number?).

I just checked the invoice you mention. I can confirm that no work or conferences took place on US soil during the period in question. Please call (#s below) if you need any further information.

Regards, David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) [redacted]

Our new paper looking at coastwide survival of Chinook salmon has recently been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

Our rebuttal to two memos put out by the Fish Passage Center and Dr Howard Schaller & colleagues, criticizing aspects of our paper, can be found at the link below. This rebuttal was prepared as part of a presentation of our work made to the Columbia River's ISAB (Independent Scientific Advisory Board) on Feb 5th, 2021.

http://kintama.com/publications/secondary-publications/

From: Vendor MTC Team <vendormaintenance@bpa.gov>
Sent: March 10, 2021 6:06 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Vendor MTC Team <vendormaintenance@bpa.gov>; Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Eisenach,Greg A (BPA) - NSTS-4400-LL <gaeisenach@bpa.gov>
Subject: Inquiry: from Bonneville Power Administration (BPA) | RE: 2020 Kintama Research Services LTD - Contract 81498 | Invoice # 2020-03

Good evening, Dr. Welch.

Name is Kandace Hunter. Earlier, I called and left a voice message but wanted to follow-up via email as well.

BPA's Vendor Maintenance team is finalizing 2020 1042-S tax compliance reporting. As such, please kindly advise if any work pertaining to contract 81498 (Invoice 2020-003) was performed on U.S. soil to include any conference/seminar attendance hosted in the U.S.

If you prefer to discuss this over the phone, please contact me on my cell number a(b)(6) [redacted] If necessary to leave me a voice message, I will promptly return your call. I am on the Pacific Coast; Pacific time zone.

Your attention in this matter is sincerely appreciated.

Very Respectfully, Kandy Hunter

Kandace Hunter

Supply System Data Specialist | Technology Services Support

Supply Chain Services | Bonneville Power Administration

Vendor Mtc. Team Phone: 360-418-2800; leave message

Calls returned same day or next business day

Emails: klbarritt@bpa.gov | vendormaintenance@bpa.gov

From: David Welch

Sent: Wed Mar 10 19:49:25 2021

To: Vendor MTC Team

Subject: [EXTERNAL] RE: Inquiry: from Bonneville Power Administration (BPA) | RE: 2020 Kintama Research Services LTD - Contract 81498 | Invoice # 2020-03

Importance: Normal

Thanks, Kandy-

That's odd—the toll-free number should go through direct to my cell. I just tried it and got my voicemail message, but my cell didn't ring.

Thanks for the heads up—I will try to get message notification turned back on.

Stay safe and take care yourself!

David

From: Vendor MTC Team <vendormaintenance@bpa.gov>
Sent: March 10, 2021 7:29 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov>; Eisenach,Greg A (BPA) - NSTS-4400-LL <gaeisenach@bpa.gov>; Vendor MTC Team <vendormaintenance@bpa.gov>
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Kandace Hunter

Supply System Data Specialist | Technology Services Support

Supply Chain Services | Bonneville Power Administration

Vendor Mtc. Team Phone: 360-418-2800; leave message

Calls returned same day or next business day

Emails: klbarritt@bpa.gov | vendormaintenance@bpa.gov

From: David Welch

Sent: Wed Mar 17 10:40:12 2021

To: Andrew_earl@crapo.senate.gov; Andrew.neill@mail.house.gov; Bryson_Wong@Risch.senate.gov; huck@mail.house.gov; Megan.McKibben@mail.house.gov; Jennifer.cash@mail.house.gov; Jordan.Evich@mail.house.gov; Katie.r.allen@mail.house.gov; Kris.pratt@mail.house.gov; Lindsay.slater@mail.house.gov; Malcolm_mcgeary@wyden.senate.gov; Megan_thompson@cantwell.senate.gov; Michael.Taggart@mail.house.gov; Seanv.obrien@mail.house.gov; jallen@nwcouncil.org; jyost@nwcouncil.org; dgrob@nwcouncil.org; bdownen@nwcouncil.org; rdevlin@nwcouncil.org; gnorman@nwcouncil.org; poshie@nwcouncil.org; emerrill@nwcouncil.org

Cc: William.Tweit@dfw.wa.gov; tucker.a.jones@state.or.us; chpetersen@bpa.gov; bdzelinsky@bpa.gov; jcsweet@bpa.gov; gill@psc.org; jonathan.carey@noaa.gov; kcmehaffey@newsdata.com; billcrampton@bendcable.com; rbarker@idahostatesman.com; kurt@nwriverpartners.org; jmurauskas@fourpeaksenv.com; jclee@usbr.gov; mdixon@usbr.gov; redfish@bluefish.org; craigmedred@gmail.com; mdehart@fpc.org; adam.j.storch@state.or.us; Erick.S.VanDyke@coho2.dfw.state.or.us; lort@critfc.org; lotr@critfc.org; LESR@critfc.org; GOLC@critfc.org; ED.Bowles@state.or.us; lance.hebdon@idfg.idaho.gov; tim.copeland@idfg.idaho.gov; Daniel.Rawding@dfw.wa.gov; tweitwmt@dfw.wa.gov; Michael.Garrity@dfw.wa.gov; Steve_Haeseker@fws.gov; david_swank@fws.gov; ritche.graves@noaa.gov; brian.burke@noaa.gov; jayh@nezperce.org; zpenney@critfc.org; jmccann@fpc.org; bchockley@fpc.org; ecooper@fpc.org; gscheer@fpc.org; bobbyhsu@fpc.org; scott@s4s.com; steve@idahoforwildlife.com; stanley.gregory@oregonstate.edu; aileen.lee@moore.org; ausubel@mail.rockefeller.edu; knordt@gcpud.org; c.walters@oceans.ubc.ca; Erin Rechisky; Aswea Porter; rayh@u.washington.edu

Subject: [EXTERNAL] The Recent Letter by 68 Salmon Scientists on Snake River Dam Removal is Wrong.

Importance: Normal

Attachments: Welch Letter to the Governors & Legislators (17 March 2021).pdf

Dear Northwest Governors, Members of the PNW US Senate & Congress, & Policymakers-

I am writing to contradict a recent letter signed by 68 scientists claiming that Snake River dam removal is required "*to protect and restore abundant salmon and steelhead runs to the Snake/Columbia River Basin*" (22 February, 2021).

Their claims are fundamentally wrong. Their proposal to remove the 4 Snake River dams will in fact have almost negligible impact on improving Snake River salmon survival, for the reasons outlined in the attached letter.

I do not take the step of contradicting my colleagues lightly as I respect the past contributions of a number of the signatories. However, if not countered their claims will continue to place the blame on the wrong issues and fail to allow the Pacific Northwest to have a balanced debate about whether it is even possible to restore Snake River salmon populations. In my letter I articulate some basic scientific reasons why salmon recovery is impossible even if **all eight federal dams** were to be removed.

I urge you as the regional policy makers to carefully consider the major contribution the dams also make as the regional backbone to a reliable source of clean, CO2-free power. Removing the dams will work against the need to modernize energy systems while hardly changing Snake River salmon survival.

Sincerely,

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has recently been published.

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http://kintama.com/publications/secondary-publications/

Technology that Provides Answers

Kintama Research Services Ltd
755 Terminal Avenue
Nanaimo, B.C.
Canada V9S 4K1
M: (b)(6) [redacted]

17 March 2021

Subject: 68 Scientists' letter on the need for lower Snake River dam removal is wrong

TO: Northwest Governors, Members of the US Senate & Congress, Policymakers

I am writing to refute the recent letter signed by 68 scientists stating that Snake River dam removal is required "*to protect and restore abundant salmon and steelhead runs to the Snake/Columbia River Basin*" (22 February, 2021).

Only one of their four claims is correct, namely that "*The actions set forth in the 2020 Federal Environmental Impact Statement (EIS) and Biological Opinion (BiOp) are insufficient and will not reverse salmon declines*". However, my colleagues' call to remove the Snake River dams will not work. It is mathematically impossible for removing the four Snake River dams to materially change salmon survival levels and it is long past time to make this clear to decision makers. Their letter also misrepresents the state of salmon runs in most other regions of the West Coast, which have similar conservation issues. In short, their three conclusions concerning removal of the Snake River dams as a fix for the salmon problems are just plain wrong.

Let me explain.

Snake River Spring Chinook and steelhead currently have a greater than 96% survival rate per dam[i]. These survival levels are the result of major efforts taken by the action agencies and are substantially greater than in the early 1970s when the dams were constructed. They are also roughly on par with survival rates reported from other regions without dams[ii]. As my 68 colleagues correctly informed you, current adult survival levels (SARs) are inadequate to restore Snake River salmon populations to abundance. However, removing the dams will not change this, because the failure of salmon to recover is because of poor ocean survival. Removing the Snake River dams won't fix this.

What the Group of 68 have not said is that it is impossible to achieve the target of 2-6% SARs by making further changes in freshwater. This should have been stated years ago.

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[i] Skalski et al (2016). Status after 5 Years of Survival Compliance Testing in the Federal Columbia River Power System (FCRPS). N. Amer. J. Fisheries Management, 36(4), 720-730. doi:10.1080/02755947.2016.1165775

[ii] Welch, D. W., Porter, A. D., & Rechisky, E. L. (2021). A Synthesis of the Coast-wide Decline in Survival of West Coast Chinook Salmon. Fish & Fisheries, 22(1):194-211. doi:10.1111/FAF.12514

Consider a simple thought experiment. If you remove all four Lower Snake River dams as requested, it is simple to calculate that SARs will increase from 1.1% to only 1.3%--a barely measurable increase[iii] compared with the needed 4%.

My colleagues, undaunted, will then simply declare that they are still right, but it will require even more heroic efforts to achieve the goals… obviously, the four Columbia mainstem dams must now go as well; surely, taking out the four lower Columbia dams will fix the problem as claimed?

Eight dams are now gone. SARs increased from 1.1% to 1.3% to (now) 1.5%... not even close to the long-promised 4% needed for recovery[iv]. This is the stark mathematical reality that they ignore.

Much of the mortality in the FCRPS is actually due to predators feeding on salmon smolts in the regions between dams, not the dams. Suppose you as the regional decision makers also institute an unprecedented extermination program, wiping out all bird and fish predators and all disease-causing agents contributing to smolt mortality. In effect, you sterilize the river. Average historical smolt survival for the entire 8 dam FCRPS is 53%[v], so eliminating all causes of smolt deaths (8 dams + all predators) moves the SAR from 1.1% to 2.1%—the very lower limit of current recovery targets— but will require major extermination programs that are legally and ethically fraught.

In reality, SARs will hardly budge if you follow my colleagues' plan. Despite their earnest letter, taking out the four Snake River dams won't even come close to achieving what is needed.

Why so little change? My esteemed colleagues will probably assure you that the mysterious "delayed mortality" due to accumulated stresses from the dams will also vanish because the dams are gone, so my simple calculations are too pessimistic. (And they certainly won't mention those extermination programs). However, also unmentioned in their letter, the claims for delayed mortality vanish when broader data sets are considered, which until our recent paper was published[ii] had never been discussed. Evidence for delayed mortality also disappears when adjusting for juvenile salmon size, according to a 2019 NOAA Fisheries study[vi].

The Group of 68's letter simply does not mention the extensive contradictory data because it does not fit with their beliefs. However, a simple calculation shows what level of delayed mortality must be occurring to achieve the 4% recovery target. To get from 2.1% SARs (remember, all dams must be removed and all predators exterminated to achieve this) to 4%, fully 47.5%--***half*** of all Snake River smolts passing Bonneville Dam—must be dying from "delayed mortality"

[iii] Moving from 96% per-project survival to 100% would increase the SAR by a factor of (1/0.96) per dam. This would increase the SAR from 1.1% to 1.1% x $(0.96)^{-4}$=1.3% if all 4 Snake River dams were removed.

[iv] The math is equivalent for removing 8 dams and yields 1.1% x $(0.96)^{-8}$=1.5%. Haeseker (2012) reports slightly lower average historical smolt survival for the entire 8 dam FCRPS of 53%, so eliminating all smolt deaths would move the SAR from 1.1% to 1.1÷0.53=2.1%. This is an overestimate of the gain because it ignores the benefits from more recent improvements in smolt passage. It also requires extermination programs for the entire FCRPS.

[v] Average SAR values from Haeseker et al. (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

[vi] Faulkner *et al* (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

caused by those dams. If we "just" take out the 4 Snake River dams, the current demand, ***two-thirds*** of all Snake River smolts passing Bonneville must be dying because of the stress of passing those dams[vii]. This is totally unrealistic.

The ISAB is preparing an evaluation of our published study[ii], so their assessment should be available soon. Unless the ISAB contradict the findings in our paper and conclude that there is real evidence for delayed mortality, the best the region can expect is to get to the lower end of the range (2%)—but only with the help of those major extermination programs that the Group of 68 do not mention. The salmon recovery promised in their letter is impossible, ignores the basic mathematics of the situation, and relies on their personal beliefs instead of the facts.

It gets worse. The Group of 68 go on to note in their letter, *"…the four dams must be removed to not only avoid extinction, but also to restore abundant salmon runs and to achieve the region-wide goals"*. Missing from their confident assertions is any caution about the parlous state of salmon in other river systems. In British Columbia's Fraser River, the largest undammed river on the West Coast, Chinook, sockeye, and steelhead are all in catastrophic decline. For Chinook, only 2 of 15 Fraser populations received "green" status; 11 were assigned a Red status ("…*a conservation unit being considered at risk of extinction*"), one was assigned a Red/Amber status, and one was assigned Amber[viii]. For sockeye, the situation is similar, with the lowest adult returns in over a century occurring in 2019[ix]. None of my colleagues in either the US or Canada can tell you why only two Fraser Chinook and one Fraser sockeye population are doing well when all the other populations are doing extremely poorly, but it clearly can't be because of differences in the number of dams they migrate past, because there are none. Dams certainly aren't the reason the vast majority of Chinook and sockeye populations are in deep trouble. So why should you conclude that the dams are the culprit for the Snake River? Chinook populations in a much broader range of West Coast river systems are in serious trouble[ii], and the Group of 68's arguments clearly won't fix the problems in these other river systems.

For Fraser River steelhead, the situation is even worse: both the Chilcotin and Thompson River populations have tumbled to catastrophically low population numbers over the past few decades, despite having an abundance of pristine habitat and no dams to migrate past[x]. Steelhead in both

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[vii] To see this, consider what fraction of Snake River smolts passing Bonneville Dam must be dying because of the delayed effect of dam passage. Call this proportion *x*. To get from a 2.1% SAR to the target 4% SAR by "fixing" the claimed delayed mortality, the equation is $4\% = \frac{2.1\%}{(1-x)}$. Solving for *x* gives *x*=47.5% (half of all smolts must die due to delayed mortality from the dams). If you remove only the 4 Snake River dams so the SAR rises to 1.3%, the calculation yields 67.5%; two-thirds of all smolts passing Bonneville must die due to these claimed delayed effects. In short, both values are ludicrous, because they require the "delayed" effects in the ocean of the Snake River dams to be as great or greater than direct deaths from all causes occurring in the entire 8-dam FCRPS.

[viii] CSAS (2016). Integrated Biological Status of Southern British Columbia Chinook Salmon Under The Wild Salmon Policy, Canadian Science Advisory Secretariat, Pacific Region Science Advisory Report. 2016/042: 15. http://waves-vagues.dfo-mpo.gc.ca/Library/40595419.pdf

[ix] MacDonald *et al.* (2020). State of the Salmon: Informing the survival of Fraser Sockeye returning in 2020 through life cycle observations, Dept. of Fisheries & Oceans, Government of Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 3398: 76 pp. https://waves-vagues.dfo-mpo.gc.ca/Library/4088546x.pdf

[x] The Chilcotin River is pristine and has freshwater habitat conditions most regions can only dream of. The 2020 population estimate is 38 adult steelhead. For the Thompson River, the estimate is 257 adults. R. Bison, Province of B.C.; personal communication. robert.bison@gov.bc.ca

Fraser River tributaries are requested for emergency listing[xi]. Why, if the Group of 68 are correct and it is the Snake River dams blocking "*the gateway to high quality, resilient spawning habitat*" do we see such catastrophic conditions in these major tributaries of the undammed Fraser River? Why should the reduced marine survival thought to be impeding recovery of Fraser stocks not also apply to the Snake River? Similarly, why should the similar reported SARs of Puget Sound Chinook[xii] and steelhead[ii,xiii,xiv] not also tell us that removing the Snake River dams (and all those predatory populations of birds and fish) cannot possibly be a major factor in the current situation?

The reality is that Chinook populations are in trouble all the way up to the Yukon River in Alaska—despite the pristine freshwater habitat in northern areas that my colleagues are convinced will turn around the fate of Snake River populations if the dams are just removed. They have no explanation for why such problems occur elsewhere, so they simply ignore them.

Early on in our training, the principle of Occam's Razor teaches junior scientists to look for the simplest explanation. Yet too often in salmon conservation this principle is abandoned in favor of complex river-specific narratives that deliberately ignore the parallel declines in salmon abundance in other river systems. In our recent publication we found that rivers without dams or even those with truly pristine freshwater habitat values are suffering the same decline in survival as the Snake River[ii]. Perhaps the most remarkable point is that the generations of salmon biologists running these monitoring programs have not pointed this out. Predictably, the Fish Passage Center labeled our work as incompetent, without ever providing an explanation for why the different agencies performing salmon monitoring work along the West Coast should converge on similar survival values. The Group of 68 in their letter to you also chose to omit any mention of the remarkable similarity in SAR levels that all these agencies are now measuring. The reason is obvious—it doesn't fit with their preconceived ideas.

A Way Forward

The Northwest salmon debate is hardly unique in its shift from science to advocacy. Scientists are people, subject to emotion and opinions. However, to provide true value to society salmon science needs to go back to the basics. Partly this means using the simple calculations I outline to show that the basic claims made are mathematically impossible. However, it also means using the scientific method to rigorously test claims that are still within the realm of possibility. If one has a theory—for example, delayed mortality—then rigorous scientific testing is needed to prove it exists. Mere observation of patterns or correlations, such as better survival of some populations, is not proof of a cause-and-effect relationship and ***always*** need to be rigorously tested—the stakes are simply too high for the region to rely on belief. In fact, willingness to rely on "expert opinion" rather than rigorous hypothesis testing led to the current impasse, where biologists

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xi Neilson, J., & Taylor, E. (2018). *Emergency assessments of the Steelhead Trout (Oncorhynchus mykiss): Thompson River and Chilcotin River populations (2018).* Government of Canada, Ministry of Environment and Climate Change Retrieved from https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/special-reports.html

xii Sobocinski et al. (2021). A hypothesis-driven statistical approach for identifying ecosystem indicators of coho and Chinook salmon marine survival. Ecological Indicators, 124. doi:10.1016/j.ecolind.2021.107403

xiii Welch et al. (2018). The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or deeper failure? *BioRXiv*, 476408. https://www.biorxiv.org/content/10.1101/476408v1.abstract

xiv Sobocinski et al. (2020). Ecosystem indicators of marine survival in Puget Sound steelhead trout. Progress in Oceanography, 188, 102419. doi:10.1016/j.pocean.2020.102419 blindly call for evermore efforts in freshwater in the hope that they can somehow compensate for poor marine survival. The belated recognition that many of these past analyses even failed to account for changes in salmon harvest[ii] should be seen as a warning flag that all is not well in salmon science.

A conspicuous element of the Snake River debate surrounds how studies contradicting cherished beliefs are dismissed by opponents as "unrepresentative" without ever showing the claim is actually true. Unfortunately, such claims are commonplace in the Columbia Basin and make your job as policy makers more difficult. Many of the recent claims that analyses contradicting long-held dogma are "unrepresentative" are in fact directly testable using explicit scientific experiments—but currently aren't. These claims need to be tested or the region risks being held hostage by theoretical possibilities rather than proven problems.

Global Warming, Climate Change, and the Future of PNW Salmon

As the four PNW States debate what to do about salmon and the recent call by the Group of 68 to remove the dams, please bear in mind that salmon are not the only resource at risk; so too are hydropower dams as incredibly valuable sources of clean, CO_2-free power.

Dams kill small numbers of salmon in their operations, although much of what is attributed the dams is actually due to salmon predators, and smolt survival in other rivers without dams seems broadly similar[xv,xvi]. A recent paper by NOAA scientists explicitly identifies the ocean as the main cause of future decreased survival due to global warming[xvii]. A UN analysis of plans from 74 countries, accounting for a third of global CO_2 emissions, found those nations' emissions would be reduced by only 0.5% by 2030, compared with 2010 levels[xviii]. However, the Intergovernmental Panel on Climate Change reports that global emissions must fall by about 45% by 2030 to stand a chance of staying below 1.5°C[xix]. The gap is huge.

You and your advisors must balance the direct impacts of hydropower on salmon mortality with the broader goals of identifying a path to a low carbon future. Measured direct impacts of the dams on salmon are now trivial. It is time to say this and recognize that past efforts to correct passage problems have achieved this.

Renewing Salmon Science

The disputes surrounding Snake River salmon now center on differences of opinion as to the underlying causes. Opinion should really count for little. You, as decision makers, should demand

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[xv] Welch et al. (2008). Survival of Migrating Salmon Smolts in Large Rivers With and Without Dams. *PLoS Biology, 6*(10), 2101-2108. doi:10.1371/journal.pbio.0060265

[xvi] See Fig. 2. of Welch et al. (2018). The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow-moving catastrophe or deeper failure? BioRXiv, 476408. https://www.biorxiv.org/content/10.1101/476408v1.abstract

[xvii] Crozier, L. G., Burke, B. J., Chasco, B. E., Widener, D. L., & Zabel, R. W. (2021). Climate change threatens Chinook salmon throughout their life cycle. Communications Biology, 4(1), 222. doi:10.1038/s42003-021-01734-w

[xviii] https://www.newscientist.com/article/2269432-we-are-nowhere-near-keeping-warming-below-1-5c-despite-climate-plans/#ixzz6nsnkmYkf

[xix] https://www.ipcc.ch/sr15/chapter/spm/

a higher standard than simply expressions of professional opinion—there is far too much we do not know about the ocean life of salmon to rely on opinion, no matter how educated or sincere the individuals. Biomedical science recently emerged from a similar malaise with the recognition that much of their scientific literature was deeply flawed because of psychological issues surrounding interpretation of data[xx]. The solution in medicine was to ***insist on rigorous double blinded experimental testing of key issues***—not selective interpretation of data supporting a particular viewpoint—coupled with pre-publication of the study plan to avoid cherry picking of the data supporting a particular view. The importance and value of regional hydropower means that you should insist on the same standards for scientific advice you receive.

Difficult Days Ahead

The Pacific Northwest needs to prepare for a much warmer world where salmon populations will likely be reduced to vestigial remnants and, quite probably, regional extinctions. There is much to do. Ignoring this possibility will make the political and legal problems much worse as the climate warms further.

NOAA's recently released study showing massive negative impacts on Snake River salmon from future ocean warming should be a warning bell[xvii]; if future ocean survival should drop as predicted, is it really even advisable to be moving salmon to the ocean more quickly? The Group of 68 are silent on why accelerating salmon to the ocean by dam breaching is even wise, let alone whether it can actually compensate for further reductions in marine survival... and if it cannot, why do it? This question is pertinent because the benefits from decreasing spill at hydropower dams means more carbon-free energy and more flexibility in using the dams to aid in the transition to greater use of wind and solar.

Summary

Your advisors will have told you that relying solely on intermittent power resources (wind, solar) without secure sources of reliable power will likely require three times the capital expenditure otherwise required[xxi]. The required sums are enormous. The Pacific Northwest is fortunate that hydropower dams provide that backstop capacity. The recent calamity in Texas demonstrates the consequences of disrupting reliable sources of power as the climate changes.

I am not an expert on the US power grid. However, I am an expert on the biology of Pacific salmon. I have watched with dismay over three decades as fisheries agencies in both the U.S. and Canada preferentially expanded freshwater monitoring programs that are in reality simply documenting massive decreases in ocean survival without giving much insight into what is going wrong in the ocean. The reasons for this preference for freshwater over marine work are complex and deserving of careful sociological study. However, the end result has left the Pacific northwest exposed to likely catastrophic further declines in Pacific salmon returns caused by poor survival at sea as the oceans warm, with little capability to distinguish between real and imagined impacts of the dams.

[xx] Horton, R. (2015). Offline: What is medicine's 5 sigma? Lancet, 385(9976), 1380. doi:10.1016/S0140-6736(15)60696-1

[xxi] Sepulveda, et. al. (2018). The role of firm low-carbon electricity resources in deep decarbonization of power generation. *Joule, 2*(11), 2403-2420. doi:10.1016/j.joule.2018.08.006

You, as decision makers, have a difficult task—that of balancing competing risks. Snake River salmon are in trouble and there are legal obligations to protect them. The Columbia River Basin dams also need protecting, as sources of reliable CO_2-free power crucial in the pivot away from fossil fuels, which helps slow down climate change—which helps salmon. Operating the dams kills some salmon and brings some gains. My professional advice to you is to balance the risks and rewards but recognize that the claims of my 68 colleagues are impossible.

Regional salmon coordination bodies with complex working groups cannot replace an actual understanding of what is occurring in the ocean. Consider that scientists cannot even tell you with confidence that flushing salmon smolts into the ocean faster will result in smolts having better survival than in the river. That this is not known despite many of my colleagues calling for dam removal to speed smolts into the ocean faster should give you pause— they assume that this it is a good thing without knowing it is true. As so often the case with science, it is the hidden assumptions that can be the fatal flaw in the argument.

I urge you to not get stampeded by panicked calls to do ever-more of what hasn't worked well in the past. The basic mathematics make no sense, even if the objectives are laudable. There may be a need for triage with Snake River salmon —past multi-billion dollar investments have not appreciably changed their SARs compared to other regions along the west coast, so further efforts are unlikely to be more successful.

In closing, there is ample reason to question the diagnosis presented by my 68 colleagues. As the regional decision makers, I urge you to ask your own experts two hard questions: (1) Are the (very) simple mathematical calculations I laid out correct? and (2) Why were the basic issues I raise not acknowledged decades ago rather than simply continuing to focus on the dams as the problem? It is clearly time to develop a more flexible and thoughtful approach to the coming climate changes.

Sincerely,

David Warren Welch, Ph.D. (just one).
President, Kintama Research Services, Ltd.
755 Terminal Ave N, Nanaimo BC, Canada V9S 4K1
Mobile: (250) 739-9044
david.welch@kintama.com

Welch's awards and past involvement in identifying the role of ocean climate change on Pacific salmon can be viewed here: http://kintama.com/about-kintama/leadership-team/

Distribution:

Pacific NW Governors Inslee (WA), Brown (OR), Little (ID), & Gianforte (MT)

NW Congressional Delegation

Northwest Power & Conservation Council Members & Staff

From: David Welch

Sent: Tue Mar 30 13:23:30 2021

To: Renner,Marcella P (BPA) - E-4

Subject: [EXTERNAL] David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72349318838?pwd=OTJ4cnNQeHBySjFIVlJtVkJ1VVVvUT09

Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: David Welch

Sent: Tue Mar 30 13:23:30 2021

To: Ben Zelinsky

Subject: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

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Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: Pisces

Sent: Thu Apr 01 14:14:21 2021

To: Pisces

Subject: Pisces Web Release Tonight

Importance: Normal

Good afternoon Pisces Users,

Shortly after 5 PM today, we plan to release an upgrade to Pisces Web. Please be sure you have completed your work and are logged out prior to then. The systems should be back online by 6pm – we will reach out if anything changes. While we make every effort to release the upgrades on time, there is always the potential to find issues during our final testing that require us to postpone the release.

April will be the last month you will be able to access the old dashboard format. Do you know where to get help if you can't figure out how to use the new dashboard?

· Online help in CBFish can be found at:

- o Dropdown **Help** on **Dashboard** page (**Helpà** How Do I?)
- o Help Center (**Helpà Help Center**: on Contents list see Dashboard, or use search box)
- o **Program Documents (Helpà EF&W Program Documentsà** New Customizable Dashboard)

- Email Support regarding process questions or problems to support@cbfish.org
- Email suggestions or ideas for changes to pisces@bpa.gov

In rare cases, Fiscal Year filters set up for the old dashboard contracts grid are not properly carrying over to the new dashboard. We have a fix on the way, but you should check your new dashboard contract widget Fiscal Year filters.

The following is a list of updates that will be included in the release:

- Prepare users for cutoff of old dashboard
- Simplify RM&E Metadata selection by allowing direct picking of a Sample Design
- Add a sortable "Organization Type" column to People grid and change "Contractor Type" to Organization Type
- Set order for Contract search result

Important bug fixes include:

- Limit EXPLORE > Budget Change Requests option and related pages to BPA users only
- Grid width may increase exponentially when resizing columns
- "Contracts Flagged For Renewal Alert" logic is not correct

- Transmittal Memo form does not unlock previously selected document as expected

For a full list of upgrades from this release or others, please visit the Release Notes at CBFish.org.

Many of these upgrades are a result of input from users like you. If you would like to be contacted by a developer to share your thoughts and concerns about your experience with Pisces Web, please contact the Pisces team at pisces@bpa.gov

As always…

- For system access or bugs in Pisces Web – email support@cbfish.org
- For questions about any changes or to provide feedback on new functionality in Pisces Web – email pisces@bpa.gov

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all Pisces users.

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 02 11:03:15 2021

To: David Welch

Subject: RE: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

Hello David – I'm on but it says the meeting hasn't started

-----Original Appointment-----
From: David Welch <David.Welch@Kintama.com>
Sent: Tuesday, March 30, 2021 1:24 PM
To: David Welch; Zelinsky,Benjamin D (BPA) - E-4
Subject: David Welch's Zoom Meeting-Support for "IDFG" Revision
When: Friday, April 2, 2021 11:00 AM-11:30 AM (UTC-08:00) Pacific Time (US & Canada).
Where: https://us04web.zoom.us/j/72349318838?pwd=OTJ4cnNQeHBySjFIVlJtVkJ1VVVvUT09

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72349318838?pwd=OTJ4cnNQeHBySjFIVlJtVkJ1VVVvUT09

Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: David Welch

Sent: Fri Apr 02 15:55:14 2021

To: Zelinsky,Benjamin D (BPA) - E-4

Subject: [EXTERNAL] Re: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

Hi Ben

[redacted]. If it still works, I can talk today or at pretty much anytime next week.

David

David Welch, Kintama Research
Tel: [redacted]

On Apr 2, 2021, at 11:03, Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov> wrote:

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From: David Welch <David.Welch@Kintama.com>
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Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 02 16:13:39 2021

To: David Welch

Subject: RE: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

Hey David – no worries

[redacted] Any openings next Friday after 11?

From: David Welch <David.Welch@Kintama.com>
Sent: Friday, April 2, 2021 3:55 PM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] Re: David Welch's Zoom Meeting-Support for "IDFG" Revision

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David

David Welch, Kintama Research

Tel: [redacted]

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Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: David Welch

Sent: Fri Apr 02 16:20:37 2021

To: Zelinsky,Benjamin D (BPA) - E-4

Subject: [EXTERNAL] Re: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

Next Friday should work. When I get back to my laptop I will send you an invite for later in the afternoon... I need to check on something timewise before I can suggest a particular time.

[redacted]

Hope all is well with you guys,

David

David Welch, Kintama Research
Tel: +[redacted]

On Apr 2, 2021, at 16:13, Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov> wrote:

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Meeting ID: 723 4931 8838

Passcode: PV1cL7

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 02 16:20:48 2021

To: David Welch

Subject: Automatic reply: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

I will be out of the office until 4/8/21. If you need assistance while I am out, please contact Marcella Renner at (503) 230-5136.

From: David Welch

Sent: Mon Apr 05 12:04:23 2021

To: Renner,Marcella P (BPA) - E-4

Subject: [EXTERNAL] David Welch's Zoom Meeting

Importance: Normal

Trying again on this—apologies for the screw up last Friday.

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

From: David Welch

Sent: Mon Apr 05 12:04:23 2021

To: Ben Zelinsky

Subject: David Welch's Zoom Meeting

Importance: Normal

Trying again on this—apologies for the screw up last Friday.

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

DOE F 4220.10
(01-99) Previous editions are obsolete

U.S. DEPARTMENT OF ENERGY

Office of Congressional and Intergovernmental Affairs (CI)

CONGRESSIONAL GRANT/CONTRACT NOTIFICATION

TO: Office of Congressional & Intergovernmental Affairs
ATTN: Contract Notification Coordinator (CI-40)
U.S. Department of Energy
1000 Independence Avenue, SW Room 8G-070
Washington, D.C. 20585

Telephone: 202-586-2764
Fax: 202-586-5497

1. Informing Office: BONNEVILLE POWER ADMINISTRATION
Name: KRISTI VAN LEUVEN
(Contracting Office Representative)
Telephone: (503)230-3605

2. Program Office/Project Office:
Name: BARBARA SHIELDS
Telephone: (503)230-4748

3. Contractor, Grantee or Offeror:
Name: Kintama Research Inc
Street: 10-1850 Northfield Road
City: Nanaimo State BC Zip V9S3B3

4. Place of Performance: *(Required if different from #3)*
Street:
City: State Zip

5. Proposed Date of Award: 3/1/2011

Date of Public Announcement: *(If any)*

6. Contract, Grant, or Other Agreement No.:
Contract 52170
(Specify Type of Instrument)
☒ New ☐ Renewal
☐ Modification (Total to date: $)
Does this award result from an Information For Bid?
☐ Yes ☒ No

7. Obligated Cost or Price of this Action: $2,142,086
Estimate Cost or Price of Total Contract: $
Recipient Cost Sharing *(If applicable)*: $
(For incrementally funded contracts only. Report the initial obligation and total estimated contract value.)

8. Duration of Contract, Grant, or Other Agreement:
From: 12/1/2010 To: 11/30/2011

9. Brief Description. *(Please use non-technical/plain English language/no acronyms.)*

This is a continuation of research work that has been on-going since 2003 to track the movement and survival of salmon in the Pacific Ocean. The contractor has developed an acoustic telemetry array technology to directly estimate estuarine and early marine survival of juvenile Columbia River spring chinook salmon. The work to be completed in 2011 includes tagging a broad range of smolts at the Bonneville Dam, operating an accoustical array in the lower estuary, an additional array at the Oregon coast and extending all current ocean arrays to approximatley 500m depth.

TO BE COMPLETED BY OFFICIAL RESPONSIBLE FOR SUBMISSION

10. Method of Submission: ☒ Mail ☐ Fax ☐ Hand Carry
Date: 2/17/2011 Time: 1:30 ☐ A.M. ☒ P.M.

Name: KRISTI VAN LEUVEN
Title: CONTRACTING OFFICER

Signature: [redacted] (b)(6)
Office: BONNEVILLE POWER ADMINISTRATION

Electronic Form Approved by CILR 09/19/2001

H:\kintama customs ltr 32081.doc

Pdf.msg

Department of Energy
Bonneville Power Administration
ATTN: Pat O'Donnell, TLOS-4
P.O. Box 3621
Portland, Oregon 97208-3621

March 23, 2007

U.S. Customs & Immigration Service
Canada

To Whom It May Concern:

Subject: Canadian Contractor Working on U.S.DOE Contract

This letter is a request for consideration in the matter of border crossings of Kintama Research Corp. in the performance of Contract No. 00032081, Prj 200311400 Acoustic Tracking Study – Survival Columbia River Salmon, a copy of which will be shown by Kintama on request. The contract performance period is 1-15-76 /11-30-07.

The contract work will be placing experimental equipment in both US and Canadian waters that will track the movements of US salmon up into Canada. This work is being undertaken as part of a large collaborative international research project between Canadian and US researchers, and the project has been reviewed and signed off in the US by American research scientists. At the end of the project, all equipment will be brought back to Canada.

If you need additional descriptions of work being performed, please refer to the statement of work in the contract.

If you have any questions, please email me at paodonnell@bpa.gov or call me at (503) 230-4747.

Thank you for your time and attention to this matter.

Sincerely,

Patricia O'Donnell
Contracting Officer
Shared Services Purchasing

Enclosures

From: Hughes,Theresa C - NSSP-4

Sent: Fri Mar 23 15:57:18 2007

To: O'Donnell,Patricia A - NSSP-4

Subject: Pdf

Importance: High

Attachments: Congressional Affairs Notification.pdf

Theresa C. Hughes
Contracting Officer
Bonneville Power Administration
P.O. Box 3621, Portland, OR 97208
(503) 230-5341 Fax: (503) 230-4508
Email: tchughes@bpa.gov

DOE F 4220.10
(01-99) Previous editions are obsolete.

U.S. DEPARTMENT OF ENERGY

Office of Congressional and Intergovernmental Affairs (CI)

CONGRESSIONAL GRANT/CONTRACT NOTIFICATION

TO: Office of Congressional & Intergovernmental Affairs
ATTN: Contract Notification Coordinator (CI-40)
U.S. Department of Energy
1000 Independence Avenue, SW Room 8G-070
Washington, D.C. 20585

Telephone: 202-586-2764
Fax: 202-586-5497

1. Informing Office: BPA, Portland, OR
Name: Pat O'Donnell
(Contracting Office Representative)
Telephone: (503)230-4747

2. Program Office/Project Office:
Name: Ben Zelinsky
Telephone: (503)230-4737

3. Contractor, Grantee or Offeror:
Name: Kintama Research
Street: 4737 Vista View Crescent
City: Nanaimo State BC Zip V9V !N8

4. Place of Performance: *(Required if different from #3)*
Street:
City: State Zip

5. Proposed Date of Award: 3-27-07

Date of Public Announcement: -
(If any)

6. Contract, Grant, or Other Agreement No.:
Contract 00032081
(Specify Type of Instrument)
☒ New ☐ Renewal
☐ Modification (Total to date: $)
Does this award result from an Information For Bid?
☐ Yes ☒ No

7. Obligated Cost or Price of this Action: $1,197,940
Estimate Cost or Price of Total Contract: $
Recipient Cost Sharing *(If applicable)*: $

(For incrementally funded contracts only. Report the initial obligation and total estimated contract value.)

8. Duration of Contract, Grant, or Other Agreement:
From: 1-15-07 To: 11-30-07

9. Brief Description. *(Please use non-technical/plain English language/no acronyms.)*

Altho listed and nemed as a corporation, this firm operates like a non-profit organization with most of their funding coming from various organizations around the world in the form of grants. Kintama is building an ocean tracking array and establishing the relavance of this tool for addressing important resource mgmt issues. One important goal is to assess early marine survival and ocean movements for Columbia River salmon stocks, and whether low survival rates are really attributable to the operation of the hydrosystem or due to ocean climate change.

TO BE COMPLETED BY OFFICIAL RESPONSIBLE FOR SUBMISSION

10. Method of Submission: ☐ Mail ☐ Fax ☐ Hand Carry
Date: Time: ☐ A.M. ☐ P.M.

Name:
Title: Contract Specialist

Signature: Pat O'Donnell
Office:

Electronic Form Approved by CILR- 09/19/2001

BPA-2021-00513-F 6978

BONNEVILLE
POWER ADMINISTRATION

GRANT

Mail Invoice To:

Program Analyst - KEWB-4
Bonneville Power Admin. - PBL
P. O. Box 3621
Portland OR 97208-3621

Contract : 00027193
Release :
Page : 1

Vendor:
KINTAMA RESEARCH
4737 VISTA VIEW CRESCENT
NANAIMO BC V9V 1N8

Please Direct Inquiries to:

PATRICIA A. O'DONNELL
Title: CONTRACT SPECIALIST
Phone: 503-230-4747
Fax : 503-230-4508

Attn: DAVID W WELCH

Contract Title: 2003-114-00 ACOUSTIC TRACKING FOR SURVIVAL AND MOVEMENT

Total Value : $1,497,416.00
Pricing Method: COST, NO FEE
Performance Period: 03/15/06 - 10/31/06

** NOT TO EXCEED **
Payment Terms: % Days Net 30

Contractor Signature

Printed Name/Title

Date Signed

(b)(6) [redacted]

4-13-06
Date Signed

Clause 4-1 REGULATIONS APPLICABLE TO BPA FINANCIAL ASSISTANCE (BFAI 4.10) (Sep 04)

The Bonneville Power Administration's financial assistance function is managed and executed solely in accordance with the Bonneville Financial Assistance Instructions (BFAI). The BFAI is available without charge on the Internet at http://www/bpa.gov. Copies of the BFAI may be obtained for $15.00 each. Requests and comments should be sent to Head of the Contracting Activity - CK, Bonneville Power Administration, P.O. Box 3621, Portland, OR 97208. Subscriptions are not available.

(End of Clause)

Clause 4-2 NONDISCRIMINATION IN FEDERALLY ASSISTED PROGRAMS (BFAI 4.10) (Sep 04)

The recipient shall comply with 10 CFR Chapter II, Section 600.39 which provides that "...no person shall on the ground of race, color, national origin, sex, handicap, or age be excluded from participation in, be denied the benefits of, be subjected to discrimination under, or be denied employment, where the main purpose of the program or activity is to provide employment or when the delivery of program services is affected by the recipient's employment practices, in connection with any program or activity receiving Federal assistance from ..." BPA.

(End of Clause)

Clause 4-3 EXAMINATION OF RECORDS (BFAI 4.10) (Sep 04)

(a) The recipient shall maintain books, records, documents, and other evidence and accounting procedures and practices, sufficient to reflect properly all direct and indirect costs of whatever nature claimed to have been incurred and anticipated to be incurred for the performance of this award. The Financial Assistance Officer or a representative shall have the right of access to any books, documents, papers, or other records of recipients and subrecipients which are pertinent to the award, in order to make audits, examinations, excerpts and transcripts.

(b) Such material shall be made available at the office of the recipient, at all reasonable times, for inspection, audit or reproduction, until the expiration of 3 years from the date of final payment under this award or for such longer period, if any, as is required by applicable statute. If any litigation, claim, negotiation, audit or other action involving the records has been started prior to the expiration of the 3 year period, the records must be retained until completion of the action and resolution of all issues which arise from it, or until the end of the regular 3 year period whichever is later.

(End of Clause)

Clause 4-4 REPORTING PROGRAM PERFORMANCE (BFAI 4.10)(Sep 04)

(a) Frequency. Unusual events having a negative impact on the project should be reported to the Project Technical Representative (PTR) as soon as they are discovered. A progress report is due in (FAO insert specific requirements) covering the previous six months of effort. A final report on the project must be submitted no later than 90 days after completion of the project.

(b) Contents. The report should contain a comparison of the actual accomplishments to those planned for the period. If the project is not on schedule, a brief explanation of the reason is required. Unusual situations encountered which impacted the costs or effectiveness of the project should be identified and explained.

(c) Copies. Two copies of the reports required shall be submitted to the PTR.

(End of Clause)

Clause 4-6 REIMBURSEMENT PAYMENT AND FINANCIAL REPORTING REQUIREMENTS (BFAI 4.10)(Sep 04)

(a) Payment for services performed under this award will be reimbursed by Vendor Express payment after performance of the services. Recipient requests for reimbursements, and recipient financial reporting requirements shall be made as follows:

(1) Reimbursements. Standard Form 270e, Request for Advance and Reimbursement, shall be used when requesting reimbursement for costs incurred on the project. Requests should not be made more frequently than monthly. An original and two copies should be submitted to the Project Technical Representative (PTR).

(2) Interim cost reports. Interim cost reports on SF-269a, Financial Status Report (short Form), shall be submitted to the Project Technical Representative (PTR) quarterly, within 30 days after the end of the reporting period.

(3) Final Cost Report. The final cost report shall be submitted to the PTR within 90 days after the end of the effective period. It shall be submitted in the same format as the budget as awarded. The final cost report shall compare the amounts allocated in the award budget to the amounts expended for each budget element.

(End of Clause)

Clause 4-7 ENVIRONMENTAL PROTECTION (BFAI 4.10)(Sep 04)

The recipient shall insure that the facilities under its ownership, lease or supervision which will be utilized in the accomplishment of the project are not listed on the Environmental Protection Agency's (EPA) list of Violation Facilities and that it will notify BPA of the receipt of any communication from the Director of the EPA Office of Federal Activities indicating that a facility to be used in the project is under consideration for listing by the EPA.

(End of Clause)

Clause 4-8 LIMITATION OF LIABILITY (BFAI 4.10)(Sep 04)

The recipient agrees to hold BPA harmless against any direct or consequential damages claimed by the recipient or third parties arising from or related to Recipient's performance, during the period of this award.

(End of Clause)

Clause 4-9 ACKNOWLEDGMENT OF SUPPORT (BFAI 4.10)(Sep 04)

Publication of the results of this award is encouraged. The recipient shall include in any article or other announcement that is published an acknowledgment that the research was supported, in whole or in part, by BPA (including the award number), but that such support does not constitute an endorsement by BPA of the views expressed therein.

(End of Clause)

Clause 4-10 DISPUTES (BFAI 4.10) (Sep 04)

(a) Except as otherwise provided in this award, any unresolved dispute concerning a question of fact arising under this award shall be decided by the Financial Assistance Officer (FAO), who shall reduce that decision to writing and mail, or otherwise furnish a copy thereof to the Recipient. The decision of the Financial Assistance Officer shall be final and conclusive. The FAO's decision may be appealed to the BPA HCA. The decision of the BPA HCA shall be final and conclusive.

(b) This clause does not preclude consideration of law questions in connection with decisions provided for in paragraph (a) above; provided, that nothing in this award shall be construed as making final the decision of any administrative official, representative, or board, based on a question of law.

(c) The use of alternate disputes resolution processes are encouraged, and may be used as negotiated between the parties.

(End of Clause)

Clause 4-11 TRAVEL (BFAI 4.10)(Sep 04)

(a) Domestic travel may be an appropriate charge to this award, and prior authorization for specific trips is not required. In accordance with the applicable cost principles, reasonable, necessary, and allowable travel costs may be charged on an actual basis or per diem basis in lieu of actual costs incurred, provided the method used results in charges consistent with those normally allowed by the organization in its regular operations and travel is at less than business class common carrier fare, unless otherwise approved in advance by the Financial Assistance Officer.

(b) Foreign travel may be charged to this award without prior approval if detailed in the approved budget. If foreign travel is required, but not detailed in the approved budget, it must be approved in writing by the Financial Assistance Officer prior to beginning the travel. Foreign travel will be reimbursed on the same basis as domestic travel.

(End of Clause)

Clause 4-13 PROJECT TECHNICAL REPRESENTATIVE (BFAI 4.10)(Oct 94Sep 04)

(a) The Project Technical Representative (PTR) is the authorized representative of the Financial Assistance Officer (FAO) for technical actions performed in relation to the award. This includes the functions of (1) review of work performed; and (2) interpretation of technical program requirements.

(b) The PTR is not authorized to act for the Financial Assistance OfficerFAO in the following matters pertaining to the award: (l) modifications that change the amount of award, technical requirements or time for performance; (2) suspension or termination of the recipient's right to proceed; and (3) final decisions on any matters subject to appeal.

(End of Clause)

Clause 4-15 COST REIMBURSEMENT BASIS (BFAI 4.10)(Oct 94Sep 04)

This award is funded on a cost reimbursement basis without fee or profit, not to exceed the amount awarded as indicated on the face page and is subject to a refund of unexpended funds to BPA.

(End of Clause)

Clause 4-16 BPA-FURNISHED EQUIPMENT OR MATERIAL (BFAI 4.10)(Oct 94Sep 04)

(a) The recipient hereby releases and agrees to hold BPA, or persons acting upon behalf of the BPA harmless for any and all liability of every kind and nature whatsoever resulting from the receipt, shipping, installation, operation, handling, condition, use and maintenance of the material furnished by BPA under this award.

(b) Neither BPA nor persons acting on behalf of BPA make any warranty or other representation, express or implied, that the material provided under this award will accomplish the results for which it is requested or intended.

(End of Clause)

Clause 4-17 SUSPENSION OR TERMINATION (BFAI 4.10)(Oct 94Sep 04)

(a) Definitions.

(1) "Suspension" is an action by BPA that temporarily suspends BPA support under the award pending corrective action by the Recipient or pending a decision by BPA to terminate the award.

(2) "Termination" means the cancellation of BPA sponsorship, in whole or in part, at any time prior to the date of completion.

(b) Suspension or Termination for cause.

(1) Notice of Suspension. Prior to issuing a suspension notice, efforts will be made by BPA and the recipient to informally resolve disagreements. If informal efforts fail, BPA may issue a notice of suspension that specifies the date on which the suspension will take effect. During the suspension, BPA may withhold further payment and prohibit the recipient from incurring additional obligations of funds pending corrective action by the recipient or a decision by BPA to terminate. BPA shall allow all necessary and proper costs that the recipient could not reasonably avoid during the period of suspension provided that they would otherwise be allowable.

(2) Notice of Termination for Cause. Prior to issuing a termination notice, efforts will be made by BPA and the recipient to informally resolve disagreements. If informal efforts fail, BPA may issue a notice of termination that will take effect as stated in the letter. The Financial Assistance Officer shall determine the severity of the violation that caused the termination for cause, and determine what costs are appropriate for reimbursement.

(c) Termination for convenience. BPA or the recipient may request that the award be terminated in whole or in part when both parties agree that the continuation of the project would not produce beneficial results commensurate with the further expenditure of funds. The two parties shall agree upon the termination conditions, including the effective date and, in the case of partial terminations, the portion to be terminated. The recipient shall not incur new obligations for the terminated portion after the effective date, and shall cancel as many outstanding obligations as possible. BPA shall allow full credit to the recipient for the BPA share of the noncancellable costs, properly incurred by the recipient prior to termination.

(d) Authority to issue notices. The Financial Assistance Officer is the only person authorized to suspend or terminate the award.

(End of Clause)

Clause 4-18 CHANGE OR ABSENCE OF THE PRINCIPAL INVESTIGATOR OR DESIGNATED KEY PERSONNEL (BFAI 4.10)(Oct 94Sep 04)

Since the BPA decision to fundBPA funding of this project is based, to a significant extent, on the qualifications and level of participation of the Pprincipal Iinvestigator(s), or key personnel, a change of Pprincipal Iinvestigator(s), or key personnel, or their level of effort of the level of effort of the principal investigator is considered a change in the approved project. The approval of BPA must be obtained prior to any change of the Principal Investigator or , or in certain cases, other key personnel who have been identified as key personnel elsewhere in this award. In addition, any continuous absence of the Pprincipal Iinvestigator or key personnel in excess of 3 months, or plans for the Pprincipal Iinvestigator or key personnel to become substantially less involved in the project than was indicated in the approved application requires BPA prior approval. The recipient is encouraged tomust contact the Financial Assistance Officer (FAO) immediately upon becoming aware that any of these changes are likely to be proposed, but in any event must do so and must receive FAOinancial Assistance Officer approval before effecting any such change.

(End of Clause)

Clause 4-19 PAPERWORK REDUCTION (BFAI 4.10)(Oct 94Sep 04)

(a) This award is subject to the requirements of the Paperwork Reduction Act of 1996 as implemented by the Office of Management and Budget rules, "Controlling Paperwork Burdens on the Public," published at 5 CFR 1320 (47 FR 13666, 3-31-43) if the recipient will collect information from ten or more respondents either:

(1) At the specific request of BPA, or

(2) If the award requires specific BPA approval of the information collection or the collection procedures.

(b) A statement outlining proposed information collection under (a) above shall be submitted by the recipient to the Financial Assistance Officer named on the face page of this award at least 90 days prior to the intended date of information collection. BPA will seek the requisite approval from the Office of Management and Budget and will promptly notify the recipient of the disposition of the request.

(End of Clause)

Clause 4-20 NOTIFICATION TO OFFICE OF FEDERAL CONTRACT COMPLIANCE PROGRAMS (BFAI 4.10)(Oct 94Sep 04)

The recipient is required by Title 41 of the Code of Federal Regulations, Chapter 60, Part 4, to notify the Office of Federal Contract Compliance Programs of any construction contract awarded under this financial assistance award. The proper OFCCP office to be notified can be determined by calling the Seattle Regional Office at (206) 398-8000.

(End of clause)

Clause 4-21 REQUIREMENT FOR AUDIT (BFAI 4.10)(Oct 94Sep 04)

The recipient is required to obtain an audit in accordance with OMB Circular A-133.

(End of Clause)

Clause 4-22 ENDANGERED SPECIES ACT REQUIREMENTS (BFAI 4.10)(SEP 04)

(a) To the extent requested by BPA, the recipient shall:

(1) Pparticipate in consultations and conferences conducted under Section 7 of the Endangered Species Act (ESA);

(2) Oobtain, or assist BPA in obtaining permits under Section 10 of the ESA, and

(3) Pprovide to BPA all information, materials, documents, records and other assistance requested by BPA for such consultations, conferences, or the acquisition of permits.

(b) The recipient shall not proceed with action/activities in this agreement until completion of requisite consultations and conferences and the acquisition of necessary permits. To the extent requested by BPA, the recipient shall comply with conditions identified during consultations and conferences and with the provisions of any requisite permit.

(End of clause)

Clause 4-23 PERSONAL PROPERTY MANAGEMENT (BFAI 4.10) (Oct 94Sep 04)

(a) This clause provides guidance for the utilization and disposition of personal property furnished by BPA or acquired in whole or in part with BPA funds, or whose cost was charged to a project supported by BPA funds. Also see BPI Clause 19-1.

(b) BPA-owned personal property.

(1) The following BPA property will be provided for use in this award:

This will be decided by BPA Project Technical Representative at the completion of the project

(2) Title remains vested in BPA. The recipient shall submit an annual reconciled physical inventory listing by October 1 of each year of such property in its custody to the PTR.

(3) Upon completion of the award, or when the property is no longer needed, the recipient shall provide an inventory of the property to BPA and request disposition instructions.

(c) Recipient-acquired personal property.

(1) When such property is acquired by the recipient acquires personal property using BPA funds, in whole or in part, title vests with the recipient.

(2) BPA will request the recipient to transfer title to the following property at the end of the project:

This will be decided by BPA Project Technical Representative at the completion of the project

(3) BPA reserves the right to transfer title to the property listed below to itself or a third party at the completion of the project.

This will be decided by BPA Project Technical Representative at the completion of the project

(4) If BPA does not provide disposition instructions for property identified in (b)(3) within 120 days of the end of the project, BPA relinquishes the right to transfer title, and the recipient may retain the property, or dispose of it as they deem appropriate.

(5) BPA does not reserve the right to transfer title to the following personal property. The recipient may retain, use or dispose of this property as desired.

This will be decided by BPA Project Technical Representative at the completion of the project

(6) The recipient shall submit a reconciled physical inventory listing by October 1 every second year of the award of personal property in its control.

(d) Property Management Standards for property which BPA will, or reserves the right to, require the transfer of title at the conclusion of the award:

(1) Property records shall be maintained which include a description of the property, source of property, including award number, acquisition date, location, use and condition of the property and the date the information was reported, unit acquisition cost, ultimate disposition of property, and date of disposition.

(2) The recipient shall maintain a system to insure adequate safeguards to prevent loss, damage, or theft of the property.

(3) The recipient shall follow adequate maintenance procedures to keep the property in good condition.

(End of Clause)

Clause 4-26 BUDGET CHANGES AND LINE ITEM TRANSFERS (BPI 4.10) (Oct 94Sep 04)

If unanticipated project needs arise, the recipient is authorized to make budget line item transfers not exceeding ten per cent of the total approved budget (or Financial Assistance Officer (FAO) may change this to "current year's budget" as appropriate to the transaction). Reallocation of funds exceeding this amount must have the prior written approval of the BPA Financial Assistance Officer (FAO). The recipient shall send a written request for such budget changes to the FAO through the Project Technical Representative. The FAO will respond to the request within 30 days.

Recipients or subrecipients shall obtain prior approval whenever any of the following changes are anticipated:

(a) Changes in the scope or the objective of the project or program that will require a budget revision.

(b) The need for additional funding.

(End of clause)

Clause 17-1 AUTHORIZATION AND CONSENT (Sep 98)(BPI 17.2.1)

(a) BPA authorizes and consents to all use and manufacture of any invention described in and covered by a United States patent in the performance of this contract or subcontract at any tier.

(b) BPA authorizes and consents to all use of any work protected under the copyright laws of the United States in the performance of this contract or subcontract at any tier.

(c) The Contractor shall report to the Contracting Officer, promptly and in reasonable written detail, each notice or claim of patent or copyright infringement based on the performance of this contract of which the Contractor has knowledge.

(d) The terms of this clause shall apply to subcontracts at any tier whether or not incorporated into such subcontracts.

(End of clause)

Clause 4-27 INCREMENTAL FUNDING (BPI 4.10) (Oct 94Sep 04)

This project is not fully funded at the time of the award. It is anticipated that further BPA funding will be provided on an incremental basis. If funds are not available for any reason, BPA shall be under no obligation to provide funding for any additional portion of the project. If BPA does not fund the balance of the effective period, the award will be terminated when the funds committed by BPA have been expended.

(End of Clause)

Statement of Work Report

Project Title: Acoustic Tracking For Survival

Project #: 2003-114-00

Contract Title: 2003-114-00 ACOUSTIC TRACKING FOR SURVIVAL AND MOVEMENT

Contract #: 27193

Province: Systemwide **Subbasin:** Systemwide Projects

Workorder ID: 142742 **Task ID:** 1

Perf. Period Budget: $1,497,416 **Perf. Period:** 3/15/2006 - 10/31/2006

Contract Type: Grant **Pricing Type:** Firm Fixed Price

Contractor(s): Kintama Research (Prime - KINTRESE00)

BPA Internal Ref: 27193

Contacts:

Name	Role	Organization	Phone	Email	Address
Benjamin Zelinsky	COTR	Bonneville Power Administration	(503) 230-4737	bdzelinsky@bpa.gov	P.O. Box 3621 Mailstop - KEWL-4 Portland OR 97208-3621
David Welch	Contract Manager	Kintama Research		david.welch@kintamaresearch.org	3212815 Departure Bay Rd Nanaimo BC Canada V9S
Carl Keller	Env. Compliance Lead	Bonneville Power Administration	(503) 230-7692	cjkeller@bpa.gov	
Patricia O'Donnell	Contracting Officer	Bonneville Power Administration	(503) 230-4747	paodonnell@bpa.gov	

Work Element Table of Contents:

BPA-2021-00513-F 6987

Work Element - Work Element Title	EC Needed*	Estimate	(%)
H : 157. Collect/Generate/Validate Field and Lab Data - Array data recovery, Data QA/QC checks, & vessel charters for data recovery off array	*	$156,420	(10 %)
I : 162. Analyze/Interpret Data - Establish relative movements and survival of Yakima & Snake R smolts		$48,200	(3 %)
	Total:	$1,497,416	

* Environmental Compliance (EC) needed before work begins.

Contract Description:

Project Goals

Kintama Research is endeavouring to build an ocean tracking array & establish the relevance of such a tool for addressing important resource management issues. In particular, an important goal is to develop an ability to allow the assessment of early marine survival and ocean movements for Columbia River salmon stocks. In 2004, Dr Carl Schreck tagged a total of 900 chinook salmon smolts at Bonneville Dam as part of a project that seeks to follow the movements of transported fish from their release the dam to the river mouth. In 2005, Kintama Research tagged 200 Snake R smolts that were barged to below Bonneville Dam and released.

Dr Schreck's results indicate survival of acoustically tagged smolts to the river mouth have been very high, raising questions about why Columbia River chinook have very low smolt-to-adult survival rates, and whether the differential (or delayed) mortality issues for various Columbia River chinook stocks are really attributable to the operation of the hydrosystem. An alternative hypothesis is that differences in smolt-to-adult returns (SARS, or more simply, marine survival) might be more simply explained by differences in the marine life history of different salmon stocks. This project seeks to provide objective baseline information as to whether Columbia River chinook salmon smolts can be tracked in the sea, and the first information on their initial rates of marine mortality during the initial phase of the marine life cycle. Successful demonstration of the application of the array to Columbia River salmon recovery issues would address a number of key RPAs which existing approaches cannot adequately address. Given the record salmon returns to the Columbia River since the ocean climate changes of 1999, a critical issue for successful salmon management is to distinguish the true effects on salmon returns caused by the operation of the hydrosystem from those due to ocean climate change.

Statement of Work Report

Work Element Details

A: 118. Coordination

Title: Kintama time for administering project & tag programming/prep

Description: Coordinate with tag and sensor manufacturer to ensure new tag code map successfully programmed into both tags and array sensors, and that transition to new 64,000 code tags is carried ofut successfully.

Metrics: <None>

Deliverable Specification: Coordinate with tag and sensor manufacturer to ensure new tag code map successfully programmed into both tags and array sensors, and that transition to new 64,000 code tags is carried ofut successfully.

Milestone Title	Start Date	End Date	Status	Milestone Description
Manage & Administer project direction & conduct tag preparation-Kintama	3/15/2006	9/30/2006	Inactive	Co-ordinate programming of new code map in tags and array sensors.
Deliverable: Implement new tag coding scheme		9/30/2006	Inactive	*See the Deliverable Specification above*

B: 119. Manage and Administer Projects

Title: BPA requirements

Description:

Metrics: <None>

Deliverable Specification: Contractor must sign the contract and mail it back to the BPA Contracting Officer (CO). No invoices will be paid by BPA until the CO receives the signed contract. The CO must be in receipt of contractor-signed copy of contract before the end of the current contract.

Milestone Title	Start Date	End Date	Status	Milestone Description
Deliverable: Funding Package - Sign contract	10/15/2006	10/31/2006	Inactive	*See the Deliverable Specification above*
Accrual - Submit June estimate to BPA	6/1/2006	6/10/2006	Inactive	Provide BPA with an estimate of contract work that will occur prior to June 30, but will not be billed until July 1 or later. Generally, this should be done by June 10.
Funding Package - Submit draft to COTR	7/1/2006	8/1/2006	Inactive	Submit next year's SOW, Budget, Spending Plan, and Property Inventory to the BPA COTR. The SOW should include location information (latitude and longitude) for those work elements that require it. If contractor or contractor's organization takes longer than 30 days to sign the contract, the contractor will need to send this funding package to BPA more than 90 days before the end of the current contract.
Accrual - Submit September estimate to BPA	9/1/2006	9/10/2006	Inactive	Provide BPA with an estimate of contract work that will occur prior to September 30 but will not be billed until October 1 or later. Generally, this should be done by September 10.

C: 132. Produce Annual Report

Title: FY06 Report

Description: Summarize results from 2006 field season, and place in context of the policy issues concerning the status of Snake River spring chinook

Metrics: <None>

Deliverable Specification: Summarize results from 2006 field season, and place in context of the policy issues concerning the status of Snake River spring chinook. Synthesize 2006 data with past data and provide a crtique of the effectiveness of the POST array to date. Include a discussion of lessons learned and next steps to be taken. Annual repoprt to be uploaded to BPA's website.

Milestone Title	Start Date	End Date	Status	Milestone Description
Deliverable: Submit annual report to BPA documenting this year's activities and accomplishments.	7/17/2006	10/31/2006	Inactive	*See the Deliverable Specification above*

D: 185. Produce Pisces Status Report

Title: Periodic Status Reports for BPA

Description: The Contractor shall report on the status of milestones and deliverables in Pisces. Reports shall be completed either monthly or quarterly as determined by the BPA COTR. Additionally, when indicating a deliverable milestone as COMPLETE, the contractor shall provide metrics and the final location (latitude and longitude) prior to submitting the report to the BPA COTR.

Metrics: <None>

Deliverable Specification:

Milestone Title	Start Date	End Date	Status	Milestone Description
Mar-Jun 2006 (3/15/2006 - 6/30/2006)	7/1/2006	7/1/2006	Inactive	
Final Jul-Oct 2006 (7/1/2006 - 10/31/2006)	10/31/2006	10/31/2006	Inactive	

E: 165. Produce Environmental Compliance Documentation

Title: Obtain permits for array deployment, hatchery use, and Animal Care Review Permits

Description: Permits or approvals must be secured for three aspects of the project:
1. Permits from gov't agencies for deployment of permanent equipment on sea or river bed.
2. Permission must be obtained from Dworshak and Cle Elum hatcheries for retention or collection of smolts
3. An animal care permit must be renewed to cover off the surgery done by the tagging crews.

Metrics: <None>

Deliverable Specification:
1. Obtain necessary government permits
2. Secure verbal agreement
3. Obtain written clearance from Animal Care Committee on methods to be used in 2006.

Milestone Title	Start Date	End Date	Status	Milestone Description
Obtain all permits for ocean & river bed deployment locations	3/27/2006	4/15/2006	Inactive	1. Permits must be obtained from federal, state, and county authorities for placement of acoustic nodes on the river or seabed. The specific authorities in charge of each location are complex and are addressed on a node-by-node basis. Permit applications are then drawn up for the specific authority and submitted for approval.
Obtain review & permission of animal care committee for surgical implantation of tags	3/27/2006	4/7/2006	Inactive	Kintama will secure Canadian Council on Animal Care (CCAC) approval for surgical tagging procedures. This blanket approval will cover all North American work by Kintama in 2006, and ensures that the ethical issues and surgical procedures meet the highest standard. It is also a necessary requirement before publication is possible in some scientific journals. CCAC approval will also cover work in the United States because Kintama is a Canadian research company.
Secure hatchery agreement for use of Snake & upper Columbia R stocks	3/27/2006	4/5/2006	Inactive	Contact hatchery staff and secure agreement for smolt collection and/or holding of smolts prior to release (for barged & run-of-river smolts) and smolts held-back for surgical implantation and long-term observation of growth, mortality, and tag retention.
Deliverable: Secure permits	3/27/2006	4/17/2006	Inactive	*See the Deliverable Specification above*

F: 156. Develop RM&E Methods and Designs

Title: Install Acoustic tracking array

Description: Four detection "lines" will be deployed in the Columbia/Snake R system, to track acoustically tagged smolts downriver and allow a comparison of survival of acoustically tagged smolts with previous measurements using PIT tags.

Equipment will be deployed in the system as follows (positions have been changed from the original proposal to reflect the use of the Yakima stock and give better comparison with other studies).

Three detection lines will be placed in the ocean using BPA funding in 2006.

Metrics: <None>

Deliverable Specification:
4 nodes below Lower Granite Dam (Lake Bryant), Two each at Snake River Miles 95 & 98
4 nodes in Lake Wallula, below the confluence of the Snake & Upper Columbia Rivers (River mile 309)
4 nodes below the John Day Dam; Two each at River mile 212 & 213
4 nodes below Bonneville Dam; Two each ca. half mile above and below river mile 140

The northern-most detection line (22 nodes; 22 VR3, 2 VR2) will be placed perpendicular to shore off Topknot Point, NW Vancouver Island
The middle line (40 nodes; 27 VR3, 13 VR2) will be placed just south of Willapa Bay, Washington
The southern-most line (24 VR2) will be placed perpendicular to shore off Cascade Head, Oregon

Milestone Title	Start Date	End Date	Status	Milestone Description
Order equipment	3/20/2006	4/1/2006	Inactive	Core components of the array must be ordered, as well as acoustic tags. The critical equipment needed are: (1) acoustic modem equipped VR3 "wireless" sensors (2) 1,000 acoustic tags (3) Purpose-built flotation collars and mounting brackets for VR3 units (4) "Am-Steel" high strength synthetic line for deployments
Assemble & construct component	3/21/2006	5/1/2006	Inactive	Equipment must be assembled from the components to form each seabed node. Once all components are delivered, the 70 VR3 sensor units must be built into the seabed nodes so that their orientation is optimal for tracking passing smolts. Conventional VR2 "pop-up" units used for the remainder of the listening lines need to be re-built & refurbished to minimize last year's problems with the anchoring systems fouling by being buried under the soft sand bottom near the Columbia.
Charter vessels for array deployment	3/20/2006	5/5/2006	Inactive	Vessel charters must be arranged and scheduled for the initial deployment of equipment in the Columbia River, Cascade Head, Willapa, and Topknot.
Arrange transportation for completed units and truck to vessel pick up points	4/5/2006	5/10/2006	Inactive	Chartered vessels must be loaded at pre-arranged locations, and equipment must be trucked by land to meet those vessels.
Deploy array in Columbia River	4/15/2006	4/17/2006	Inactive	Four detection "lines" will be deployed in the Columbia/Snake R system, to track acoustically tagged smolts downriver and allow a comparison of survival of acoustically tagged smolts with previous measurements using PIT tags. Equipment will be deployed in the system as follows (positions have been changed from the original proposal to reflect the use of the Yakima stock and give better comparison with other studies): 4 nodes below Lower Granite Dam (Lake Bryant), Two each at Snake River Miles 95 & 98 4 nodes in Lake Wallula, below the confluence of the Snake & Upper Columbia Rivers (River mile 309) 4 nodes below the John Day Dam; Two each at River mile 212 & 213 4 nodes below Bonneville Dam; Two each ca. half mile above and below river mile 140
Deploy Array in Ocean lines	4/12/2006	5/17/2006	Inactive	Three detection lines will be placed in the ocean using BPA funding in 2006. The northern-most detection line (22 nodes; 22 VR3, 2 VR2) will be placed perpendicular to shore off Topknot Point, NW Vancouver Island The middle line (40 nodes; 27 VR3, 13 VR2) will be placed just south of Willapa Bay, Washington The southern-most line (24 VR2) will be placed perpendicular to shore off Cascade Head, Oregon

Milestone Title	Start Date	End Date	Status	Milestone Description

Assemble & construct component	3/21/2006	5/1/2006	Inactive	Equipment must be assembled from the components to form each seabed node. Once all components are delivered, the 70 VR3 sensor units must be built into the seabed nodes so that their orientation is optimal for tracking passing smolts. Conventional VR2 "pop-up" units used for the remainder of the listening lines need to be re-built & refurbished to minimize last year's problems with the anchoring systems fouling by being buried under the soft sand bottom near the Columbia.

G: 158. Mark/Tag Animals

Title: Tagging of 1,000 smolts for release & 400 to be held as controls

Description: Snake River and Yakima River spring chinook smolts will be surgically implanted with Vemco V9-6L acoustic tags. Acoustic tags will be distributed between replicate groups for:
1. Yakima & Snake R ROR smolts (N=200/group)
2. Snake River barged smolts (N=100/group)

Dummy tags will be implanted into an additional 100 smolts at each hatchery, and matched with 100 PIT tagged controls (i.e. 200 smolts/stock). These will be held long-term at the two hatcheries to follow growth, survival and tag retetnion over the duration of the study

Metrics:
* R, M, and E Focal Area [Tributaries, Hydrosystem, Estuary, Ocean, Harvest, Hatchery, Systemwide, Emerging Issues]
* Primary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]
* Secondary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]

Deliverable Specification: Surgically implant tags under anaesthesia using MS-222.
Release replicate groups about two weeks apart.
Timing of the release groups of Yakima & Snake R ROR smolts and Snake R barged smolts will be selected so that all three groups should reach the barge release site below Bonneville at about the same time, and the two sets of released animals will be spaced about 2-3 weeks apart.

Milestone Title	Start Date	End Date	Status	Milestone Description
Order 1000 acoustic tags & specify programming	3/17/2006	3/28/2006	Inactive	1,000 acoustic tags must be ordered and delivered with correct programming - Tags are to be divided equally between the old 4K & new 64K code map, to compare detectability over the array. (Programming for new code map must be implemented to provide sufficient code space). - Tags will be used equally in each release group, to allow objective assessment of performance - 400 dummy acoustic tags with embedded PIT tags will be ordered to follow long-term smolt performance in the source hatcheries
Environmental compliance requirements complete	3/15/2006	3/30/2006	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
Confirm hatchery agreement to supply and hold smolts (Upper Columbia & Snake R)	3/17/2006	3/30/2006	Inactive	Complete site review with hatchery staff and confirm staff agreement and availability of holding facilities for fish
Release ROR upper Columbia & Snake R smolts (1st group)	4/26/2006	4/29/2006	Inactive	1st group of ROR smolts released from Snake & Yakima River hatcheries, with timing chosen to have them reach the confluence of the Snake and Columbia Rivers at about the same time. N=200 smolts released from each hatchery.
Transport Snake R smolts (1st group)	5/1/2006	5/3/2006	Inactive	Snake R smolts destined for transport are trucked in a transport tank to the Lower Granite barge site (N=100 smolts). Timing is to be selected so that these fish will be released below Bonneville at the time the first ROR release groups should reach the release site.
Surgically implant smolts with acoustic tags & dummy tags	4/11/2006	5/10/2006	Inactive	Smolts will be surgically implanted under anaesthesia following Kintama's surgical protocols. 600 smolts will be implanted with both acoustic & PIT tags at the Kooskia hatchery, and 400 smolts will be similarly implanted at the Yakima site. 100 smolts will be implanted with dummy tags at each site (along with 100 PIT tagged controls).
Release ROR upper Columbia & Snake R smolts (2nd group)	5/10/2006	5/12/2006	Inactive	2nd group of ROR smolts released from Snake & Yakima River hatcheries, with timing chosen to have them reach the confluence of the Snake and Columbia Rivers at about the same time. N=200 smolts released from each hatchery.
Transport Snake R smolts (2nd group)	5/15/2006	5/17/2006	Inactive	Second group of Snake R smolts destined for transport are trucked in a transport tank to the Lower Granite barge site (N=100 smolts). Timing is to be selected so that these fish will be released below Bonneville at the time the second ROR release groups should reach the release site.

Milestone Title	Start Date	End Date	Status	Milestone Description
survival, growth, & tag retention				the two facilities and the tank will be checked daily for dead smolts or extruded tags. Dead animals & extruded tags will be placed in a plastic bag labelled with the date of discovery and stored in a single large placstic bag in the freezer for later pick-up. Data will be used to define the time course of mortality and tag extrusion for each stock, to provide an estimate of tagging induced losses. These data can then be compared for free-ranging fish detected on the POST array.
Deliverable: Tag smolts with acoustic tags	4/11/2006	5/10/2006	Inactive	*See the Deliverable Specification above*

Environmental compliance requirements complete	3/15/2006	3/30/2006	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).

H: 157. Collect/Generate/Validate Field and Lab Data

Title: Array data recovery, Data QA/QC checks, & vessel charters for data recovery off array

Description: Data will be recovered off the array of tracking sensors, and will then be analyzed to verify quality & internal consistency before transferring to POST database. To do so, vessels will be chartered for data recovery and equipment will be prepared to maximize the chances of recovering the information.

Metrics:
* R, M, and E Focal Area [Tributaries, Hydrosystem, Estuary, Ocean, Harvest, Hatchery, Systemwide, Emerging Issues]
* Primary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]
* Secondary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]

Deliverable Specification: Data will be verified through a series of steps to ensure integrity and reliability prior to uploading to the database.

Milestone Title	Start Date	End Date	Status	Milestone Description
Arrange mid-summer charter of vessels	6/22/2006	6/30/2006	Inactive	Vessels must be chartered to recover data from the in-river and ocean array lines. Mid-summer recovery of the Columbia data will probably require a different vessel, as the vessel to be used in the spring work will be in Alaska fishing.
Environmental compliance requirements complete	3/15/2006	3/30/2006	Inactive	On-the-ground work associated with this work element cannot proceed until this milestone is complete. Milestone is complete when final documentation is received from BPA environmental compliance staff (completion can be based on pre-existing environmental documentation from BPA).
Mid-Summer data recovery, equipment repair & replacement of lost units	7/1/2006	7/31/2006	Inactive	VR3 units will be recovered using acoustic modems, and VR2 data will be recovered by triggering the acoustic release and bringing the VR2 to the surface, and then re-deploying the equipment. Where possible, lost equipment will be replaced with spare VR2 units held in inventory.
Arrange late-summer charter of vessels	8/1/2006	8/4/2006	Inactive	Vessels must be chartered to recover data from the in-river and ocean array lines. Late-summer recovery of the Columbia data will probably require a different vessel, as the vessel to be used in the spring work will be in Alaska fishing.
Late-summer data recovery, equipment repair & replacement of lost units	8/16/2006	9/20/2006	Inactive	VR3 units will be recovered using acoustic modems, and VR2 data will be recovered by triggering the acoustic release and bringing the VR2 to the surface, and then re-deploying the equipment. Where possible, lost equipment will be replaced with spare VR2 units held in inventory.
QA/QC of all data	7/1/2006	9/28/2006	Inactive	Data on the recovery process as well as all data recovered from the array must be reviewed and vetted before being transferred into the POST data base.
Deliverable: Collect movement and survival data	6/22/2006	9/28/2006	Inactive	*See the Deliverable Specification above*

I: 162. Analyze/Interpret Data

Title: Establish relative movements and survival of Yakima & Snake R smolts

Description: Assess the relative movements and survival of tagged smolts from the two stocks over the in-river and ocean array. Develop a statistical comparison of whether survival is similar between the stocks, and if not, identify in what geographic sectors of the array survival differs.

Metrics: * R, M, and E Focal Area [Tributaries, Hydrosystem, Estuary, Ocean, Harvest, Hatchery, Systemwide, Emerging Issues]

* Primary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]

* Secondary R, M, and E Type [Status and Trend Monitoring, Action Effectiveness Research, Uncertainties Research, Project Implementation/ Compliance Monitoring]

Deliverable Specification: Complete preliminary report on the year's work placing the results in context of the two primary ppolicy issues of whether:

(a) Below Bonneville survival measured over the array is similar for the two stocks; if so, this will make "delayed" mortality caused by the hyrdrosystem less likely as an explanation of the poorer SARs of Snake R fish;

(b) Establish whether barging helps or reduces Snake R chinook survival by effectively increasing the period of time the smolts are placed in the ocean environment (if survival per day is lower here than in freshwater, then overall survival may be reduced more by transportation than if the smolts are allowed to migrate downriver)

Milestone Title	Start Date	End Date	Status	Milestone Description
Prepare data to evaluate array performance, and begin answering policy question	5/1/2006	9/29/2006	Inactive	Data must be organized and prepared for data analysis, first by completing a basic verification of data integrity.
Establish survival and tag retention of dummy tagged smolts	4/9/2006	9/29/2006	Inactive	The collected data on the time smolts held in hatchery tanks either die or drop their tags will be analyzed. The time course of mortality and tag shedding will be compared between the two stocks and (if similar) will be combined to form a descrption of how tagged smolts dissapear (die or lose tags) over the lifespan of the tags. These data can be compared to the results from the free-ranging smolts to provide a correction for tagged smolts that would not be detected by the array as a result of post-surgical complications or tag extrusion.
Establish movements and survival of each group of free-ranging smolts	7/5/2006	9/29/2006	Inactive	Determine proportion of each group that is detected at successive array lines, and establish (a) overall survival to that point and (b) survival between detection points. These data will provide a perspective on relative mortality during different parts of the migration during the 4-9 months post-release. The hatchery study of tag loss & mortality will then be used to provide a perspective to correct these data on free-ranging fish for probable losses not associated with "natural" factors independent of the tagging process.
Deliverable: Prepare report on results (oral and written)	4/9/2006	9/29/2006	Inactive	*See the Deliverable Specification above*

BPA-2021-00513-F 6999

Kintama Research Corporation

FY2006 Budget: An Acoustic Tracking Array for Studying Ocean Survival and Movements of Columbia River Salmon

15/12/2005 to 9/30/2006

		Units	Number	Unit Cost	Subtotal	Total
512111 Wages	Tagging - Surgery (Biologists)	days	63	375	**23,625**	
	Tagging - Planning, Tag Preparation & Co-ordination (Biologists)	days	80	375	**30,000**	
	Tagging - Planning & Co-ordination (Welch)	days	26	685	**17,810**	
	John McKern- Regional co-ordination, including tagging permission and hatchery co-ordination	days	20	375	**7,500**	
	Array Deployment- Planning, Initial Deployment, Initial & Second Data Recovery. (Biologists)	days	225	375	**84,375**	
	Permitting (Staff costs; (Biologists))	days	40	375	**15,000**	
	Data Analysis, Data QA/QC, and Report Generation (Biologists)	days	120	375	**45,000**	
						223,310
519111 Fringe Benefits	Calculated at 25% of base rate				**55,828**	
						55,828
541122 Sensitive Equipment	VR-3 Base units	unit	(b)(4) [redacted]		**399,000**	
	Bottom node deployment platform (acoustic release/ROV, concrete	unit			**140,000**	
	Redesign & rebuild of VR2 pop-up "R2D2" bottom nodes	unit			**17,000**	
	Acoustic tags, V8SC-6L	tag			**296,400**	
	PIT tag readers	unit			**2,400**	
	Dummy tags (200)	tag			**2,000**	
						856,800
581121 Travel Per Diem	Surgical tagging work (3 people x 21 days)	days	63	175	**11,025**	
	Array Operations (2 people x 30 days)	days	60	175	**10,500**	
						21,525
551295 Rental Vehicle	Vessel Charter (Initial deployment plus two data recoveries)	days	45	3000	**135,000**	
	Surgical Tagging Work (incl. fuel)	days	26	225	**5,850**	
	Trucks for equipment preparation, transport, & vessel loading	days	10	650	**6,500**	
						147,350
Miscellaneous	Meeting & Conference travel: 6 trips for BPA, NWPPC or Columbia River related conferences	trip	6	1500	**9,000**	
	Brokerage charges (Cross-border equipment transport; 8 trips)	per trip	3	1000	**3,000**	
	Surgical Supplies-consumables (Drug (Metomidate, MS-222), Veterinary prescriptions, absorbable sutures, gloves, surgical tools, cost to build 2 portable surgical tables, repair & replacement parts). This value is based on our average per fish cost in 2004-05.		1200	19.1	**22,920**	
	Air Travel to SE Alaska & associated costs in Sitka (3 trips)	per trip	3	1800	**5,400**	
	Telecommunications (Cell & Sat phone charges, wireless internet connectivity from boats; office)	months	12	1000	**12,000**	
	Lithium batteries and other consumables				**2,000**	
	Insurance; Company & Vessel				**7,000**	
	Software, Purchase (SolidWorks; $6500; MatLab ($2200), Annual maintenance updates (ArcView)				**9,500**	
	Rental-- Storage units & construction work space				**12,000**	
	Shipping charges				**2,500**	
	1 Desktop computer system for engineering design work, 1 server for network, plus purchase of GPS interface equipment (incl. differential antennae) for 2 existing laptops				**5,000**	
						90,320
621251 Indirect Cost Expense	Calculated on wages, miscellaneous, and travel related items only (19%)					**102,283**
Grant Total						**1,497,416**
	PIT Tags (1,200)	tag	1200	2.06	**2,472**	
Project Total						**1,499,888**

Capital and Non-capital Equipment Inventory

Form Revised PTL 19 Aug 2005

BPA Project Number: 2003-114-00 e.g., 1989-098-45
Contract Number: 27193
Contractor: Kintama Research Corp

Date Updated: 11-Mar-06
Person Who updated: D Welch

#	Item Description (Each item must have a separate line)	Model #	Serial Number (if applicable)	Date Acq'd	Type of Acquisition (check one): Purchased	Surplused	Shop Built	Transferred in (from BPA contract #)	Cost/Owner: at time of purchase	% ownership this project	Current Condition (Check one): Excellent	Good	Fair	Inoperable	Missing	Physical Location	Disposition (R, A, T) (BPA decision only): Disp Code	Contract #	Other Comments	Ownership
1	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X				(b)(4) [redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
2	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
3	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
4	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
5	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
6	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
7	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
8	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
9	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
10	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
11	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
12	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
13	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
14	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00

15	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					(b)(4) [redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
16	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
17	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
18	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
19	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
20	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
21	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
22	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
23	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
24	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
25	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
26	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
27	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
28	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
29	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
30	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
31	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
32	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
33	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00

34	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					(b)(4) [redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
35	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
36	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
37	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
38	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
39	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
40	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
41	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00
	Vemco Tracking Receiver	VR3	UK	1-Apr-06	X					[redacted]	100%	x					Kintama Research (To be deployed in ocean)	A	New	Will be deployed in ocean; locations will be updated when known	100% BPA Project 2003-114-00

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Tue Apr 06 10:18:31 2021

To: David Welch

Subject: Accepted: David Welch's Zoom Meeting

Importance: Normal

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 09 11:40:54 2021

To: David Welch

Subject: New Time Proposed: David Welch's Zoom Meeting

Importance: Normal

I have a conflict at 2:30. Would this work? Monday afternoon looks pretty open if not.

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 09 13:05:44 2021

To: David Welch

Cc: Renner,Marcella P (BPA) - E-4

Subject: RE: David Welch's Zoom Meeting

Importance: Normal

Hello David,

Looks like the alternate time I proposed today won't work for you so let's try for early next week. I'm including Marcella in the hopes that she can provide some scheduling magic for us.

Thanks,

Ben

-----Original Appointment-----
From: David Welch <David.Welch@Kintama.com>
Sent: Monday, April 5, 2021 12:05 PM

To: David Welch; Zelinsky,Benjamin D (BPA) - E-4
Subject: David Welch's Zoom Meeting
When: Friday, April 9, 2021 2:30 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Trying again on this—apologies for the screw up last Friday.

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Fri Apr 09 13:05:50 2021

To: David Welch

Subject: Declined: David Welch's Zoom Meeting

Importance: Normal

From: David Welch

Sent: Fri Apr 09 13:56:49 2021

To: Zelinsky,Benjamin D (BPA) - E-4

Cc: Renner,Marcella P (BPA) - E-4

Bcc: mprenner@bpa.gov

Subject: [EXTERNAL] Re: David Welch's Zoom Meeting

Importance: Normal

Hi, Ben and Marcella-

I just emerged from an area of no cell coverage on my drive north to Port Hardy, 4hrs North of Nanaimo. I will be in Port Hardy just before 2:30, as planned.

I (and some others) get picked up by a boat and we are headed off to a week off diving at a remote island... back in the office next Friday

Try giving my cell a call anytime after 2:30 today if Ben has time for a quick chat. Otherwise, i will be out of good communication r range for the next week, although I should be able to get slow emails to go through.

David Welch
M: [redacted]
Kintama Research Services
Sent from my iPhone

> On Apr 9, 2021, at 1:05 PM, Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov> wrote:

Hello David,

Looks like the alternate time I proposed today won't work for you so let's try for early next week. I'm including Marcella in the hopes that she can provide some scheduling magic for us.

Thanks,

Ben

-----Original Appointment-----
From: David Welch <David.Welch@Kintama.com>
Sent: Monday, April 5, 2021 12:05 PM
To: David Welch; Zelinsky,Benjamin D (BPA) - E-4
Subject: David Welch's Zoom Meeting
When: Friday, April 9, 2021 2:30 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

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https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

From: Renner,Marcella P (BPA) - E-4

Sent: Fri Apr 09 15:38:11 2021

To: Zelinsky,Benjamin D (BPA) - E-4; David Welch

Subject: RE: David Welch's Zoom Meeting

Importance: Normal

The 13th at 11am or 4pm works

The 14th between 10-12

The 15th at 4pm also works

Hope one of these will work. Sorry for the delay. Today has been a doozer. J

Thanks,

Marcella P. Renner

503-230-5136

(b)(6) [redacted]

From: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Sent: Friday, April 9, 2021 1:06 PM
To: David Welch <David.Welch@Kintama.com>
Cc: Renner,Marcella P (BPA) - E-4 <mprenner@bpa.gov>
Subject: RE: David Welch's Zoom Meeting

Hello David,

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Thanks,

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-----Original Appointment-----
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To: David Welch; Zelinsky,Benjamin D (BPA) - E-4
Subject: David Welch's Zoom Meeting
When: Friday, April 9, 2021 2:30 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).

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https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

From: David Welch

Sent: Fri Apr 09 19:56:35 2021

To: Renner,Marcella P (BPA) - E-4

Cc: Zelinsky,Benjamin D (BPA) - E-4

Subject: [EXTERNAL] Re: David Welch's Zoom Meeting

Importance: Normal

Hi Marcella

I am now almost out of range... 1 bar territory for my cell and reception won't improve until I return to land. Thursday the 15th at 4pm will work, as well as anytime on Friday the 16th.

David Welch, Kintama Research
Tel: +[redacted]

On Apr 9, 2021, at 15:38, Renner,Marcella P (BPA) - E-4 <mprenner@bpa.gov> wrote:

The 13th at 11am or 4pm works

The 14th between 10-12

The 15th at 4pm also works

Hope one of these will work. Sorry for the delay. Today has been a doozer. J

Thanks,

Marcella P. Renner

503-230-5136
[redacted]

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Sent: Friday, April 9, 2021 1:06 PM
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Cc: Renner,Marcella P (BPA) - E-4 <mprenner@bpa.gov>
Subject: RE: David Welch's Zoom Meeting

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Sent: Monday, April 5, 2021 12:05 PM
To: David Welch; Zelinsky,Benjamin D (BPA) - E-4
Subject: David Welch's Zoom Meeting
When: Friday, April 9, 2021 2:30 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

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David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/72745980099?pwd=ZitTKzgyaC92L3NUY3hTZDJWalhuQT09

Meeting ID: 727 4598 0099

Passcode: v5hRPP

From: David Welch

Sent: Mon Apr 26 10:54:49 2021

To: Ben Zelinsky

Subject: [EXTERNAL] Try again?

Importance: Normal

Hi, Ben-

I'm available pretty well all week, if you want to try to re-schedule our call again.

[redacted]

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +(b)(6) [redacted]

Our new paper looking at coastwide survival of Chinook salmon has recently been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: https://onlinelibrary.wiley.com/doi/10.1111/faf.12514

Recently, 68 scientists wrote a letter claiming that Snake River dams must be removed if salmon runs are to recover. Their claim is mathematically impossible and ignores similar issues in BC and Alaska. Kintama's letter refuting these claims is here: https://tinyurl.com/yjprd6su

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Mon Apr 26 14:45:28 2021

To: David Welch

Subject: Check In

Importance: Normal

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Mon Apr 26 14:47:35 2021

To: David Welch

Subject: RE: Try again?

Importance: Normal

Yes – let's try again. We can do this. J

Just sent an invite for 11 on Friday if that works. I can call you or feel free to send a zoom if you prefer.

From: David Welch <David.Welch@Kintama.com>
Sent: Monday, April 26, 2021 10:55 AM
To: Zelinsky,Benjamin D (BPA) - E-4 <bdzelinsky@bpa.gov>
Subject: [EXTERNAL] Try again?

Hi, Ben-

I'm available pretty well all week, if you want to try to re-schedule our call again.

[redacted]

David

David Welch, Ph.D.

President, Kintama Research Services

755 Terminal Avenue, Nanaimo, BC Canada V9S 4K1

(m) +[redacted]

Our new paper looking at coastwide survival of Chinook salmon has recently been published.

Summary for Policy Makers-

Animation: https://youtu.be/FN7yp3FefB8

Text:https://www.scientia.global/wp-content/uploads/David_Welch/David_Welch.pdf

The research paper: **https://onlinelibrary.wiley.com/doi/10.1111/faf.12514**

Recently, 68 scientists wrote a letter claiming that Snake River dams must be removed if salmon runs are to recover. Their claim is mathematically impossible and ignores similar issues in BC and Alaska. Kintama's letter refuting these claims is here: https://tinyurl.com/yjprd6su

From: David Welch

Sent: Mon Apr 26 15:07:59 2021

To: Renner,Marcella P (BPA) - E-4

Subject: [EXTERNAL] David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal

I will try to actually be on the call this time!

David Welch is inviting you to a scheduled Zoom meeting.

Join Zoom Meeting

https://us04web.zoom.us/j/78848770929?pwd=U2RucEVuMytZclNhNDIxNDd2cmVRZz09

Meeting ID: 788 4877 0929

Passcode: bKZ1Ad

From: Zelinsky,Benjamin D (BPA) - E-4

Sent: Mon Apr 26 15:09:31 2021

To: David Welch

Subject: Accepted: David Welch's Zoom Meeting-Support for "IDFG" Revision

Importance: Normal