Department of Energy

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

FREEDOM OF INFORMATION ACT PROGRAM

June 28, 2022

In reply refer to: FOIA #BPA-2021-00513-F

SENT VIA EMAIL ONLY TO: amissel@advocateswest.org

Andrew Missel
Advocates for the West
3701 SE Milwaukie Ave., Ste. B
Portland OR 97202

Dear Mr. Missel,

This communication is the Bonneville Power Administration's (BPA) third partial response to your request for agency records made under the Freedom of Information Act, 5 U.S.C. § 552 (FOIA). BPA received your records request on March 29, 2021, and formally acknowledged your request on April 12, 2021. A first partial response to your FOIA request was provided to you on December 16, 2021; a second partial response was provided to you on March 21, 2021.

Request
"…copies of the records described below relating to the Bonneville Power Administration's ("BPA") relationship with Kintama Research Services ("Kintama") and/or its CEO, Dr. David Welch:

1. All contracts between BPA and Kintama and/or Dr. Welch from the start of the year 2000 through the date of search.
2. All communications between BPA and Kintama and/or Welch from the start of the year 2000 through the date of search.
3. All records from the start of the year 2000 through the search date that document, memorialize, or refer to any meetings, conversations, or other communications between BPA and Kintama and/or Welch.

Any reference to an entity—such as "BPA" or "Kintama"—includes all employees and agents of that entity as well as the entity itself and any division thereof. Any non-identical duplicates of records that include any information not contained in the original record should be disclosed in response to this request. Non-identical duplicates may contain additional information due to notation, attachment, or other alteration or supplement, or because of differences in metadata.

For this request, the term "records" includes, but is not limited to, any and all documents, correspondence (including, but not limited to, inter and/or intra-agency correspondence as well as correspondence with entities or individuals outside the federal government), emails, letters, notes, recordings, telephone records, voicemails, telephone notes, telephone logs, text messages, chat messages, minutes, memoranda, comments, files, presentations, consultations, assessments, evaluations, schedules, reports, studies, photographs and other images, data, maps, and/or all other responsive records, in draft or final form.

The term "communications" includes, but is not limited to, any and all emails, letters, faxes, notes, voicemails, text messages, chat messages, comments, presentations, and recordings, as well as any document, file, or other thing included with a letter or fax, attached to an email, or linked to in a text message, chat message, or email."

Third Partial Response
The agency collected responsive records from knowledgeable agency personnel in the Environment, Fish & Wildlife Commodity Investment Office within Supply Chain Services and the Cyber Security Forensics & Intelligence Office conduced a search within the agency's Outlook email system. Accompany this communication are 6,942 pages of responsive records with redactions applied under the following FOIA exemptions: 174 pages with redactions applied under 5 U.S.C. § 552(b)(2); and 90 pages with redactions applied under 5 U.S.C. § 552(b)(4); and 1,172 pages with redactions applied under 5 U.S.C. § 552(b)(5); and 849 pages with redactions applied under 5 U.S.C. § 552(b)(6). A more detailed explanation of the applied exemption follows.

Explanation of Exemptions
The FOIA generally requires the release of all agency records upon request. However, the FOIA permits or requires withholding certain limited information that falls under one or more of nine statutory exemptions (5 U.S.C. §§ 552(b)(1-9)). Further, section (b) of the FOIA, which contains the FOIA's nine statutory exemptions, also directs agencies to publicly release any reasonably segregable, non-exempt information that is contained in those records.

<u>Exemption 2</u>
Exemption 2 permits withholding of agency information "related solely to the internal personnel rules and practices of an agency." BPA relies on Exemption 2 here to protect internal internet portals, telephonic meeting call-in numbers and related passwords and passcodes found on the subject responsive records. Records protected by Exemption 2 may be discretionarily released. BPA considered a discretionary release and determined that the subject information should not be discretionarily released because a public release would hinder BPA internal procedures and policies.

<u>Exemption 4</u>
Exemption 4 protects "trade secrets and commercial or financial information obtained from a person [that is] privileged or confidential." (5 U.S.C. § 552(b)(4)). Information is considered commercial or financial in nature if it relates to business or trade. This exemption is intended to protect the interests of both the agency and third party submitters of information. BPA was required by Exemption 4 to solicit objections to the public release of any third party's confidential commercial information contained in the responsive records set. BPA provided

Kintama and sub-contractors whose information was included in the responsive records with an opportunity to formally object to the public release of their information contained in BPA records. Innovasea Systems, Inc., owner of Vemco Tracking, submitted their objections to BPA. BPA accepted those objections, based on guidance available from the U.S. Department of Justice, and is withholding Innovasea Systems, Inc. commercial confidential information from public release, specifically pricing information. BPA also withheld third party banking and financial routing account numbers and wire transfer information. The FOIA does not permit a discretionary release of information otherwise protected by Exemption 4.

Exemption 5

Exemption 5 protects "inter-agency or intra-agency memorandums or letters which would not be available by law to a party other than an agency in litigation with the agency" (5 U.S.C. § 552(b)(5)). In plain language, the exemption protects privileged records. The FOIA's Exemption 5 deliberative process privilege protects records showing the deliberative or decision-making processes of government agencies. Records protectable under this privilege must be both pre-decisional and deliberative. A record is pre-decisional if it is generated before the adoption of an agency policy. A record is deliberative if it reflects the give-and-take of the consultative process, either by assessing the merits of a particular viewpoint, or by articulating the process used by the agency to formulate a decision. Here, BPA relies on Exemption 5 to protect deliberative and pre-decisional communications appertaining to the agency's interests in the Columbia River System Operations Environmental Impact Statement ("CRSO EIS") dated July 2020, the associated Endangered Species Act consultations, and the 2020 CRSO EIS Record of Decision. Records protected by Exemption 5 may be discretionarily released. BPA has considered and declined a discretionary release of some pre-decisional and deliberative information in the responsive records set because disclosure of that information would harm the interests and protections encouraged by Exemption 5.

Exemption 6

Exemption 6 serves to protect Personally Identifiable Information (PII) contained in agency records when no overriding public interest in the information exists. BPA does not find an overriding public interest in a release of the information redacted under Exemption 6—specifically, individuals' signatures, cell numbers, and personal matters. BPA cannot waive these PII redactions, as the protections afforded by Exemption 6 belong to individuals and not to the agency.

Lastly, as required by 5 U.S.C. § 552(a)(8)(A), information has been withheld only in instances where (1) disclosure is prohibited by statute, or (2) BPA foresees that disclosure would harm an interest protected by the exemption cited for the record. When full disclosure of a record is not possible, the FOIA statute further requires that BPA take reasonable steps to segregate and release nonexempt information. The agency has determined that in certain instances partial disclosure is possible, and has accordingly segregated the records into exempt and non-exempt portions.

Certification

Pursuant to 10 C.F.R. § 1004.7(b)(2), I am the individual responsible for the records search, redactions, and partial records release described above.

Appeal
Note that the records release certified above is partial. Additional and remainder records releases will be forthcoming as agency resources and records volumes permit. Pursuant to 10 C.F.R. § 1004.8, you may appeal the adequacy of the records search, and the completeness of this partial records release, within 90 calendar days from the date of this communication. Appeals should be addressed to:

Director, Office of Hearings and Appeals
HG-1, L'Enfant Plaza
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585-1615

The written appeal, including the envelope, must clearly indicate that a FOIA appeal is being made. You may also submit your appeal by e-mail to OHA.filings@hq.doe.gov, including the phrase "Freedom of Information Appeal" in the subject line. (The Office of Hearings and Appeals prefers to receive appeals by email.) The appeal must contain all the elements required by 10 C.F.R. § 1004.8, including a copy of the determination letter. Thereafter, judicial review will be available to you in the Federal District Court either (1) in the district where you reside, (2) where you have your principal place of business, (3) where DOE's records are situated, or (4) in the District of Columbia.

Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer. The contact information for OGIS is as follows:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Road-OGIS
College Park, Maryland 20740-6001
E-mail: ogis@nara.gov
Phone: 202-741-5770
Toll-free: 1-877-684-6448
Fax: 202-741-5769>

Processing Update & Final Release Target Date
BPA continues to review and process the remaining records collected in response to your request. Those remaining records are potentially subject to the application of 5 U.S.C. § 552(b)(4). In light of the above conditions and determinations BPA currently estimates the final release to your FOIA request by September 9, 2022. BPA invites you to contact us to narrow the scope of your request, if desirable, or to discuss the estimated completion date.

Questions about this communication or the status of your FOIA request may be directed to the FOIA Public Liaison Jason Taylor at jetaylor@bpa.gov or 503-230-3537. Questions may also be directed to E. Thanh Knudson, Case Coordinator (ACS Staffing Group), at 503-230-5221 or etknudson@bpa.gov.

Sincerely,

Candice D. Palen
Freedom of Information/Privacy Act Officer

Attachments / Enclosures: Agency records responsive to FOIA request BPA-2021-00513-F accompany this communication.

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: $)

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.)

Does this award result from an Information For Bid?
☐ Yes ☒ No

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: [redacted]
Office:

Electronic Form Approved by CILR- 09/19/2001

From: Fish Support

Sent: Tue Jul 26 17:09:07 2011

To: 'nthakkar@acmebusinessconsulting.com'; 'kendal@aar-crm.com'; 'meganaccd@cableone.net'; 'kellee.murphy@bioanalysts.net'; 'brian.beckley@biomark.com'; 'maria.clark@burnspaiute-nsn.gov'; 'peggy.entzel@wa.nacdnet.net'; 'harrellh@cwu.edu'; 'jeff.randall@ch2m.com'; 'kathy.bangs@co.chelan.wa.us'; 'mickey@cdlandtrust.org'; 'tmiethe@co.clatsop.or.us'; 'cheusser@cdatribe-nsn.gov'; 'jann.eckman@cbfwa.org'; 'dn-ccd@columbiainet.com'; 'smcewen@columbialandtrust.org'; 'pgerttula@columbiaestuary.org'; 'rodd@critfc.org'; ?norma.sanchez@colvilletribes.com'; 'michael.karnosh@grandronde.org'; 'arthurm@wstribes.org'; 'rsalakory@cowlitz.org'; 'crossingborders@q.com'; 'cswcd@custertel.net'; 'warrenasc@comcast.net'; 'rstevens@ewu.edu'; 'nbouwes@gmail.com'; 'environmentaldataservices@gmail.com'; 'sherry.jeffery@hdrinc.com'; 'sdurfee@360comm.net'; 'condonswcd@gmail.com'; 'mary@grmw.org'; 'janice.fisher@hdrinc.com'; 'rich@hinrichsenenvironmental.com'; 'wahs@bmi.net'; 'susan.smith@idfg.idaho.gov'; 'amy.hines@osc.idaho.gov'; 'billcrampton@bendcable.com'; 'debbe.chadwick@oacd.org'; 'rentz@knrd.org'; 'john.robb@kintama.com'; 'kct@inlandnet.com'; 'sherry-swanson@conservewa.net'; 'ireland@kootenai.org'; 'dk@theofficenet.com'; 'info@lrf.org'; 'kstinson@latahsoil.org'; 'tammy@lcfeg.org'; 'argent@lcrep.org'; 'mara.mcmillen@mcmillen-llc.com'; 'joy@methowconservancy.org'; 'msrf@centurytel.net'; 'jtohtz@mt.gov'; 'andrew.purkey@nfwf.org'; 'mary.nolting@noaa.gov'; 'tkoloszar@tnc.org'; 'lynnrasmussen@co.nezperce.id.us'; 'arleenh@nezperce.org'; 'habitat@nwhi.org'; 'emerrill@nwcouncil.org'; 'kims@okanogancd.org'; 'sandy.e.sovay@state.or.us'; 'gransber@ohsu.edu'; 'kim.calvery@oregonstate.edu'; 'kevin.obrien@otak.com'; 'janie.vickerman@pnl.gov'; 'pam_kahut@psmfc.org'; 'cpaulsen@spiritone.com'; 'phil@pctrask.com'; 'pcdistrict@qwestoffice.net'; 'edward.pinkos@pgn.com'; 'tierney@pdx.edu'; 'chris@qcinc.org'; 'ytahp@scwrcd.org'; 'lese@cskt.org'; 'krista.coelsch@or.nacdnet.net'; 'pwaterhouse@sbtribes.com'; 'paradise.alicia@shopai.org'; 'keith@sitkatech.com'; 'win.goodbody@gmail.com'; 'carol@southforkresearch.org'; 'lorettam@spokanetribe.com'; 'ccryan@synergyhq.com'; 'wardski@wildblue.net'; 'jennifer.oneal@tetratech.com'; 'angie@tricountycwma.org'; 'brian.burns@tristatesteelheaders.com'; 'sbradshaw@tu.org'; 'julieburke@ctuir.org'; 'ucd@gorge.net'; 'hnelson@uidaho.edu'; 'margaret.roberts@umontana.edu'; 'jroshan@uw.edu'; 'derek.vanmarter@ucsrb.com'; 'lori@ucut-nsn.org'; 'heather.ray@uppersnakerivertribes.org'; 'ben.j.hausmann@usace.army.mil'; 'skobes@usbr.gov'; 'bneuman@pn.usbr.gov'; 'patricia_crandell@fws.gov'; 'joan_george@fws.gov'; 'bob_haverkate@fws.gov'; 'linda_hoffmeister@fws.gov'; 'sharon_hooley@fws.gov'; 'rd_nelle@fws.gov'; 'lori_orr@fws.gov'; 'peter_schmidt@fws.gov'; 'dchurch01 @fs.fed.us'; 'bcoffin@fs.fed.us'; 'pdawson@fs.fed.us'; 'rdobson@fs.fed.us'; 'jplatz@fs.fed.us'; 'kpolivka@fs.fed.us'; 'tsmergut@fs.fed.us'; 'rthurow@fs.fed.us'; 'egordon@usgs.gov'; 'jschei@usgs.gov'; 'swinkler@usgs.gov'; 'wendy.harris@wwbwc.org'; 'janet.snell@wwcc.edu'; 'rick.jones@my180?net'; 'ron.graves@or.nacdnet.net'; 'haje461@ecy.wa.gov'; 'sheri.combs@dfw.wa.gov'; 'wid.mw@machmedia.net';

'judy.potter403@gmail.com'; 'debbie@yakama.com'; 'adrienne@yakama.com'

Cc: Avocette,Wynn G - KEWU-4; Baesler,Greg - KEWM-4; Baugher,John R (BPA) - KEWL-4; Beaty,Roy E (BPA) - EWU-4; Brady,Jan E (BPA) - EWM-4; Branum,Sarah T (BPA) - DKR-7; Brown,Cecilia K (BPA) - EWM-4; Byrnes,David M (BPA) - KEWM-4; Connor,Joseph W (BPA) - EWU-4; Creason,Anne M (BPA) - EWL-4; DeHerrera,Joe (BPA) - KEWM-4; Dick,Ben M (BPA) - EWB-4; Docherty,Deborah L (BPA) - EWM-4; Dondlinger,Gregory J (BPA) - E-4; Fife,Sandra A (BPA) - EWM-4; Fisher,Kathy P (BPA); Foster,Marchelle M (BPA) - DIT-7; Frye,Suzanne L ?BPA) - EWU-4; Furey,Chris H (BPA) - ECT-4; Geiselman,Jim (BPA); Gislason,Jeff (BPA); Golden Jr,Richard L (BPA) - EWL-4; Grant,Sharon D (BPA) - EWU-4; Haight,Mary Todd (BPA) - EWU-4; Hauser,Tracy L (BPA) - EWL-4; Hermeston,Linda L (BPA) - KEWU-4; Ifama,Adanna M (BPA) - KEWB-4; Kaplowe,David J (BPA) - EWM-4; Karnezis,Jason P (BPA) - EWL-4; Krueger,Paul Q (BPA); L'Heureux,Andre L (BPA) - EWU-4; Lofy,Peter T (BPA) - EWU-4; Mandish,Timmie A (BPA) - KEWL-4; Marcotte,Jay G (BPA) - KEWU-4; Matthew,Carlos J (BPA) -?EWU-4; Mazaika,Rosemary (BPA) - ECP-4; McClintock,Gerald (BPA) - EWB-4; McCloud,Jonathan M (BPA) - EWM-4; Mendenhall,Alicia A (BPA) - EWB-4; Mercier,Bryan K (BPA) - EW-4; Pansky,Tom (BPA) - EWB-4; Read,Christine L (BPA) - EWB-4; Renner,Marcella P (BPA) - E-4; Roberts,David A (BPA) - EWU-4; Scranton,Russell W (BPA) - EWP-4; Shields,Barbara A (BPA) - EWM-4; Skidmore,John T (BPA) - EWL-4; Smith,Patricia R (BPA) - KEWU-4; Stier,Jeffrey K (BPA) - E-4; Cleveland,Jamie A (BPA) - EWU-4; Van Leuven,Kristi J (BPA) -?NSSP-4; Janssen,Michele L (CONTR) - EWB-4; Watts,Virgil L (BPA) - EWM-4; Welch,Dorothy W (BPA) - EWM-4; Woodall,Cheryl A (BPA) - KSL-4; Yarman,Jennifer A (CONTR) - EW-4; Yerxa,Tracey (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - EWP-4

Subject: FY2011 BPA Year-end Accrual Submittal -- Please open immediately

Importance: High

Dear BPA Fish & Wildlife contractor,

You have been identified by your COTR as the point of contact for your organization on at least one contract, to submit an accrual estimate for fiscal year (FY) 2011which ends September 30, 2011. If you believe this is an error, please notify fishsupport@bpa.gov immediately and provide the name of the correct Accrual Contact no later than July 31, 2011.

Accrual entry for the FY2011 year-end close begins August 1. Although the official end of the fiscal year is September 30, BPA must close its books on September 28 to allow sufficient time for processing invoices and payments.

This year, as in previous years, contractors will enter accrual estimates directly into Pisces, BPA's software tool for managing contracts in the Fish and Wildlife Program. Starting on Friday, July 29, you will find a new help document located at http://www.efw.bpa.gov/contractors/reporting/Accruals/docs/Year_end_instructions.pdf, where you will find illustrated instructions, as well as examples about what to include and how to calculate your accrual estimate. If you do not have a Pisces account, or if you need help, please contact the Pisces team at fishsupport@bpa.gov.

If you would prefer to talk to a live person, our program analyst Alicia Mendenhall (503-230-3774) and our accountant Ben Dick (503-230-3346) are happy to answer your questions. For questions about a specific contract, please contact your COTR.

Accrual estimates must be entered in Pisces no later than September 10, 2011.

Your participation is essential and appreciated. Thank you for your cooperation.

Fish Support (GM)
Bonneville Power Administration
fishsupport@bpa.gov
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BPA-2021-00513-F 0090

From: Fish Support

Sent: Wed Oct 03 08:32:10 2012

To: 'jasonv@nezperce.org'; 'rickz@nezperce.org'; 'habitat@nwhi.org'; 'golc@critfc.org'; 'christine.mallette@state.or.us'; 'christine.mallette@state.or.us'; 'cindi.confer@dfw.wa.gov'; Fisher,Kathy P (BPA); Beaty,Roy E (BPA) - EWU-4; Welch,Dorothy W (BPA) - EWM-4; Zelinsky,Benjamin D (BPA) - EWP-4; 'adam.haarberg@oacd.org'; 'allenchilds@ctuir.org'; 'info@lrf.org'; 'andrew.purkey@nfwf.org'; 'andrew.purkey@nfwf.org'; 'akohler@sbtribes.com'; 'angelas@nezperce.org'; 'gfid13@360comm.net'; 'wahs@bmi.net'; 'barryh@cskt?org'; 'billa@nezperce.org'; 'billa@nezperce.org'; 'billa@nezperce.org'; 'billcrampton@bendcable.com'; 'bill.muir@noaa.gov'; 'bill.muir@noaa.gov'; 'bill.muir@noaa.gov'; 'bill@ucut-nsn.org'; 'billy@nezperce.org'; 'parb@critfc.org'; 'rosb@yakamafish-nsn.gov'; 'rosb@yakamafish-nsn.gov'; 'brian.c.jonasson@state.or.us'; 'brianzimmerman@ctuir.org'; 'brianzimmerman@ctuir.org'; 'brianzimmerman@ctuir.org'; 'brucem@nezperce.org'; 'brucem@nezperce.org'; 'bruce_schmidt@psmfc.org'; 'cholderman@kootenai.org'; 'cpaulsen@spiritone.com'; 'cbrun@hrecn.net'; 'cbrun@hrecn.net'; 'cbrun@hrecn.net'; 'chris.fisher@colvilletribes.com'; 'chris.jordan@noaa.gov'; 'mccd@critfc.org'; 'rawdidr@dfw.wa.gov'; 'rawdidr@dfw.wa.gov'; 'daniel.roby@oregonstate.edu'; 'daves@nezperce.org'; 'daves@nezperce.org'; 'peterdjp@dfw.wa.gov'; 'peterc@nezperce.org'; 'wid.mw@machmedia.net'; 'timothy.l.hoffnagle@state.or.us'; 'ewann.berntson@noaa.gov'; 'sharon_hooley@fws.gov'; 'amikkelsen@cdatribe-nsn.gov'; 'amikkelsen@cdatribe-nsn.gov'; 'jjand@u.washington.edu?; 'jjand@u.washington.edu'; 'emerrill@nwcouncil.org'; 'emerrill@nwcouncil.org'; 'patricia_crandell@fws.gov'; 'osprey@qwestoffice.net'; 'don.larsen@noaa.gov'; 'bfiander@yakama.com'; 'sharp@yakama.com'; 'sharp@yakama.com'; 'sharp@yakama.com'; 'sharp@yakama.com'; 'wardski@wildblue.net'; 'wardski@wildblue.net'; 'barry.berejikian@noaa.gov'; 'brian.wolcott@wwbwc.org'; 'peter_schmidt@fws.gov'; 'jnuckols@tnc.org'; 'aeddingsaas.sbtribes@gmail.com'; 'kathy.cousins@idfg.idaho.gov'; 'coby@grmw.org'; 'olsonjpo@dfw.wa.gov'; 'rich.watson@dfw.wa.gov'; 'rich.watson@dfw.wa.gov'; 'brad.houslet@wstribes.org'; 'rod.a.french@state.or.us'; 'will@ykfp.org'; 'tom.a.rien@state.or.us'; 'stephen_pastor@fws.gov'; 'kelly.s.stokes@state.or.us'; 'gary.johnson@pnl.gov'; 'dicerid@dfw.wa.gov'; 'lyle@grmw.org'; 'ron.graves@or.nacdnet.net'; 'ron.graves@or.nacdnet.net'; 'craigr@nezperce.org'; 'des.maynard@noaa.gov'; 'rogb@yakamafish-nsn.gov'; 'rogb@yakamafish-nsn.gov'; 'richardc@nezperce.org'; 'geneshippentower@ctuir.org'; 'dn-ccd@columbiainet.com'; 'oftl@critfc.org'; 'matt@sitkatech.com'; 'jzendt@ykfp.org'; 'tovatillinghast@gorge.net'; 'brianmahoney@ctuir.org'; 'sherry.jeffery@hdrinc.com'; 'cathy.nowak@state.or.us'; Hilliard Creecy,Jamae (BPA) - PTK-5; 'michael.rayton@colvilletribes.com'; 'bcoffin@fs.fed.us'; 'sue.g.beilke@state.or.us'; 'richard.whitney@colvilletribes.com'; 'ajvitale@cdatribe-nsn.gov'; 'ajvitale@cdatribe-nsn.gov'; 'beckyj@nezperce.org'; 'beckyj@nezperce.org'; 'jennifer_bayer@usgs.gov'; 'jennifer_bayer@usgs.gov'; 'mike.peterson@idfg.idaho.gov'; 'tom.iverson@cbfwa.org'; 'ryan.hardy@idfg.idaho.gov'; 'geoffrey.s.whisler@state.or.us'; 'pinecreek@wildblue.net'; 'ed.shallenberger@colvilletribes.com'; 'ed.shallenberger@colvilletribes.com';

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Subject: FY2012 Cost Share Funding Plan Submission Deadline October 31, 2012

Importance: High

Attachments: Cost_Share_Help_Document_External_FY2012.doc

Dear Project Lead,

For those projects funded in FY2012 we are asking project sponsors to input the amount and source of cost share funding secured for their projects in FY12 (October 1, 2011 – September 30, 2012). **Please update your cost share information by Wednesday, October 31, 2012.** Your contribution is important to ensure the information on your project that is captured in Pisces is accurate and based on updated information from you, the sponsor. Even if you did not receive cost share funding in FY12, please confirm this fact by simply submitting your cost share plan in Pisces.

Why Collect Updated Cost Share Data?

Reporting the level and source of cost share funding associated with projects in the Fish and Wildlife Program demonstrates transparency, the broad base of partnership and funding associated with regional fish and wildlife rebuilding efforts, and cost-effectiveness in program implementation spending from all sources.

Confirming and quantifying cost share data is most important in areas of shared authority, where reasonable cost sharing can demonstrate that BPA funding is not supplanting that (or "in lieu") of another entity already authorized or required to undertake the activity. As projects are implemented, the nature and extent of another entity's authority or requirements to undertake the activity may change. New or additional information about the amount and nature of cost sharing offered may emerge.

For guidance about how to account for cost share funding in each fiscal year, and a glossary of terms used in this activity, please see the attachment, or visit our website at http://www.efw.bpa.gov/contractors/reporting/costshare.aspx.

If you have any questions, please contact your BPA Project Manager. Thank you for your participation.

Fish Support (Gerald)

Bonneville Power Administration

fishsupport@bpa.gov

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P **Please consider the environment before printing this email.**

Topic

Cost Share

Background

The Fish and Wildlife Program must be able to identify and confirm the amounts and sources of cost share funding for each of its projects.

Discussion

A couple of key aspects of Cost Share:

- Cost share entry is built on a hierarchy
  - *Funding Source (who is providing the funds)*
    - *Item (i.e., purpose for the funds. May have multiple items per funding source)*
      - *Fiscal Year*
- Proposed Cost Share is neither expected nor allowed at this point. All projects with proposed cost share were submitted during the FY2007-09 Council solicitation
- Even if no cost share was proposed or received, the sponsor is still expected to submit a cost share report
- Once a cost share report is Submitted changes can only be made by the BPA project manager. To allow the sponsor to make the changes the report must be "Unsubmitted" or returned (only Fish Support can do this)

The cost share data entry will enable our project sponsors to provide us with the most up-to-date information. This is especially important for project work in areas of shared responsibility, where cost sharing can demonstrate that BPA's funding is not supplanting that of (or "in lieu" of) another entity already authorized or required to undertake the activity.

Beginning with the submission of cost share for FY2010, no values, proposed or actual, will be displayed on the Cost Share tab. Previous years were automatically entered as a part of the FY2007-2009 solicitation for those projects that had identified cost share during the review. Going forward, only actual values are required/allowed. We will ask sponsors to update this information once per year, in late October.

After the close of each fiscal year, individuals identified as Project Leads in each Project Contact List will receive auto-emails inviting them to confirm and/or update their cost share information in Pisces. Notifications will only be sent for those projects that had a BPA approved budget for the previous fiscal year.

Guidance for entering cost share data, including a glossary of terms, will be posted at http://www.efw.bpa.gov/contractors/reporting/costshare.aspx. BPA Project Managers will be available to advise how to complete this activity.

Details

The following is a description of the steps necessary for project leads. The only action necessary on the part of BPA Project Managers is to click the Confirm button (located in the same place as the submit button in Figure 2 below). You will receive a notification that a cost share estimate has been submitted (this works similarly to Status Report submissions).

Cost Share Timing

- For "cash" cost share, use the date that money was spent on a given item.
- For "in-kind" cost share, use the date that the materials were acquired or the date(s) on which the service or labor occurred.

Terms:

Cost share – For our purposes, the term covers funds or donations that directly support a project in the Council's Fish and Wildlife Program.

Source - The agency or organization providing the original funding for the cost share.

Item - A brief description of the work, service, or item that makes up the cost share.

Fiscal Year - The Federal fiscal year (10/1 - 9/30) in which the cost share occurs. See Cost Share Timing below for more information.

Cash - Cost share that is paid for with money.

In-kind - Cost share that is donated. In-kind may include materials, labor, or services.

To submit your FY2012 cost share open the project (not the contract). From My Stuff, right click on a contract and select View Project then click on the Cost Share tab. Or using the new quick access tool click File > Open, type the project number into the field and press enter. Then click the Cost Share tab.

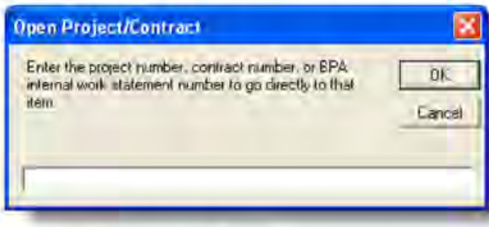

Figure 1 (Quick Access dialog)

You will notice there are no FY2012 entries on the cost share tab. This was done to prevent requiring you from entering zeros needlessly. The downside is you will have to add a fiscal year for each item you do have cost share. When you first enter the cost share tab, note the 3 buttons at the top, "Add Funding Source...", "Add Item", and "Add Fiscal Year." The cost share screen is hierarchical; in other words, depending on which level of the tree you select, only certain buttons are available. Add Funding Source is always available. Add Item (use or purpose of the funding) is enabled when a funding source is selected. Add Fiscal Year is enabled only when an item is selected. In the example below, Oversight and Planning is selected (denoted by the gray box around the entire field).

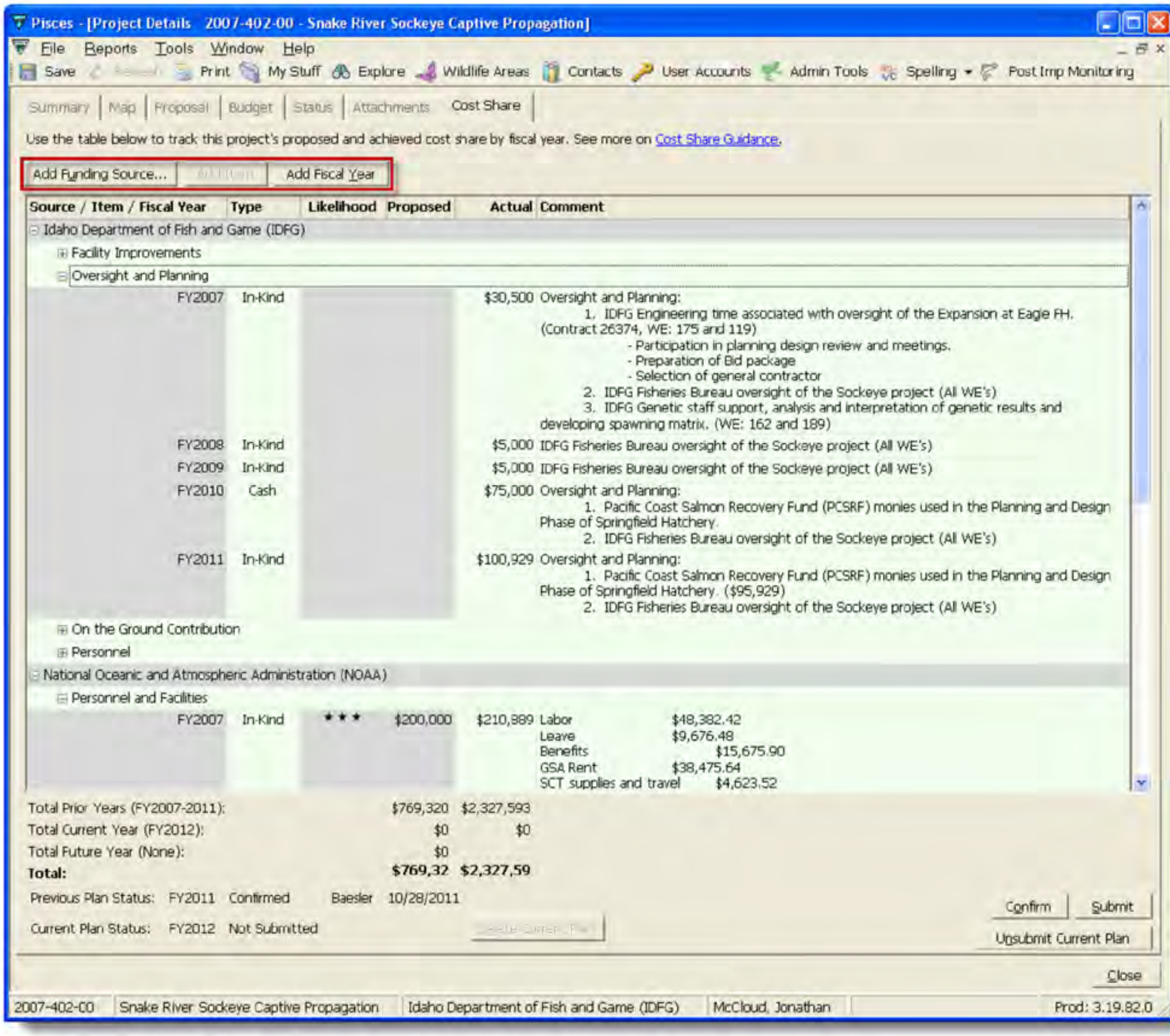

Figure 2 (Project Cost Share sample)

Review the cost share funding sources and items of your project (if any).

1. If your project did not obtain any cost share during the FY2012, you still need to click "Submit."
2. Determine if the list of funding sources and items are complete.
3. If you only need to add a fiscal year, go to 7 below, otherwise continue.
4. To add a new funding source click Add Funding Source button, select an organization from the dropdown list. If you do not find the organization you are looking for be sure to check variants of the name (e.g., US Bureau of Reclamation instead of Bureau of Reclamation). If the organization cannot be found send an email to fishsupport@bpa.gov and request the organization be added. **Please note:** the funding source should be the originator of the monies (e.g., Pacific Coast Salmon Recovery Fund dollars come from NOAA-Fisheries).

Figure 3 (Add Funding Source)

5. Click the Add Item, and a new line appears under the "Funding Source" just identified. Enter a title that describes what the cost share was to go toward. **Note:** Cost share is not a valid item description.
6. Click the Add Fiscal Year button (FY2012 will appear) and choose Cash or In-kind for the type.
7. Finally, enter the amount of cost share received.
8. For additional funding sources repeat steps 5-7, for additional items, repeat steps 6 and 7.
9. When you've updated all pre-existing cost share items and/or added new ones, click the Submit button in the lower right corner of the screen. This will send an email to the BPA Project Manager alerting them you've submitted your cost share data. When the BPA PM confirms receipt of your submission, you will receive an email in return.

From: Scranton,Russell W (BPA) - EWP-4

Sent: Mon Jun 10 08:27:40 2013

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Subject: BPA Reporting Pilot Reminder

Importance: Normal

Attention: To all sponsors conducting RM&E and submitting technical reports or FCRPS RPA reports.

This is a reminder that BPA's pilot effort to test reporting tools for our new mandatory calendar year reporting is coming to a close. To participate in the pilot, sponsors have until the June 28th to submit either draft or final reports along with comments to RMEsupport@bpa.gov. As of May 30th about 15 sponsors have submitted annual reports to their COTRs and BPA's RM&E support team. For Sponsors who wish to submit additional comments, some suggested topics are:

1. The annual report technical content that was pre-populated directly from Pisces and Taurus (this content is found in the web-based template on cbfish.org);
2. The function of the outline for the technical report outline template found on cbfish.org;
3. The due date of reports: drafts in January, and final reports in March; and
4. If applicable, the BiOp online report tool.

In addition Council State staff (WA: Stacy Horton, shorton@nwcounci.org, OR: Karl Weist kweist@nwcouncil.org, ID: Jeff Allen jallen@nwcouncil.org; and MT Raquel Crosier rcrosier@nwcounci.org have offered their support to solicit feedback on the tools and process as well. Upon completion of the pilot, BPA will review comments and establish a mandatory technical reporting process for 2013 reports beginning in the spring of 2014. If you have any questions please contact, BPA's RM&E support team, your state's council staff representative listed above, or your COTR.

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BPA-2021-00513-F 0105

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Subject: Pisces Status Report late notice: BPA may be unable to pay your next invoice

Importance: Normal

Dear Contractors,

You will notice that we have endeavored to use the data in Pisces to remind you that you have upcoming (5 days ahead), or late Status Reports.

We will be more conscientious and consistent about reminders in the future because we are improving our enforcement of BPA’s invoice payment process.

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BPA Fish and Wildlife has been somewhat lax in contract enforcement and we have often been willing to pay invoices without full and proper contract reporting.

We will now require status reporting to be current before an invoice is paid. If a status report is more than 2 weeks overdue, invoices covering the unreported period will not be paid.

Reporting has always been required, but BPA will be enforcing this with more diligence than in the past.

++++++

What does this mean for me as a contractor?

a) We want to pay your invoices on time, and do not want to return any invoices due to late reports.

b) We will be giving you more reminders, to help you submit your reports on time. These reminders have always been available to select, but some contractors were not aware they were available. These are now automated and will let you know if you're late enough to jeopardize invoice payment. See example below.

c) Going forward, if BPA has received an invoice for a period for which the Pisces Status Report has not been submitted, BPA will be informing the contractor, and returning the invoice unpaid. Once the report is submitted, the contractor can re-email the invoice to the BPA invoice team.

d) If you always submit your Pisces Status Reports on time, you will not notice much change. The only change is that you may receive additional reminders before the end of the reporting period to "gather your thoughts" in preparation for your report, which is either due the last day of the contract (if the contract expiration is imminent) or 15 days after the reporting period has expired (for all other reports).

If you have any question, please contact your COTR.

Peter Lofy

BPA Fish and Wildlife Supervisor

++++++ EXAMPLE ++++++++++++++++++++++++++++++++++

From: Jamie Swan <jaswan@bpa.gov>
Date: April 1, 2014 at 3:01:45 AM PDT
To: <brian.cochran@wstribes.org>
Subject: BPA may be unable to pay your next invoice. 15 days ago, milestone "(XXX)" was due.

Dear Brian,

Without a submitted Status Report, BPA has no basis upon which to pay your next invoice. Please submit it.

Milestone "(XXX)" of work element "(XXX)" on (XXX) under project #(XXX) ("(XXX)") was due on (XXX) and has not been marked complete.

If you feel this email has reached you in error, please contact (XXX).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Lofy,Peter T (BPA) - EWU-4

Sent: Thu Apr 17 12:17:24 2014

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Subject: [revised] Pisces Status Report late notice: BPA may be unable to pay your next invoice

Importance: Normal

I have had a lot of great feedback so far.

Instead of asking your COTRs questions, as I originally requested, please direct any questions about this email to me instead.

I will follow up with FAQs that you have posed as a group, instead of replying to individual emails, if others could benefit from the answers.

Second, I need to make a couple of apologies.

1) Old email example. By the way, the previous example at the bottom was a randomly selected contactor and COTR for format only. Brian has not been late on his reports. I apologize to Brian for any misconception that might have occurred.

I have replaced his, and his COTR's name with "generic" references to names.

2) This was supposed to go to only to contacts with active contract. I apologize to those of you who got this, and have no active contracts. It will take us a while to redo the list. In the meantime, please bear with us as we refine the list. Please disregard if you have no active BPA contracts. Please do not email me back. We are in the midst of correcting the list.

Thanks for your patience.

Peter

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Dear Contractors,

You will notice that we have endeavored to use the data in Pisces to remind you that you have upcoming (5 days ahead), or late Status Reports.

We will be more conscientious and consistent about reminders in the future because we are improving our enforcement of BPA's invoice payment process.

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BPA Fish and Wildlife has been somewhat lax in contract enforcement and we have often been willing to pay invoices without full and proper contract reporting.

We will now require status reporting to be current before an invoice is paid. If a status report is more than 2 weeks overdue, invoices covering the unreported period will not be paid.

Reporting has always been required, but BPA will be enforcing this with more diligence than in the past.

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What does this mean for me as a contractor?

a) We want to pay your invoices on time, and do not want to return any invoices due to late reports.

b) We will be giving you more reminders, to help you submit your reports on time. These reminders have always been available to select, but some contractors were not aware they were available. These are now automated and will let you know if you're late enough to jeopardize invoice payment. See example below.

c) Going forward, if BPA has received an invoice for a period for which the Pisces Status Report has not been submitted, BPA will be informing the contractor, and returning the invoice unpaid. Once the report is submitted, the contractor can re-email the invoice to the BPA invoice team.

d) If you always submit your Pisces Status Reports on time, you will not notice much change. The only change is that you may receive additional reminders before the end of the reporting period to “gather your thoughts” in preparation for your report, which is either due the last day of the contract (if the contract expiration is imminent) or 15 days after the reporting period has expired (for all other reports).

If you have any question, please contact your COTR.

Peter Lofy

BPA Fish and Wildlife Supervisor

++++++ EXAMPLE ++++++++++++++++++++++++++++++++++

From: C.O. Tar <COTR@BPA.gov>
Date: April 1, 2014 at 3:01:45 AM PDT
To: <Jane Doe@fictitious_entity.org>>
Subject: BPA may be unable to pay your next invoice. 15 days ago, milestone "(XXX)" was due.

Dear Jane,

Without a submitted Status Report, BPA has no basis upon which to pay your next invoice. Please submit it. Milestone "(XXX)" of work element "(XXX)" on (XXX) under project #(XXX) ("(XXX)") was due on (XXX) and has not been marked complete.

If you feel this email has reached you in error, please contact (XXX).

Thank you,

Environment Fish and Wildlife
Bonneville Power Administration

From: Salmon Ocean Ecology Meeting

Sent: Tue Jan 20 11:38:29 2015

To: alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; alex.wertheimer@noaa.gov; aedsall@aptalaska.net; abidlack@ecotrust.org; amy.brookman@vemco.com; Andres.Araujo@dfo-mpo.gc.ca; Andrew.Claiborne@dfw.wa.gov; andrew.gray@noaa.gov; andrew.piston@alaska.gov; andy.wink@mcdowellgroup.net; osterbac@biology.ucsc.edu; amcreason@bpa.gov; anne.reynolds@alaska.gov; arnold.ammann@noaa.gov; Asit Mazumder; bashields@bpa.gov; Barry.Berejikian@noaa.gov; Ben_Becker@nps.gov; bvanalen@fs.fed.us; ben.sandford@noaa.gov; bev.agler@alaska.gov; bill.heard@noaa.gov; bill.muir@noaa.gov; bill.smoker@uaf.edu; William Sydeman; bill.peterson@noaa.gov; robert.emmett@noaa.gov; smirnov@vniro.ru; brendan.lehman@noaa.gov; bbair@fs.fed.us; brian.burke@noaa.gov; Brian Ma; brian.wells@noaa.gov; Bridget E. Ferriss; Bridget E. Ferriss; bruce.macfarlane@noaa.gov; Bruce Wallace; bruce.wing@noaa.gov; Cameron Freshwater; cara.wilson@noaa.gov; cjmahara@fs.fed.us; cathy.robinson@alaska.gov; cbracis@uw.edu; cbyron@gmri.org; charles.brazil@alaska.gov; charlie?petrosky@idfg.idaho.gov; megan.lovejoy@alaska.gov; cheryl.morgan@noaa.gov; chris.habicht@alaska.gov; cvmanhard@alaska.edu; chris@tirn.net; Christie Hendrich; Churchill.Grimes@noaa.gov; colleen.petrik@noaa.gov; curtis.roegner@noaa.gov; cynthia.bucher@noaa.gov; cyril.michel@noaa.gov; davebea@u.washington.edu; dave.griffith@noaa.gov; david.sterritt@alaska.gov; David.Cook@scwa.ca.gov; david.demer@noaa.gov; david.huff@noaa.gov; david.kuligowski@noaa.gov; david.manning@scwa.ca.gov; dave.pwsac@ak.net; david.rupp@oregonstate.edu; dstormer@uvic.ca; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; David Welch; Deborah.Harstad@noaa.gov; denise.king@vemco.com; Dennis.E.Schwartz@usace.army.mil; des.maynard@noaa.gov; Devon.Pearse@noaa.gov; beamishr@pac.dfo-mpo.gc.ca; dion.oxman@alaska.gov; donlyons@oregonstate.edu; Douglas.Demaster@noaa.gov; doug.jackson@noaa.gov; edmundo.casillas@noaa.gov; Ed.Farley@noaa.gov; egneal@usgs.gov; ejduffy@u.washington.edu; Elizabeth.Daly@oregonstate.edu; Elizabeth Phillips; Ellen Chenoweth;?Ellen.Martinson@noaa.gov; emily.fergusson@noaa.gov; emily.frederick@alaska.gov; epalkova@ucsc.edu; Eric.Anderson@noaa.gov; eric.bjorkstedt@noaa.gov; eric.buhle@noaa.gov; eric.crandall@noaa.gov; eric.danner@noaa.gov; Eric Hertz; Chum Troller; eric_prestegard@dipac.net; jenkins7@uvic.ca; erick.sturm@noaa.gov; erschoen@uw.edu; garold.pryor@alaska.gov; flora.cordoleani@noaa.gov; juanes@uvic.ca; Frank.thrower@noaa.gov; Franz Mueter; martinek@ak.net; Geoffrey.Mcmichael@pnl.gov; greeves@fs.fed.us; graham.goulette@noaa.gov; grant.hagerman@alaska.gov; sbrandy@fs.fed.us; gruggerone@nrccorp.com; gretchen.harrington@noaa.gov; gunnar.knapp@uaa.alaska.edu; geiger@alaska.com; Jason Hassrick; heather.kerkering@hawaii.edu; heather.stout@noaa.gov; hilary.wood@alaska.gov; igb5@cornell.edu; imkemp@uw.edu; aki@ak.net; Jamal Moss - NOAA Federal; james.hawkes@noaa.gov; james.losee@noaa.gov; James Irvine; jamison.clark@alaska.gov; Jan.Straley@uas.alaska.edu; Janelle Mueller; Hassrick, Jason;

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Subject: Registration Reminder for Salmon Ocean Ecology 2015

Importance: Normal

Hi everyone,

This is just a reminder that registration is open for the 2015 Salmon

Ocean Ecology Meeting in Victoria, B.C. on March 25th and 26th

(https://www.eventbrite.com/e/2015-salmon-ocean-ecology-meeting-tickets-14462219889). The general registration rate is $160 (CAD) with a student registration rate of $80. The registration and abstract deadline is **February 14, 2015,** but if possible, registering now and submitting your abstract before February 14th is encouraged. Please visit our website (http://salmonoceanecology2015.weebly.com/) for more information.

There is a block of rooms reserved at discount rates (starting at $85) at

the Harbour Towers, the hotel where the meeting will be held

(https://booking.ihotelier.com/istay/istay.jsp?hotelid=13405&rateplanid=1583392&identifier=SALMON). We encourage participants who require a hotel to take advantage of this block of rooms to help the organizers avoid the financial penalties that will be incurred if the block is not fully utilized.

Prior to the Salmon Ocean Ecology Meeting, this year we are also hosting an optional, free, International Science - Salmon Forecasting Workshop on March 24th. The goal of the workshop is to maintain coast-wide discussions about current ocean conditions and how they might impact salmon survival. Discussions will focus on the North Pacific warm blob, the (hidden) PDO signature, the potential El Niño, coastal primary productivity, and how all of these may relate to salmon survival in the ocean.

Thanks and hope to see you there,

Eric Hertz, Will Duguid and Cameron Freshwater

From: Salmon Ocean Ecology Meeting

Sent: Fri Mar 06 14:25:51 2015

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Subject: SOEM agenda

Importance: Normal

Attachments: SOEM agenda.docx

Hi all,

Attached please find the agenda for the 2015 Salmon Ocean Ecology Meeting. If you are interested in attending the optional forecasting workshop on March 24th and have yet to sign up, please let us know as soon as possible.

We have a total of 37 talks over the two day Salmon Ocean Ecology Meeting, covering everything from magnetic ocean navigation to bird predation, and everything in between. Talks will be 15 minutes long, with 5 minutes for questions. We will be running a PC for all presentations. There will be a poster session following the talks on Wednesday (March 25th), and this will be followed by a reception dinner at The Breakwater Cafe and Bistro. We will continue the tradition of the Forecasting Contest at the Breakwater Cafe, so bring your best (or worst) forecast from the previous year...

Lunch and coffee breaks will be provided on the 25th and 26th. Please let us know if you have any other questions,

Thank you,

Eric, Will and Cam

16th Salmon Ocean Ecology Meeting Agenda

Harbour Towers, Victoria, British Columbia

Tuesday, March 24th: Optional Workshop (Salon B)

8:00-8:45 AM	Registration in Mezzanine: East Harbour Ballroom
8:45-9:00:	Coffee at Mezzanine: East Harbour Ballroom
9:00-12:30:	Part I: Ocean Salmon Forecasting
12:30-2:00	LUNCH BREAK
2:00-5:00	Part II: Ocean Salmon Forecasting
7:00	Optional dinner reservations @ TBA

Wednesday, March 25th

8:00-8:30	Registration in Mezzanine: East Harbour Ballroom
8:30-8:40	Welcoming remarks
8:40-9:00	2014 Ocean Update. **Brian Burke**
	Session I: Diet and Trophic Interactions
9:00-9:20	Interannual variability in the diets and survival of subyearling Chinook salmon with consideration of oceanographic conditions. **Elizabeth Daly**
9:20-9:40	The influence of shellfish aquaculture on abundance and diet of juvenile Pacific salmon. **Brenna Collicutt**
9:40-10:00	Marine-estuarine trophically transmitted parasites indicate estuarine foraging and suggest differences between natural-origin and hatchery-produced Mid/Upper Columbia River spring Chinook salmon (*Oncorhynchus tshawytscha*). **K.C. Jacobson**
10:00-10:20	Effects of starvation on the isotopic ratios of nitrogen and carbon: an experiment on juvenile Chinook Salmon and meta analysis. **Eric Hertz**
10:20-10:50	COFFEE BREAK
10:50-11:10	Potential impacts of climate change on the trophic ecology and production of juvenile salmonids in the California Current**. Ric Brodeur**
11:10-11:30	Lipid and isotope biomarkers: an integrated biochemical approach to understanding juvenile salmon marine feeding ecology. **Marisa N. C. Litz**

Session II: Physical Oceanography, Climate, and Ocean Productivity

11:30-11:50 The use of ecosystem metrics for pre-season forecasts of pink salmon harvest in Southeast Alaska: What have we learned? **Joseph Orsi**

11:50-12:10 Blue highways and roadblocks for California Current steelhead stocks. **Sean A. Hayes**

12:10-12:30 Testing hypotheses for variable effects of climate and competition on sockeye salmon populations across the Eastern North Pacific. **Brendan Connors**

12:30-1:30 LUNCH BREAK

1:30-1:50 Assessment and management of environmental and health factors affecting early marine survival of hatchery reared Coho salmon in the Strait of Georgia, British Columbia, Canada**. Elan Downey**

1:50-2:10 Disentangling freshwater and marine drivers of salmon productivity, survival, and abundances in the CCLME. **Jennifer L. Gosselin**

2:10-2:30 Relative importance of river flow, ocean conditions, and hatchery practices on early ocean growth and overall survival of Central Valley fall run Chinook salmon. **Megan Sabal**

2:30-2:50 COFFEE BREAK

Session III: Salish Sea Marine Survival

2:50-3:10 The Salish Sea Marine Survival Project: An overview and update. **Michael Schmidt**

3:10-3:30 Qualitative analysis of the Puget Sound zooplankton community. **Iris Kemp**

3:30-3:50 Microtrolling: Assessing the feasibility of an economical, non-lethal method to sample and tag juvenile Pacific salmon at sea. **Will Duguid**

3:50-4:10 **Ryan Flagg.**

4:10-4:30 Identifying Critical Periods of Growth and Mortality in Pacific Salmon-Then Deciphering Underlying Mechanisms. **David A. Beauchamp**

4:30-5:30 **Poster Session at Mezzanine: East Harbour Ballroom**

6:30 RECEPTION DINNER – BREAKWATER CAFÉ (see map for location)

Thursday, March 26th

Session IV: Growth, Mortality and Forecasting

8:20-8:40	Forecasting salmon -- Why is it so hard, and what can we do about it? **Tom Wainwright**
8:40-9:00	Quantifying seabird and fish associations near the Columbia River plume to understand predation risk to juvenile salmon. **Elizabeth Phillips**
9:00-9:20	Common productivity trends of pink and chum salmon stocks in western North America. **Michael J. Malick**
9:20-9:40	Delayed mortality of Pacific salmon released as bycatch from commercial fisheries in coastal waters of British Columbia. **K.V. Cook**
9:40-10:00	Stress and disease susceptibility of wild adult Pacific salmon. **A.K. Teffer**
10:00-10:20	An "odd" pattern in Coho Salmon growth and survival off the west coast of Vancouver Island. **Marc Trudel**
10:20-10:50	COFFEE BREAK
10:50-11:10	At what life history stage does relative abundance of Fraser sockeye stocks become 'stable'? **Erica Jenkins**
11:10-11:30	Regional patterns of juvenile coho and chum salmon growth in the Strait of Georgia and surrounding waters. **Meredith Journey**
11:30-11:50	Does ocean avian predation matter to early marine survival of ESA-listed Columbia River salmon? **Jeannette Zamon**
11:50-12:10	Puget Sound and Washington coast steelhead marine survival since 1974: trends and potential drivers. **Neala Kendall**
12:10-1:10	LUNCH BREAK

Session V: Migration and other aspects of salmon biology

1:10-1:30	Stock-specific variability in yearling Chinook salmon migration behavior, as far as we can tell. **Brian Burke**
1:30-1:50	Genetic analysis of the summer steelhead stock composition in the Columbia River and Snake River tribal and sport fisheries from 2011 to 2013. **Alan Byrne**
1:50-2:10	Movement & Survival of Cook Inlet Sockeye & Chinook Salmon Measured Using a Marine Telemetry Array. **Erin Rechisky**
2:10-2:30	Juvenile Life History Strategies of Selected Chinook Salmon Spawning Populations within Puget Sound and the Columbia River, as Inferred From Otolith Microchemistry. **Lance Campbell**
2:30-2:50	The original jet set: Chinook salmon catch distribution in a dynamic ocean. **Peter Lawson**
2:50-3:20	COFFEE BREAK

3:20-3:40	Please don't go! Efforts to increase juvenile salmon retention when using marine mammal excluder devices. **Laurie Weitkamp**
3:40-4:00	Using past survey results to inform future survey design or "How to catch threatened wild juvenile salmon." **Cheryl Morgan**
4:00-4:20	Telemetry-based estimates of early marine survival and travel time of wild juvenile Fraser River sockeye salmon in the Strait of Georgia and Queen Charlotte Strait. **Erin Rechisky**
4:20-4:40	Inherited magnetic ocean navigation in juvenile Pacific salmon (*Oncorhynchus* species). **David Noakes**
4:40-4:45	Closing remarks

From: Erin Rechisky

Sent: Tue Mar 31 13:06:29 2015

To: Anne Creason

Subject: Kintama's published papers on Col R Chinook

Importance: Normal

Attachments: Brosnan et al 2014 Environmental factors and Col R CH plume survival MEPS.pdf; Rechisky and Welch TTM 2010.pdf; Rechisky et al 2013 PNAS Delayed mortality 2006-9.pdf; Rechisky et al 2013 PNAS Reply to Haeseker.pdf; Rechisky et al 2014 Testing for Col R CH delayed mortality MEPS Supplement.pdf; Rechisky et al 2014 Testing for Col R CH delayed mortality MEPS.pdf; Rechisky et al Nature Sci Report (Transport Differential-Delayed Mortality 2012).pdf; Rechisky et al-CJFAS Rapid Communication.pdf; Haeseker Comment on Rechisky PNAS 2013.pdf

Hi Anne,

It was nice to see you last week. As promised, attached are several papers resulting from our PBA funded research on Columbia/Snake R Chinook survival. I have also include Steve Haeseker's comment on our 2013 PNAS paper, as well as our reply to his comment. The PNAs paper covers the work done from 2006-2009. The Rechisky et al. 2014 MEPS paper reports the result for 2010 and 2011 studies, when we captured fish at the dams. Many of the caveats I discussed in the PNAS paper are addressed in the MEPS paper (e.g., release timing, fish size), and in general our results were the same: early marine survival was similar for Columbia and Snake spring Chinook, i.e. delayed mortality was not evident. And in 4 of 5 years, we saw no evidence of delayed mortality due to transportation.

Let me know if you have any questions.

Warm regards,
Erin

Erin Rechisky, PhD

Research Manager

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Contribution to the Theme Section 'Tracking fitness in marine vertebrates'

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Evaluating the influence of environmental factors on yearling Chinook salmon survival in the Columbia River plume (USA)

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ABSTRACT: The impact of oceanographic processes on early marine survival of Pacific salmon is typically estimated upon adult return, 1 to 5 yr after ocean entry, and many 1000s of kilometers after initial exposure. Here, we use direct estimates of early marine survival obtained from acoustic-tagged yearling Chinook salmon *Oncorhynchus tshawytscha* that entered the Columbia River plume (USA) after migrating down the river and then north to the coastal waters off Willapa Bay, Washington. Plume residence time averaged 7 d, and was of such short duration that predation, rather than feeding and growth conditions, was the likely primary cause of mortality. Plume survival ranged from 0.13 to 0.86, but was stable when scaled by plume residence time, and we find that a simple exponential decay model adequately describes plume survival. Plume survival, and perhaps adult returns, could be improved by reducing plume residence time if the drivers controlling residence time were amenable to management control. However, we show that a statistical model of plume residence time that includes only sea-surface temperature far outperforms models that include river discharge and coastal upwelling. Timing hatchery releases using marine environmental forecasts could potentially improve smolt survival by minimizing their residence time in regions of poor survival. Acoustic telemetry may be used to evaluate the value and effectiveness of such approaches.

KEY WORDS: Juvenile salmon · Juvenile survival · Columbia River plume · Acoustic telemetry · Environmental factors

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INTRODUCTION

The Columbia River basin once supported large stocks of Pacific salmon, but their abundance has declined significantly under the combined effects of overfishing, damaging land-use practices, hydropower development, periodically unfavorable conditions for salmon survival in the North Pacific Ocean, and hatchery supplementation that accompanied the industrialization of the Pacific Northwest (National Research Council 1996, Mantua et al. 1997, Coronado & Hilborn 1998). Since the passage of the Endangered Species Act in 1973, 5 of the 7 evolutionarily significant units (ESUs) of Chinook salmon *Oncorhynchus tshawytscha* in the Columbia River basin have been listed as 'Threatened' or 'Endangered' and significant effort has been directed towards understanding the ocean ecology of salmon in the hopes of restoring depleted stocks (Brodeur et al. 2003, USNARA 2012).

Pearcy (1992) suggested that the number of juvenile salmon returning to spawn in their natal streams as adults may be established during the cohort's first month at sea, a 'critical period' of early marine survival. The possibility of predicting, and perhaps influencing, adult returns by elucidating the drivers of early marine survival has subsequently been an important focus for salmon ecologists. Numerous

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environmental variables have been examined for potential relationships with early marine survival. Although some variables lack clear mechanistic links to survival, they are generally related to feeding and growth opportunities, predation, and the effect of experiences in the river on subsequent fitness.

The annual transition to dominant northerly winds in spring, the 'spring transition', drives upwelling of cold nutrient-rich waters that support phytoplankton blooms and advect lipid-rich cold-water copepod species into the marine waters of Oregon and Washington, displacing relatively lipid-poor warm-water species and providing a food web input believed to be favorable for juvenile salmon growth (Huyer et al. 1979, Hickey & Banas 2003, Peterson & Keister 2003, Peterson & Schwing 2003, Schwing et al. 2006). The timing of ocean entry of juvenile salmon relative to the spring transition has been proposed as a driver of early marine survival (Logerwell et al. 2003, Scheuerell et al. 2009; but see Tomaro et al. 2012).

DeRobertis et al. (2005) and Morgan et al. (2005), in companion papers, directly examined the potential relationships between feeding and survival by sampling juvenile salmon and their prey at tidally driven Columbia River plume fronts and in the adjoining plume waters and coastal ocean. They found that the fronts aggregate salmon prey, but found little evidence that juvenile salmon take advantage of the feeding opportunities at the fronts, potentially due to their ephemeral nature. While juvenile salmon may not take advantage of unique feeding advantages presented by the fronts, field sampling and bioenergetics modeling have indicated that they are not food limited in the plume region (Brodeur et al. 1992, Morgan et al. 2005).

Although they may not be food limited, juvenile salmon are subject to predation. Emmett et al. (2006) describe the seasonal migration of predatory Pacific hake *Merluccius productus* into coastal waters off the Columbia River and note that improvements in marine survival of juvenile salmon beginning in 1999 were coincident with a decrease in predator fish abundance. Emmett & Sampson (2007) used a trophic model to demonstrate that high numbers of Pacific hake could account for high mortality of juvenile salmonids leaving the Columbia River. Collis et al. (2002) describe high and increasing proportions of juvenile salmonids in the diets of Caspian terns *Sterna caspia* and double-crested cormorants *Phalacrocorax auritus* from April into May. Colonies studied by Collis et al. (2002) on Rice Island in the mid-Columbia River were subsequently successfully encouraged to nest on East Sand Island (adjacent to the plume), reducing the proportion of their diet that consisted of juvenile salmon (Roby et al. 2002), but potentially increasing predation pressure in the plume. Turbidity in the plume may offer some relief as it has been shown to reduce predation on juvenile salmon (Gregory & Levings 1998, DeRobertis et al. 2003), despite reducing predator avoidance behavior (Gregory 1993).

There may also be latent effects of the river experience on early marine survival; Budy et al. (2002) and Schaller & Petrosky (2007) examined the effects of dam passage and concluded that there is evidence that the hydrosystem experience results in mortality that is delayed into early marine residence. Additionally, as a consequence of water being spilled over the dam faces (to reduce the physical and physiological stressors juveniles are exposed to during dam passage), air is entrained in the river, resulting in gas supersaturation below the dams. Exposure to supersaturated river water may result in gas bubble trauma in juvenile salmon (Bouck 1980), and, even when exposure is non-lethal, it may reduce their fitness and increase their susceptibility to predation (Mesa & Warren 1997).

Other environmental variables that have been associated with early marine survival do not have mechanistic explanations as clear as those described above. Ryding & Skalski (1999) and Cole (2000) linked survival with sea-surface temperature (SST), although when SST was examined in a suite of coastal oceanographic variables, including upwelling, wind mixing, mixed layer depth, sea level, and the timing of the spring transition, it was proven to be a dominant driver and is often an inconsistent predictor of adult returns (Hobday & Boehlert 2001, Koslow et al. 2002, Scheuerell & Williams 2005, Burke et al. 2013). Burla et al. (2010a) considered the effect of plume size and position, which are largely shaped by river discharge and wind-driven current, on juvenile survival and found no significant relationship with Chinook salmon returns and only a very weak relationship with steelhead salmon returns.

Here, we combine 2 novel approaches to gain insight into yearling Chinook survival in the Columbia River plume region, in their first period of marine residency. First, we use acoustic telemetry, which permits direct empirical measures of early marine survival to be evaluated against the environmental conditions experienced by tagged smolts (e.g. Rechisky et al. 2009, Moore et al. 2010, Welch et al. 2011, Thorstad et al. 2012, Melnychuk et al. 2013). This improves on the current approach to identifying critical environmental variables, which primarily relies on correlating them with smolt-to-adult return rates estimated over 1 to 5 yr and many 1000s of miles after exposure.

Second, we recognize that the plume is a region where occupancy is short and predators are rich, and thus it is conceivable that plume survival of telemetered smolts is regulated by their period of exposure (i.e. plume residence time) and that variables associated with survival, but lacking a direct link, may be acting on survival by influencing residence time. Therefore, in our analysis, we (1) evaluate the ability of a simple exponential decay model, equivalent to those used to model the decay of radioactive elements, to describe plume survival data for tagged yearling Chinook, (2) use the model residuals in survival analyses to examine whether measures of biological productivity or gas supersaturation levels, which may directly affect survival, would add additional predictive power to the model, and (3) evaluate the effect of 3 variables, potentially related to survival but lacking clear mechanistic links, on plume residence time. These variables are SST, river discharge and wind-driven surface currents, the latter reflected in the coastal upwelling index. Finally, in light of our findings, we briefly discuss manipulating the dynamics of the Columbia River plume through flow control as a potential mechanism for improving plume survival of salmon (Jacobson et al. 2012).

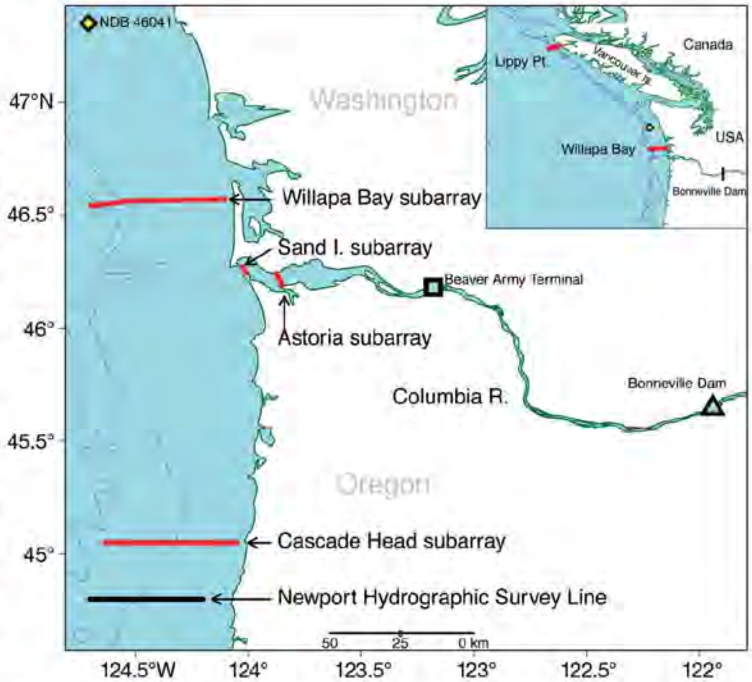

Fig. 1. Study region. The red lines mark the named telemetry sub-arrays. Contour lines mark the 200 m and 500 m isobaths

MATERIALS AND METHODS

Acoustic tagging and tracking

From 2008 to 2011, yearling Chinook *Oncorhynchus tshawytscha* from the Columbia River basin were surgically implanted with uniquely coded VEMCO V7-2L (7 × 20 mm, 1.6 g in air, 69 kHz transmission frequency) acoustic transmitters and then tracked as they migrated down the Columbia River and north along the continental shelf (Fig. 1). Yearling Chinook were used because several evolutionarily significant units in the Columbia River are listed as 'Threatened' or 'Endangered' under the USA Endangered Species Act and because their larger size reduces their tag burden. Although all groups of fish tagged and released for this study had a common migratory route in the lower river, estuary, plume, and coastal ocean, they followed 3 different migratory paths to the lower river, depending upon their origin and handling. They include Columbia run-of-the-river (CR) groups, Snake run-of-the-river (SR) groups, and Snake River transport (ST) groups (Table 1). In 2011, CR fish were identified as upper-Columbia (UC) or mid-Columbia (MC) using genetic stock identification (Table 1). Run-of-river groups were collected from hatcheries or at dams in their respective rivers, and then released to migrate to the ocean. Transported groups were collected from a hatchery or from Lower Granite Dam in the Snake River basin and then transported via truck or barge to below Bonneville Dam, the final dam on the Columbia River. With the exception of a unique early-April release of a group of transported fish in 2009, all releases occurred between late-April and late-May to minimize potential effects of emigration timing (Muir et al. 2006); release dates are reported in Table 1. The methods summarized here are also available in uncondensed reports to the Bonneville Power Administration (Porter et al. 2009b, 2010, 2011, 2012a,b) and in Rechisky & Welch (2010).

In 2008 and 2009, the CR groups were reared at the Cle Elum Supplementation and Research Facility on

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Table 1. *Oncorhynchus tshawytscha*. Group names, release dates, sample sizes, fork length (FL) range, proportion (%) of the population represented by the size range tagged, and estimates of plume survival for acoustic-tagged Chinook smolts released in the Columbia (CR) and Snake Rivers (SR), or Snake River–sourced smolts that were transported and released below Bonneville Dam (ST). Chinook smolts released in the Columbia River in 2011 were identified as mid-Columbia (MC) or upper-Columbia (UC) using genetic stock identification. The ST_09ER (early release) group, shown for reference, was excluded from the analysis

Year	Group	Release dates	No. of fish	FL range (mm)	Percent of population	Median plume entry date	Plume survival (SE)
2008	SR_08	25 Apr & 2 May	395	130–159	10	28 May	0.41 (0.07)
	ST_08	17 & 23 May	199	131–159	10	26 May	0.52 (0.08)
	CR_08	15 & 21 May	378	129–158	72	29 May	0.38 (0.06)
2009	SR_09	4 & 11 May	389	130–164	68	30 May	0.53 (0.16)
	ST_09	27 May & 3 Jun	392	130–167	68	31 May	0.86 (0.14)
	ST_09ER	17 Apr	196			27 Apr	0.78 (0.15)
	CR_09	18 & 25 May	393	130–159	69	2 Jun	0.36 (0.12)
2010	SR_10	17–24 May	383	130–167	74	4 Jun	0.69 (0.11)
	ST_10	18–26 May	406	130–171	74	27 May	0.58 (0.07)
	CR_10	28 Apr–13 May	790	130–215	88	14 May	0.41 (0.05)
2011	SR_11	23 Apr–28 May	80	132–168	78	25 May	0.25 (0.07)
	ST_11	3–22 May	200	130–165	71	24 May	0.13 (0.03)
	UC_11	23 Apr–28 May	386	130–170	78	21 May	0.31 (0.04)
	MC_11	23 Apr–28 May	59	131–168	74	11 May	0.22 (0.07)

the Yakima River (a tributary of the Columbia River), but were captured, tagged, and re-released in 2 sub-groups 6 d (2008) and 7 d (2009) apart at the downstream Chandler Juvenile Monitoring Facility (CJMF). This was done to avoid the significant mortality, and thus reduced sample size, that occurs between these 2 facilities (Yakima Nation 2011). The SR and ST groups consisted of yearling Chinook reared at the Dworshak National Fish Hatchery (DNFH) on the Clearwater River (a Snake River tributary). The SR groups were released upstream of DNFH in 2 sub-groups 7 d apart. The ST groups were trucked to Lower Granite Dam and then placed in a barge for transport and release below Bonneville Dam in 2 sub-groups 6 d apart. There was also a single early transport release in 2009 (ST_09ER).

In 2010, the CR group consisted of hatchery- and wild-origin smolts (62 % had fin clips) collected and tagged at the John Day Dam (Columbia River) before being released 42 km upstream in small sub-groups over 15 d. The Snake River groups consisted largely of hatchery-origin fish (97 % had fin clips) that were collected and tagged at Lower Granite Dam and released in the tailrace over 8 d, or transported and released below Bonneville Dam in the lower Columbia River over 9 d. Unlike 2008, 2009, and 2011, the stocks of origin for fish tagged in 2010 are unknown. We have assumed that smolts collected at John Day Dam originated in the Columbia River (although some could be Snake River smolts) and those collected at Lower Granite Dam were of Snake River origin. We have also assumed that these fish are yearling Chinook, but since they were not known to be hatchery fish (as in 2008 to 2009) or genetically identified (as in 2011), it is possible that a proportion were hold-over fall type yearlings.

In 2011, juveniles in the CR and SR groups were captured and tagged at Bonneville Dam and then released in the tailrace over 14 and 7 d, respectively. Genetic stock identification was used to distinguish the spring Snake, mid- and upper-Columbia smolts used in the analysis (Porter et al. 2012b). The ST group fish were collected at Lower Granite Dam and transported for release below Bonneville Dam in 2 groups 8 d apart.

The surgical protocol for implanting the VEMCO V7-2L acoustic tag included sedation, anesthetic induction, tagging, and recovery. Briefly, fish captured for tagging were allowed to acclimate to their holding tank, and food was withheld for approximately 24 h prior to surgery. Fish were sedated with a 20 ppm dose of tricaine methane sulphonate (TMS or MS-222), and anesthetic induction was accomplished in a bath containing 70 ppm TMS. Once they reached Stage IV anesthesia, smolts were placed ventral side up, and their gills and mouths gently irrigated with a water tube. An incision to accommodate the tag was made on the mid-ventral line, and the tag was inserted into the abdominal cavity. Incisions were closed with sterile monofilament absorbable suture, and fish were transferred to a recovery tank for at least 24 h before release.

Although this study focuses on survival in the plume region between the mouth of the Columbia River (Astoria, Oregon) and the coastal waters off Willapa Bay, Washington, the sub-arrays of acoustic receivers used to delineate the plume were part of a much larger array deployed within the Columbia River basin and eastern North Pacific coastal ocean. The Columbia River basin array elements were emplaced in 2006. However, we have used only the 2008 through 2011 data to build the models, as there was no sub-array at Astoria in 2006 to distinguish between survival in the lower river and the plume, and problems with smolt tagging precluded use of 2007 data (Porter et al. 2009a). Although lower river and plume survival were conflated in 2006 due to the lack of a sub-array at Astoria, we derived estimates of plume survival and residence time for 2006 using travel times and average survival between Bonneville Dam and Astoria from 2008 to 2011. The derived estimates were plotted against the exponential decay model output as an additional test of the model's adequacy.

Environmental data

Researchers have identified a number of environmental variables that may be related to the early marine survival of juvenile salmon. Using current literature as a guide, we identified 6 variables with publicly available datasets for exploratory analysis. These were timing of the biological spring transition (Koslow et al. 2002, Logerwell et al. 2003, Tomaro et al. 2012, Burke et al. 2013), cumulative upwelling prior to ocean entry (Schwing et al. 2006), turbidity (Gregory & Levings 1998, DeRobertis et al. 2003), SST (Ryding & Skalski 1999, Hobday & Boehlert 2001, Koslow et al. 2002, Logerwell et al. 2003, Burke et al. 2013), and upwelling and river discharge (Budy et al. 2002, Schaller & Petrosky 2007, Burla et al. 2010a). We lacked predator data, but hypothesized that if predation was the primary driver of survival, then survival could be related to period of exposure, i.e. plume residence time. Finally, flooding in the Columbia River basin in 2011 resulted in high levels of involuntary spill at Bonneville Dam, supersaturating the river below the dam with dissolved gas and raising our interest in the effect of physiological damage resulting from exposure to supersaturated water on subsequent plume survival (Mesa &Warren 1997, Mesa et al. 2000, USACOE 2011). We performed an initial exploration of the data with pairwise plots and used Pearson correlation coefficients to identify strongly collinear variables (Pearson correlation coefficient ≥ 0.95).

Coastal upwelling (UP), 2 and 4 wk cumulative upwelling (CU2, CU4). Daily upwelling index values at 48° N (cubic meters per second per 100 meters of coastline) were obtained from the NOAA Pacific Fisheries Environmental Laboratory (www.pfeg. noaa.gov/). Values were averaged over the period between plume entry and plume departure (see 'Analysis' section for how entry and departure dates were determined) for each salmon group in each year and cumulative upwelling was calculated for the 14 and 30 d periods prior to plume entry of each group in each year.

Biological spring transition (BST). We used transition dates for 2008 to 2011 that were calculated using the Peterson method and obtained through Columbia River Data Access in Real Time (DART; www.cbr.washington.edu/dart/). The Peterson method identifies the BST date as the day when cluster analysis of copepods sampled during biweekly research cruises at the hydrographic baseline station NH 05 off Newport, Oregon, indicates the transition from a southern, warm-water zooplankton assemblage to a northern, cold-water assemblage (Peterson & Keister 2003, Peterson & Schwing 2003, Hooff & Peterson 2006, Peterson et al. 2006). The timing of ocean entry of the tagged smolts in relation to the spring transition was calculated by subtracting the date of the transition from the date of entry into the plume by each group in each year.

Lower river gas saturation (PDG). We obtained gas saturation data, measured as percent dissolved gas (PDG), from an automated US Army Corp of Engineers water quality monitoring station located at Camas, Washington/Washougal, Oregon (CWMW), 40 km downstream of Bonneville Dam (Fig. 1; www.cbr.washington.edu/dart/). Hourly values were averaged over the period between median arrival date on the acoustic sub-array below Bonneville Dam or release date at Bonneville Dam and the plume entry date for each salmon group in each year.

Sea-surface temperature (SST). SST (°C) is measured hourly at several NOAA data buoys (NDB) off the Columbia River. NDB 46041, located approximately 111 km northwest of the mouth of the Columbia River (Fig. 1), had a complete SST data set for periods when tagged juvenile salmon were transiting the plume (www.ndbc.noaa.gov/). Hourly values collected at this buoy were averaged over the period between plume entry and plume departure for each salmon group in each year.

River discharge (DIS). River discharge data are recorded at Beaver Army Terminal near Quincy, Oregon, 150 km downstream of Bonneville Dam (Fig. 1). This is the last discharge recording station in the Columbia River. Daily mean discharge is recorded in cubic feet per second (converted to cubic meters per second) and was extracted from the National Water Information System (http://waterdata.usgs.gov/). Daily values were averaged over the period between plume entry and plume departure for each group in each year.

Turbidity (TB). River turbidity is measured daily at Bonneville Dam in units of Secchi-feet (converted to Secchi-meters), and the data were accessed through Columbia River DART (www.cbr.washington.edu/dart/). Bonneville Dam is located at River Mile 146.1, well upstream of the plume, but it is the closest continuous measurement of turbidity available. Turbidity in the plume should lag turbidity measured at Bonneville, with the lag time dependent on discharge levels. To estimate lag times for each group, we used the difference between their median arrival date at Astoria and median arrival, or release, date at Bonneville. Based on previous studies correlating juvenile travel time and discharge, we believe that using detection data to establish a lag time between turbidity measure and turbid water mass arrival in the plume is reasonable (Berggren & Filardo 1993). Lagged daily turbidity measurements were averaged over the period between plume entry and plume departure for each group.

ANALYSIS

Plume survival and occupancy

Estimates of yearling Chinook salmon *Oncorhynchus tshawytscha* survival in the plume were obtained using the data and analytical methods described in Porter et al. (2012b). Briefly, a total of 4646 acoustic tagged smolts were released in the Columbia River basin from 2008 to 2011 (Table 1). Detection data from the array components extending from the Snake River to Lippy Point, British Columbia, Canada (Fig. 1), were used to estimate apparent survival for each treatment group between each detection site in each year using a special case of the Cormack-Jolly-Seber (CJS) live-recapture modeling framework, implemented in the program MARK (Table 1; Lebreton et al. 1992, White & Burnham 1999). Unique detection probabilities (p) for each release group were estimated at each sub-array in the river; however, at the ocean sub-arrays, a common p for the groups was used each year. Eight of the 19 fish detected migrating upriver in their release year were detected at the river mouth, but not at Willapa Bay. We did not remove them from the analysis because they affect plume survival estimates by only a fraction of a percent and have no effect on the final results. However, all upstream migration detections were scrubbed prior to analysis.

In 2010 and 2011, an additional sub-array was placed at Sand Island, seaward and adjacent to the Astoria sub-array (Fig. 1). Porter et al. (2012a) report 2010 and 2011 plume survival in 2 segments: Astoria and Sand Island and Sand Island to Willapa Bay. To permit inter-year comparisons, the methods in Porter et al. (2012a) were modified by setting survival to Sand Island at 1 so that mortality was estimated from Astoria to Willapa Bay. Plume survival estimates in 2008 and 2009 are as reported in Porter et al. (2012a). Median $\hat{c}$ goodness-of-fit tests, carried out in the program MARK, of the 2008, 2009, and 2011 special-case CJS models used to estimate plume survival did not give evidence of extra-binomial variation (i.e. greater variability than would be expected under binomial sampling, which, if present, would result in underestimates of the variance of the CJS model parameters; Burnham & Anderson 2002). We made corrections to the 2010 survival estimates because there was evidence of minor overdispersion ($\hat{c} = 1.16$; Burnham & Anderson 2002).

Plume occupancy included the period between plume entry and plume departure. Entry and departure dates were calculated as the median of final detection dates on the Astoria sub-array (plume entry; Fig. 1) and the median of final detection dates on the Willapa Bay sub-array (plume departure; Fig. 1). Plume entry and departure were calculated for each group in each year. Median absolute deviation of the plume entry time (i.e. the spread) was calculated for each group in each year.

Modeling survival and plume residence time

If smolt survival was mediated by travel time through the plume, time-scaled survival, calculated as $S_{TS} = S_P^{1/T_P}$, should be nearly constant and survival could be explained as an exponential decay process, which is time dependent. We fit an exponential decay model to the survival estimates using the nls function in R (R Development Core Team 2011):

$$S_P = e^{-k\,T_P}$$

where S_P is plume survival, T_P is median residence time, k is the mortality rate constant, and e^{-k} is the apparent daily survival rate. The assumptions of nonlinear regression — (1) correct function, (2) homoscedasticity, and (3) normally distributed error terms — were evaluated with a plot of the fitted regression curve, a plot of the model residuals against fitted values, and a quantile-quantile (QQ) plot, respectively (Kutner et al. 2005, Ritz & Streibig 2008). We obtained an estimate of the bias in k through bootstrap resampling (n = 10000; Kutner et al. 2005). We calculated the confidence intervals for the exponential decay model by log transforming the confidence intervals of the linear form of the exponential model ($\log S_P = -k\ T_P$).

We plotted logit-transformed survival estimates and residuals from the exponential decay model against the variables representing productivity (BST, CU2, CU4) and gas supersaturation (PDG) to evaluate the potential role of biological productivity and exposure to supersaturated river water on plume survival (Kutner et al. 2005). We also calculated the coefficients of determination (R^2) between logit-transformed survival estimates and each of the variables representing productivity and exposure.

We used linear regression models and information theoretic approaches to evaluate the environmental factors potentially governing plume residence time (Burnham & Anderson 2002, Johnson & Omland 2004, Kutner et al. 2005). Our general model of plume residence time, which included 3 covariates and 1 interaction term, was:

$$T_P \sim \text{SST} + \text{UP} + \text{DIS} + \text{UP:DIS}$$

We used corrected Akaike information coefficients (AICc), Akaike weights (w_i), and evidence ratios, implemented in R with the package MuMIn, to evaluate and rank the general model and 8 sub-models in our candidate set (Burnham & Anderson 2002, Barto 2012). We used diagnostic plots of the residuals to assess whether the assumptions of linear regression were met for the top ranked model. Additionally, the residuals of the top model were plotted against variables omitted from the general model to verify that they did not add descriptive or predictive power (Kutner et al. 2005).

Model evaluation with 2006 survival data

Although lower river and plume survival were conflated in 2006 due to the lack of a sub-array at Astoria, we derived estimates of plume survival and residence time for 2006 using travel times and average survival between Bonneville Dam and Astoria from 2008 to 2011. The derived estimates are plotted against the exponential decay model output as an additional test of the model's adequacy. We estimated plume survival in 2006 by dividing the 2006 estimates of combined lower river/plume survival (Bonneville Dam to Willapa Bay) by the average lower river survival (Bonneville Dam to Astoria) in 2008 to 2011 (average = 0.85). We used the range of lower river survival from 2008 to 2011 (0.71 to 0.99; Porter et al. 2012a) to estimate a 2006 maximum and minimum plume survival (Table 2). To estimate 2006 plume residence time, we first calculated the average proportion of time spent in the plume relative to the combined time in the lower river and plume for 2008 to 2011 (proportion = 0.64). This proportion was multiplied by the 2006 combined lower river/plume residence time to yield estimates of 2006 plume residence time for each group (Table 2).

ASSUMPTIONS AND TESTS

The use of acoustic telemetry and CJS modeling to estimate survival requires a number of assumptions, including that (1) there are no tag effects, (2) tags are not lost, (3) the size range of fish used in the study is representative of the source populations and there is no effect of fork length on survival, (4) every tagged smolt has the same probability of being detected, (5) sampling is instantaneous, (6) the offshore extent of the marine sub-arrays is sufficient to bound the early marine migratory path, and (7) smolts departing the Columbia River migrate north. Here, we summarize the results of tests of these assumptions, which are also available in uncondensed form in Porter et al. (2009b, 2010, 2011, 2012a,b).

Captive tag effects and tagging-induced mortality studies were conducted in 2008 to 2011 to study the

Table 2. *Oncorhynchus tshawytscha*. Estimates of combined lower river/plume survival and residence time and derived plume residence time and survival for acoustic-tagged Chinook smolts released in 2006 in the Snake River (SR_06) and Columbia (CR_06), or Snake River–sourced smolts that were transported and released below Bonneville Dam (ST 06)

Group	No. of fish	Combined residence time (d)	Combined survival (SE)	Derived plume residence time (d)	Derived plume survival (range)
SR_06	380	3.73	0.71 (0.19)	2.40	0.83 (0.72–1.00)
ST_06	203	8.10	0.56 (0.14)	5.22	0.66 (0.56–0.79)
CR_06	398	5.76	0.81 (0.20)	3.71	0.95 (0.82–1.00)

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survival, tag retention, and growth of *Oncorhynchus tshawytscha* smolts implanted with V7-2L dummy acoustic tags (DATs) relative to PIT-tagged controls (Porter et al. 2009b, 2010, 2011, 2012b). Small initial effects on growth rates of DAT-tagged smolts were observed. Tag retention was high; no V7-2L DATs were shed in 2008. In 2009, 9 (of 210) DATs were shed, 2 (of 188) were shed in 2010, and 1 (of 87) was shed in 2011. In all years, there were no significant differences in survival or mean fork length between the DAT-tagged and control fish at the conclusion of the studies. To ensure that tag burdens were unlikely to impact survival, we restricted tagging in all years to smolts with a minimum fork length (FL) of 130 mm (one 129 mm smolt was tagged in 2008), which is below the ratio of tag size to smolt size where tag burdens have been found to be significant (Lacroix et al. 2004). Ninety-two percent of tagged smolts also had tag burdens <6.7% of their body weight, the level at which Brown et al. (2006) found that tag burdens may begin to exert an effect on survival.

The 130 mm FL minimum generally restricted tagging to the upper 68 to 88% of the study populations. In 2008, Snake River smolts collected at the Dworshak hatchery were small, and tagged smolts represented only the upper 10% of the population of smolts reared at Dworshak National Fish Hatchery. However, the fork length spectrum represented 76% of the population of hatchery Chinook sampled at the Lower Granite Dam smolt monitoring facility in 2008. Fork length ranges and the proportions of study populations they represent are reported in Table 1. Smolt size has been linked to adult returns and may influence early marine survival (Tomaro et al. 2012). We recorded fork lengths at tagging and compared the fork length frequency distributions of the released fish to those that survived to Willapa Bay. If larger size conferred a survival advantage to Willapa Bay, we would expect the size distribution of survivors to be right-skewed relative to the overall release group. However, the distributions were virtually identical, indicating that there was no size-selective effect (Fig. 2).

Violations of the assumption that every tagged smolt has the same probability of detection should be evident in a lack of fit of standard CJS models to the detection data (the standard CJS model has unique parameters for the probability of survival to, and detection at, each sub-array and thus contains more parameters than the special-case model used to estimate survival in this analysis). There was no evidence in median $\hat{c}$ tests, conducted in the program MARK, of a lack of fit to the 2008 through 2011 data, indicating that this assumption was not violated (Porter et al.

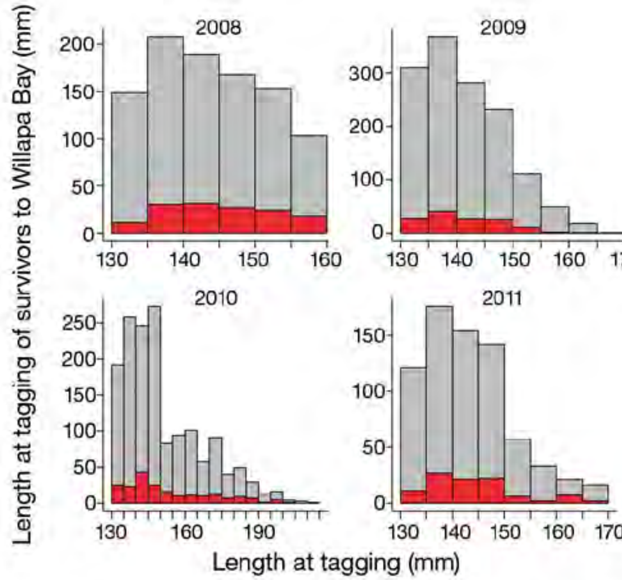

Fig. 2. *Oncorhynchus tshawytscha*. Frequency distributions of the fork lengths of all tagged smolts (gray) and smolts detected at the Willapa Bay sub-array (red). Fork length was measured at the time of tagging. The similarity in the distributions indicates that there was no size-selective effect on survival to the Willapa Bay sub-array

2012a). Instantaneous sampling is the assumption of demographic closure at each sampling period, and, in practice, sampling periods in mark-recapture studies are short, rather than truly instantaneous. From 2008 to 2011, individual fish crossed the arrays within hours of first detection, and the sampling periods at the lower river and Willapa Bay sub-arrays (i.e. the periods between arrival of the first and last smolts in each group) only lasted for several days.

Extensive ocean sampling of juvenile salmon off Oregon and Washington has shown that juveniles are generally confined to the shelf region (Bi et al. 2007, Peterson et al. 2010). From 2008 to 2010, the sub-array at Willapa Bay extended offshore to the 200 m isobath, but was extended to the 500 m isobath in 2011 because smolts continued to be detected on the outermost receivers. In 2011, 9 smolts were detected on the extended receivers, indicating a small number of smolts may have passed outside the detection range of the Willapa Bay sub-array in 2008 to 2010. No smolts were detected on the outermost receivers in 2011, although the receivers were lost, likely to fishing activity, sometime during the 2011 migration season (Porter et al. 2012a). Missed detections could result in a downward bias in plume survival estimates, although CJS modeling alleviates this problem by using subsequent detections at the

Lippy Point sub-array (which are heavily skewed towards the inner shelf) to adjust estimates of survival at Willapa Bay (Porter et al. 2012a).

Miller et al. (1983) demonstrated with north- and south-opening nets that juvenile salmon swim north after entering the ocean. In 2009 and 2011, a sub-array was deployed at Cascade Head, Oregon, to verify the assumption that fish swim north at ocean entry (Fig. 1). The small number of detections at Cascade Head (3 fish in 2009 [number released = 1370] and 6 in 2011 [number released = 725]), suggest the conclusion by Miller et al. (1983) was correct. One of the 6 tagged fish detected at Cascade Head in 2011 was subsequently detected at both Willapa Bay and Lippy Point, further supporting this conclusion. Fish detections at Cascade Head were included in the Willapa sub-array detections to reflect their survival in the plume. We have excluded a group of transport fish released in early-April 2009. This group was released much earlier in the season than the remaining groups (Porter et al. 2009b) and may have entered the plume before predators became abundant (see 'Discussion').

RESULTS

Initial exploration with pairwise plots of the variables and their Pearson correlation coefficients revealed that several variables potentially related to survival, but without clear mechanistic relationships, were also associated with plume residence time. Thus, we divided the variables into 2 categories, those that might affect survival of *Oncorhynchus tshawytscha* indirectly by influencing plume residence time (upwelling at ocean entry, discharge, SST), and those that might directly affect survival by way of feeding opportunities (timing of the biological spring transition, 2 and 4 wk cumulative upwelling prior to ocean entry) or reduced physiological fitness (dissolved gas levels). We excluded turbidity (measured at Bonneville Dam) due to its high correlation with discharge (Pearson correlation coefficient = 0.95) and the distance (146 km) between the dam and the plume. Similarly, we did not consider spill at Bonneville Dam (the final dam in the river) because it is correlated with discharge and does not reflect additional downstream freshwater inputs to the plume.

Plume survival varied widely, but the daily plume survival rate (S_{TS}) was similar among groups (Fig. 3). The estimated mortality rate constant, k, across the groups was 0.12 d^{-1}. There was no evidence of violation of homoscedasticity in the exponential decay

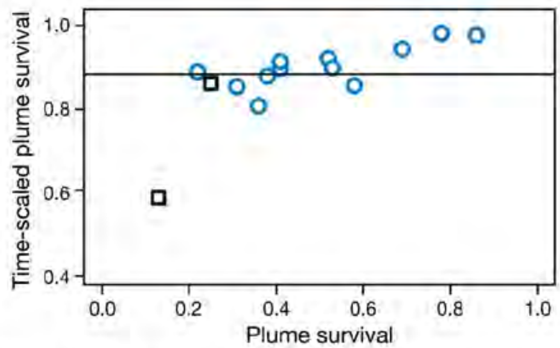

Fig. 3. *Oncorhynchus tshawytscha*. Comparison of plume survival with daily survival rates (open circles). Although plume survival varied widely, the daily survival rate was similar among groups, illustrating the potential effect of residence time on plume survival. The outlier with both low survival and low time-scaled survival was 1 of 2 groups (open squares), exposed to high total dissolved gas concentrations (TDG > 120 %) in the lower river. The gray line is the model estimated daily survival rate

model, the error terms appeared normal, and the bias of the estimate of k was low (bias = −0.003). However, the plot of the fitted regression curve suggests that the model performed well in predicting survival of the groups that migrate in-river, but did not perform as well for groups transported and released below Bonneville Dam (Fig. 4). In-river migrants entered the plume in a more continuous fashion, whereas transported fish entered in brief pulses; the median absolute deviation from the median plume entry date of transported juveniles was <1 d (mean = 0.56 d), but ranged from 1 to 7 d (mean = 3.39 d) for the in-river migrants (Fig. 4). The plume residence time of all groups was brief, averaging 7.29 d (Table 3).

The high variability in survival of the 2008 to 2011 transport groups limits further inference regarding these groups, and the remaining results pertain only to the in-river groups (transport group data are plotted in Fig. 5 for reference). Plots of logit-transformed survival estimates against timing of the biological spring transition relative to plume entry and 2 and 4 wk cumulative upwelling prior to plume entry did not provide evidence of any influence on plume survival (Fig. 5). Additionally, there were no strong patterns in the plots of the model residuals against these variables to suggest that incorporating them would improve the model (Fig. 5).

Survival appears lower at higher (>120 %) levels of dissolved gas supersaturation, which may be evidence of a threshold level of exposure at which gas supersaturation levels experienced in the lower river noticeably affect subsequent plume survival, al-

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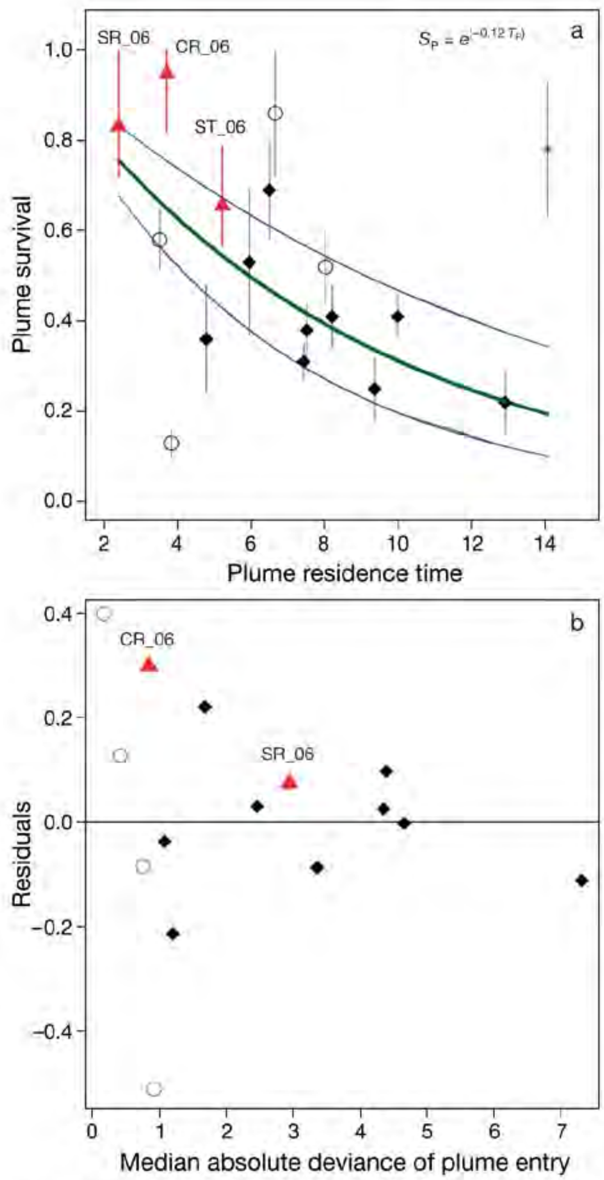

Fig. 4. *Oncorhynchus tshawytscha*. (a) Comparison of plume survival with plume residence time, showing the regression curve (thick green line) and 95% confidence intervals (thin blue lines). The model clearly fits the in-river migrant groups (black diamonds, ±95% CI) better than transported groups (open circles, ±95% CI). Derived estimates of 2006 plume survival and residence time (red triangles; vertical red lines show maximum and minimum estimates) also fit the pattern of a simple exponential decline in survival with residence time. The 2009 early-release transport group excluded in calculations is also shown (star, ±95% CI). (b) Residuals from the regression relationship exhibit greater variance when the spread in plume entry times is low (measured by median absolute deviation), as is also the case for all of the transport groups (open circles) in this study. Median absolute deviation at the Bonneville dam sub-array is shown for 2006 (triangles); there are no data for the 2006 transport group as they were released in the vicinity of Bonneville sub-array

though the evidence for this is weak (Fig. 5). The density of data points at high levels of dissolved gas is less than at lower levels, and the apparent relationship is determined by low survival in a single year, 2011, when dissolved gas levels below Bonneville Dam exceeded the 120% limit established under Oregon and Washington water quality law (USACOE 2011). We did not see evidence in the residual plot that this exposure should have been incorporated into the survival model (but see 'Discussion').

In 2006, smolt travel time between Bonneville Dam and Willapa Bay was short and survival was high, as are the derived estimates of plume residence time and survival (Table 2; Porter et al. 2012a). Additionally, the model performs better in predicting survival of the SR_06 group, which entered the lower river in a more continuous manner than the CR_06 group (Fig. 4). Refitting the exponential decay model to include the 2006 data only changes the decay constant slightly, from 0.12 to 0.11.

Among the 9 candidate models for predicting plume residence time, the model containing only SST outperformed all others, as measured by AICc distance and model weights (weight = 92%; Table 4 and Fig. 6). Diagnostic plots of the SST model did not show evidence of heteroscedasticity or non-normal error terms, and there were no patterns in the plots of the SST-model residuals against the omitted variables, upwelling and discharge, to indicate that that these variables should be included.

DISCUSSION

The Columbia River plume was once posited to benefit juvenile salmon by providing food and refuge while transporting them to safer environs (Casillas 1999). However, research has shown that juvenile salmon do not take advantage of feeding opportunities presented by the plume (DeRobertis et al. 2005, Morgan et al. 2005) and that the plume is rich in salmon predators (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005 Emmett et al. 2006). More recently, acoustic telemetry studies have shown that yearling Chinook *Oncorhynchus tshawytscha* survival in the plume is low in relation to river, estuary, and coastal ocean habitats (Porter et al. 2010, 2012a). Thus, the telemetry data suggest that reducing plume residency may increase yearling Chinook salmon productivity by allowing the smolts to move into regions with higher survival, which runs contrary to initial thinking that the plume might be a refuge where longer residence could increase adult return rates.

Table 3. *Oncorhynchus tshawytscha*. Plume residence time and environmental data summary. The ST_09ER group, shown for reference, was not included in the analysis. For explanation of group designations, see Table 1

Group	Plume residence time (d)	Days since biological spring transition	Cumulative upwelling ($m^3 s^{-1}$ 100 m^{-1}) 2 wk	4 wk	Percent dissolved gas	Sea-surface temperature (C°)	Upwelling ($m^3 s^{-1}$ 100 m^{-1})	Discharge ($m^3 s^{-1}$)
SR_08	8.21	84	243	233	118.1	11.46	8.22	13756.4
ST_08	8.03	82	32	48	118.0	11.42	12.44	13866.7
CR_08	7.52	85	267	332	118.3	11.44	10.44	13496.3
SR_09	5.96	84	286	−550	117.7	13.16	9.71	11194.7
ST_09	6.66	85	383	−527	117.9	13.49	3.57	11271.6
ST_09ER	14.08	51	470	445	113.3	9.95	−27.87	9551.8
CR_09	4.79	87	323	−424	118.3	13.82	2.80	11243.3
SR_10	6.50	−23	25	261	113.3	13.43	18.50	12461.1
ST_10	3.52	−31	128	297	113.4	11.02	14.00	8814.2
CR_10	9.99	−44	612	324	113.1	11.00	−34.55	8074.7
SR_11	9.36	62	57	16	124.6	12.33	2.00	16717.2
ST_11	3.84	61	−52	−98	123.7	11.49	−7.20	16419.6
UC_11	7.44	58	2	−71	116.8	11.47	1.75	14940.6
MC_11	12.92	48	35	−86	113.4	10.73	6.79	13781.0

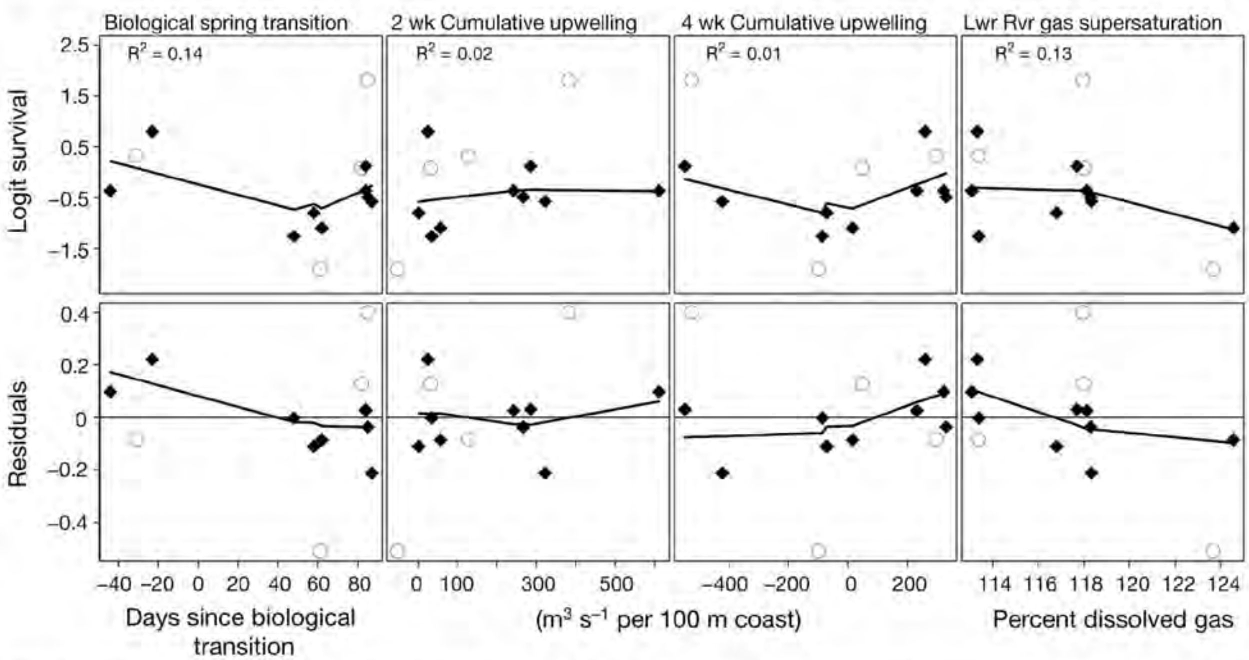

Fig. 5. *Oncorhynchus tshawytscha*. Upper panels: logit-transformed survival compared with measures of coastal productivity and lower river total dissolved gas levels; no clear relationships are evident. Lower panels: plots of residuals from the exponential decay model do not reveal patterns, indicating that the model would be improved by including biological productivity or exposure to gas supersaturated water. Coefficients of determination (R^2) and Friedman's supersmoother lines (R Development Core Team 2011) are fitted to the in-river groups (diamonds). Transport group data (open circles) are shown for reference

Although plume survival estimates in this study ranged from 0.13 to 0.86, they stabilized when scaled by residence time (Fig. 3). If mortality rates in the plume are consistent at comparable periods in the migratory season (groups used in this analysis were released at similar periods each year), then plume survival could be governed by residence time. Consistent with this idea, we find that a simple exponential decay model largely describes plume survival, although the model performs best when analysis is restricted to groups of yearling Chinook whose individuals enter the plume over a longer time period.

Table 4. *Oncorhynchus tshawytscha*. AIC-based ranking of 9 candidate models of plume residence time containing hypothesized combinations of 3 predictor variables, sea-surface temperature (SST), upwelling (UP), and river discharge (DIS). Evidence is a measure of how many times less likely the model is the best model relative to the top ranked model. AIC_c: corrected Akaike's information criterion

Model	Parameters					AIC_c	ΔAIC_c	Model weight	Evidence
	Intercept	SST	UP	DIS	DIS:UP				
SST	29.06	−1.74	–	–	–	41.77	0	0.92	1.0
SST + DIS	27.83	−1.72	–	0.000078	–	48.81	7.034	0.027	33.7
SST + UP	29.12	−1.74	0.00094	–	–	48.97	7.19	0.025	36.6
UP	8.228	–	−0.053	–	–	50. 25	8.47	0.013	69.2
DIS	5.966	–	–	0.00016	–	51.0092	9.24	0.0091	101.3
UP + DIS	1.838	–	−0.10	0.00051	–	55.37	13.59	0.0010	894.6
SST + UP + DIS	25.89	−1.62	−0.016	0.00014	–	60.69	18.92	0.000071	12834.7
UP × DIS	−2.11	–	−0.66	0.00069	0.000058	65.056	23.28	0.0000081	113745.3
SST + UP × DIS	22.15	−1.45	−0.20	0.00023	0.000018	84.37	42.59	0.0000000052	1778441824.7

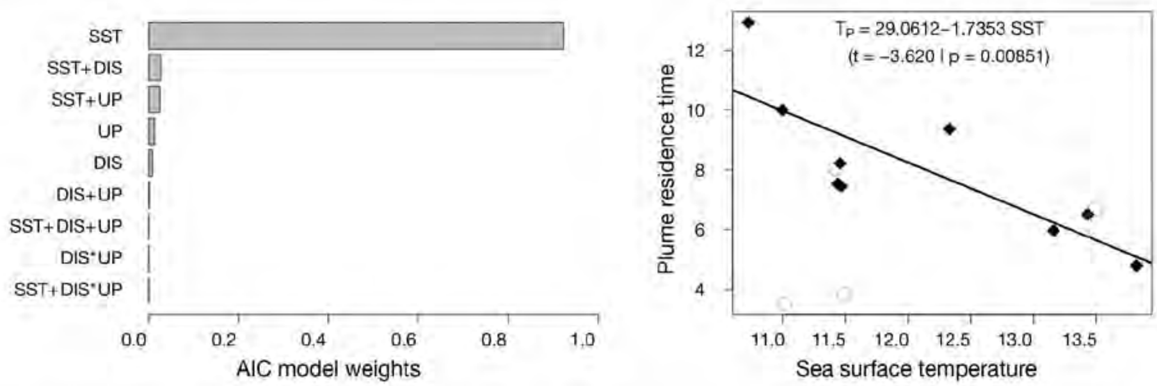

Fig. 6. *Oncorhynchus tshawytscha*. (a) Model ranking for the influence of environmental variables on plume survival; the sea-surface temperature (SST) model receives the greatest proportion of model weight. (b) The inverse relationship between SST and plume residence time suggests that most of the predictive power occurs because smolts do not remain in the plume for long when coastal temperatures are high, increasing survival to Willapa Bay. Diamonds: in-river migrants; open circles: transport groups. For explanation of model abbreviations, see Table 4

This scenario is also consistent with the hypothesis that predation is a key driver of survival in the plume region and provides a plausible bridge between survival and environmental variables, such as river discharge and SST, that have been hypothesized to influence early marine survival, but lack a clear link. The derived estimates of 2006 plume residence time and survival provide additional qualitative support to the idea that plume survival is negatively related to travel time.

The variability in plume survival of the 2008 to 2011 transport groups relative to the fitted regression line suggests that there may be substantial variation in mortality events around the average daily rate that we propose. Over short periods of time (<1 d), pulses of smolts travelling between the Astoria and Willapa Bay sub-arrays may or may not encounter significant numbers of foraging predators, resulting in groups experiencing either very high survival if they pass through the plume without encountering predator aggregations, or very low survival if they encounter substantial number of predator groups. In this scenario, survival of such groups would appear to be more variable than groups whose plume entry times are more dispersed over time, even though the same underlying mortality rate process may apply.

We believe that plume residence times (average: 7.29 d) were too short for starvation to have had an effect and that predation was the most likely cause of plume mortality. The density of piscivorous hake *Merluccius productus* in the plume generally increases in May and peaks in June and July (Agostini et al. 2006, Emmett et al. 2006), and, similarly, the contribution of salmonids to the diet of Caspian terns *Sterna caspia* and double-crested coromorants *Phalacrocorax auritus* that nest near the plume peaks in May (Collis et al.

2002, Lyons et al. 2005). Predation by these piscivorous birds and fish may exert significant top-down control on plume survival (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005, Emmett et al. 2006, Emmett & Sampson 2007), although this has not been conclusively demonstrated. We suspect that the high survival of the early-April 2009 release group, despite a long plume residence time, may be related to the May and June peaks in predation by piscivorous birds and fish (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005, Emmett et al. 2006). This is consistent with an effect of emigration timing on early-marine survival (Muir et al. 2006) and the idea that the mortality rate may vary through the migration season. Unfortunately, with only a single data point and no predator data, any inference is severely restricted.

Although the temporal match, or mismatch, between juvenile salmon entering the plume and the timing of spring increases in marine productivity and advection of lipid-rich copepods into marine waters off Oregon and Washington (the biological spring transition) may affect feeding opportunities, plume survival of the groups used in this study does not appear to be related to biological productivity measures. However, biological productivity and the availability of higher quality prey is still potentially relevant to survival at larger temporal scales as it may affect whether juveniles obtain sufficient energy reserves to survive their first winter at sea (Beamish & Mahnken 2001, Tomaro et al. 2012).

The practice of spilling water over Columbia River dam faces (rather than through turbines) to reduce the physical and physiological stress on juvenile salmon can supersaturate the river below the dam with atmospheric gases, potentially leading to gas bubble trauma and, when exposure is non-lethal, reducing fitness (Bouck 1980, Mesa & Warren 1997). During the 2008 to 2011 period, percent dissolved gas levels recorded at the Camas/Washougal monitoring station below Bonneville Dam ranged from a relatively benign 113% to a potentially harmful 125% during flood conditions in 2011 (Bouck 1980, USACOE 2011). Although we found little evidence that dissolved gas exposure explains the variation in plume survival among the groups used in this analysis, an intra-year analysis of the smolts released in 2011 after total dissolved gas levels exceeded state legal limits at the Bonneville Dam release site suggests they may have experienced lower daily survival rates in the river and plume compared with their unexposed counterparts (I. G. Brosnan et al. unpubl. data).

Plume residence time may be affected by water temperature, which has been related to migration timing and speed (Brett et al. 1958, Sykes & Shrimpton 2010, Martin et al. 2012), and river discharge and wind-driven surface currents (reflected in the coastal upwelling index) that may affect travel time by changing the area and depth of the plume and adjusting its orientation between a northern, onshore configuration, or a southwestern, offshore configuration (Hickey et al. 2005, Burla et al. 2010b). The best model of plume residence, by a significant margin, included only SST. Models that included river discharge, which can be influenced by management action, or coastal upwelling, have little weight. This is consistent with Burla et al. (2010a), who found that the physical dynamics of the plume at the time of ocean entry do not affect adult returns of yearling Chinook (although it may affect steelhead returns). If our results are widely applicable, they also suggest that plume survival may not be amenable to improvement via management of the hydropower system, although it is conceivable that hatchery and fish transport releases could be timed to minimize plume residence. However, this would require detailed forecasts of conditions in the early marine environment that are not presently available.

Advances in marine acoustic telemetry have played an important role in addressing scientific questions and conservation problems in the Columbia River basin. Rechisky et al. (2009, 2012, 2013, 2014, this volume) and Welch et al. (2009, 2011) have measured directly the survival of juvenile salmon in key marine habitats and conducted direct experimental tests of survival hypotheses related to dam passage and the downriver transport of juvenile Chinook. Additional releases of telemetered yearling Chinook would provide greater clarity regarding the drivers of plume residence time and could better address the question of plume survival in relation to predator abundance and distribution. Nonetheless, we have shown here that a simple exponential decay model adequately described the survival of juvenile yearling Chinook in the Columbia River plume, and that the ability of resource managers to affect plume survival of yearling Chinook by altering residence time may be limited. If correct, this poses a potential problem, as survival in the plume is low relative to other habitats (Porter et al. 2010, 2012a). Survival might potentially be improved by the successful development of marine environmental forecasts to aid in release timing, and the telemetry data used in this analysis can be extended to a value-of-information analysis to determine what the maximum financial outlay should be for such forecasts (Raiffa & Schlaifer 1961, Williams et al. 2011).

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Chapter 4.—Surgical Implantation of Acoustic Tags: Influence of Tag Loss and Tag-Induced Mortality on Free-Ranging and Hatchery-Held Spring Chinook Salmon (*Oncorhynchus tshawytscha*) Smolts

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Abstract

Medium to long-term acoustic monitoring (>1 month) of salmon smolts in the ocean requires that telemetry tags have minimal impact on growth and survival. In 2006 and 2008, we implanted acoustic transmitters into the abdominal cavity of spring Chinook salmon smolts (*Oncorhynchus tshawytscha*) from two populations within the Columbia River basin and tracked them to north of the Alaskan panhandle—a 2,500 km, 3-month long journey. Concurrently, we conducted captive tag effects studies to compare survival, tag retention, and growth of smolts (from the two populations) implanted with dummy acoustic transmitters (DATS) to a control group implanted with passive integrated transponder (PIT) tags, which weigh only 0.1 gram. The acoustic tags used in field studies in 2006 weighed 2.6–11.5% of the weight of the fish (in air) and were implanted into smolts ≥140 mm fork length (FL). DATs used in captive studies had identical dimensions as live acoustic tags, weighed 5.2–10.4 % of the weight of the fish, and were implanted into smolts ≥140 mm FL. The acoustic tags and DATs used in 2008 were slightly smaller and were implanted into smolts ≥130 mm FL. Acoustic tags used in field studies weighed 2.9–7.3% of fish weight. DATs used in captive studies were identical to live transmitters and weighed 2.8–7.6% of the weight of the fish.

Overall, short-term (<1 month) tag loss and tag related mortality of captive smolts were negligible for both tag types and both populations. Beyond 1 month, significant acoustic tag loss and tag mortality occurred in one of the two populations (which may be attributed to the sutures). In both years and in both populations, surgery and/or tag implantation caused an initial period of slower growth (compared to PIT tagged fish), followed by growth rates comparable to their PIT tagged counterparts.

We used the captive data to calculate the proportion of migrating fish available for detection (tagged live fish) at two detection sites in the ocean, and then we adjusted survival estimates for migrating smolts to account for tag loss and mortality. The proportion of fish available for detection was >98% at the first ocean detection site 40 km north of the Columbia River mouth, therefore the adjustment to survival was minor (2%). The proportion of fish available for detection at the more distant site (525 km north of the river mouth) was 85% for one population; however, relative to the mortality incurred during migration, the adjustment was relatively minor and the adjusted values fell well within the 95% confidence intervals of the unadjusted survival estimates.

We also compared statistical survival models for migrating smolts to determine if survival was a function of fish fork length at tagging, and we compared our survival estimates to independent PIT tag estimates for the same population in the same year. Survival models indicated that survival was not a function of size at tagging, and independent PIT tag survival estimates were similar to our acoustic tag estimates.

We conclude that short-term acoustic tag loss and tag related mortality were minimal for the size of smolts and transmitters that were used in our studies, and that tag loss that occurred over the longer term was minor when compared to high rates of natural mortality occurring in migrating smolts. Conversely, growth rates of acoustic tagged smolts were affected in the short term but were comparable to PIT tagged fish in the longer term.

Introduction

Pacific salmon researchers have acknowledged for decades that most of the mortality experienced by salmon occurs during the first several months at sea (see Quinn, 2005); however, tracking juvenile salmon through rivers and into the ocean has only recently been accomplished (Lacroix et al., 2004a; Melnychuk et al., 2007; Chittenden et al., 2008; Welch et al., 2008; Rechisky et al., 2009) due to the development of stationary acoustic receivers and the miniaturization of acoustic transmitters (see review by Voegeli et al., 1998; Heupel et al., 2006). Thus, it is possible to measure survival of individually identifiable fish and to test hypotheses regarding ocean survival during the critical months after ocean entry.

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To measure survival with acoustic tags it is necessary to surgically implant the transmitter into the abdominal cavity of a fish, as external methods of attachment are unlikely to be successful, and tag loss will confound estimates of survival (i.e., tag loss is assumed to be mortality). The surgical procedure or the tag itself, however, may potentially alter behavior, growth, or survival if the size of the tag exceeds biological limits (Lacroix et al., 2004b; Welch et al., 2007; Chittenden et al., 2009). If transmitters cause mortality or are expelled by the animal, then the results may not be representative of the untagged population. It is thus important to quantify the effects of tag implantation on growth and survival.

Tag effect studies have been conducted on numerous species and with several internal tag types (coded wire tags, passive integrated transponder [PIT] tags, radio transmitters, acoustic transmitters). The results obtained from these studies is dependent on the specifics of transmitter size and fish size (often expressed as percent body weight or tag burden), and morphology of the study species, as well as the study duration. For example, Lacroix et al. (2004b) specifically recommended that transmitter weight not exceed 8% of body weight for Atlantic salmon (*Salmo salar*) measuring 14–15 cm and tagged for several months. However, these specifications may not be applicable to other species and thus it is important to quantify tag effects for individual tagging studies particularly if the study focuses on survival.

Pacific salmon from the Columbia River basin (northwestern U.S.) are often the subject of tag effects studies due to their conservation status (13 of 16 *Oncorhynchus* spp. from the Columbia River basin are listed under the U.S. Endangered Species Act), and thus extensive research on salmon survival takes place within the basin (Independent Scientific Review Panel/Independent Scientific Advisory Board, 2009). PIT tags are the primary method of measuring survival in the Columbia River Basin (Faulkner et al., 2007) because they are small, light, and inexpensive, and have little or negligible effect on survival (Prentice et al., 1987); however, the use of radio transmitters (Adams et al., 1998a, 1998b; Martinelli et al., 1998; Hockersmith et al., 2003), and acoustic transmitters have become more common with the advent of smaller transmitters (Anglea et al., 2004; Brown et al., 2006).

Tag effects studies generally are conducted in controlled environments where predation or prey capture is not a factor and fish are held in artificial conditions and fed to satiation every day. Although captive studies do not incorporate stresses encountered by fish in the wild, they are the most practical method currently available for measuring changes in growth, and for monitoring survival and tag retention. If a captive study and a field study are conducted concurrently (on the same population within the same year) then the specific results from the captive study can then be extrapolated to help assess the potential negative impact of tag implantation on the release group used in field studies. If the captive tag study yields no tag effects or tag loss, then the field study may be impacted minimally by tag implantation effects; however, if captive studies reveal significant mortality or tag loss, then field study results may be severely compromised and at a minimum should be adjusted for negative tag effects (e.g., field estimates of survival could be corrected upwards to compensate for tag loss). The adjustments based on captive studies may, however, underestimate mortality and tag loss in the wild, as migrating smolts must contend with predation, prey acquisition, and other stressors such as dam passage.

Short-term tag effects may be measured in the river by using a paired release strategy to compare migration behavior or survival of a tagged group to a control group. Hockersmith et al. (2003) used this strategy in the Columbia River to compare survival and migration rate of radio transmitter tagged and PIT tagged yearling Chinook salmon (*Oncorhynchus tshawytscha*) and found no initial differences between treatments, although they did detect a decrease in survival for transmitter tagged fish tracked to more distant sites in the river. This reduced survival, however, may have been influenced by the presence of the radio tag antenna trailing behind the fish, which could become entangled, biofouled, or infected (Adams et al., 1998b; Jepsen et al., 2002). Martinelli et al. (1998) compared different methods of implantation of radio transmitters in subyearling Chinook salmon and also found no difference in migration time for fish tracked for fewer than 5 days.

To date, medium- and long-term tag effects studies are completely lacking for the ocean phase of the life history due to logistical difficulties. To address this issue we: (1) conducted captive studies to quantify tag effects in two populations of juvenile spring Chinook salmon from the Columbia River basin implanted with dummy acoustic transmitters (DATs); to do so, we measured and compared growth, survival, and tag loss of DAT tagged fish to a control group tagged with PIT tags (which is the generally accepted method for analyzing in-river survival of juvenile salmon); (2) concurrently, we released spring Chinook salmon from these two populations tagged with live acoustic transmitters and estimated their survival during the out-migration (Rechisky et al., 2009; Rechisky, 2010); to examine size effects on fish survival, we compared survival by size class and statistical survival models to determine if survival is positively associated with size at tagging; (3) we then adjusted estimated survival probabilities of migrating smolts for tag loss and tag mortality that was quantified in captivity; and (4) additionally, we compared our acoustic tag survival estimates of migrating smolts to PIT tags survival estimates estimated independently for both populations in both years of the study.

For the study, we used two different size acoustic transmitters; in 2006 smolts were tagged with 9 mm DATs and live transmitters, and in 2008 smaller 7 mm DATs and live transmitters were used.

Methods

In 2006 and 2008, we conducted captive tagging studies with two populations of hatchery spring Chinook salmon to quantify acoustic tag retention and the effect of transmitter implantation on survival and growth (table 1). Additionally, we released acoustic tagged smolts from both populations in both years (table 2) and estimated river and early ocean survival using the Pacific Ocean Shelf Tracking (POST) array (Welch et al., 2002). Smolts originated from Dworshak National Fish Hatchery (NFH; Ahsahka, ID) on the Clearwater River (a tributary of the Snake River) and Cle Elum Supplementation and Research Facility (CESRF; Cle Elum, WA) on the Yakima River (a tributary of the Columbia River).

Study/Release Sites.—For logistical reasons, all Dworshak hatchery spring Chinook salmon were tagged at Kooskia NFH. Smolts were transferred from Dworshak NFH to Kooskia NFH in early March 2006 and in February/March 2008. In 2006, captive tag effects studies were conducted at Kooskia NFH; however, in 2008, smolts were transferred back to Dworshak NFH (1 week after tagging) for tag effect studies (the transfer back to Dworshak NFH was necessary because of limited availability of tanks at Kooskia NFH). In both years, run of river (ROR) fish used in field studies were released from Kooskia NFH (60 km upstream of Dworshak NFH; fig. 1).

Table 1. Tagging summary for captive spring Chinook salmon smolts tagged with 9 mm dummy acoustic transmitters (DATs) in 2006, and 7 mm DATs in 2008.

[Dworshak smolts were transferred and tagged at Kooskia National Fish Hatchery (NFH). In 2006, the tag study was conducted at Kooskia NFH; however, in 2008, the smolts were transferred back to Dworshak NFH for the remainder of the tag study. Cle Elum smolts were captured at the Chandler Juvenile Monitoring Facility and held at Prosser Hatchery. FL, fork length; g, gram; mm, millimeter]

Tributary (hatchery)	Study site	Tag type	Number of tagged	Mean size at tagging (mm FL; range)	Mean weight at tagging (g; range)
9 mm					
Snake (Dworshak)	Kooskia NFH	DAT	100	154.5 (142–169)	41.7 (31.0–57.5)
Snake (Dworshak)	Kooskia NFH	PIT tag	100	154.8 (140–168)	41.9 (28.4–60.2)
Yakima (Cle Elum)	Prosser Hatchery	DAT	100	154.8 (143–174)	41.4 (29.9–59.6)
Yakima (Cle Elum)	Prosser Hatchery	PIT tag	92	154.4 (139–170)	40.7 (23.7–60.4)
7 mm					
Snake (Dworshak)	Dworshak NFH	DAT	100	148.2 (135–159)	39.1 (25.8–57.1)
Snake (Dworshak)	Dworshak NFH	PIT tag	100	148.1 (135–159)	38.2 (25.5–58.0)
Yakima (Cle Elum)	Prosser Hatchery	DAT	97	139.9 (132–149)	27.3 (21.1–34.4)
Yakima (Cle Elum)	Prosser Hatchery	PIT tag	100	140.2 (131–154)	27.3 (20.5–35.4)

Table 2. Tagging summary for run of river spring Chinook salmon smolts tagged with 9 mm acoustic transmitters in 2006 and 7 mm transmitters in 2008.

[Dworshak smolts were transferred to and then tagged and released at Kooskia National Fish Hatchery (NFH) (60 km upstream of Dworshak NFH). Cle Elum smolts were captured and released at Chandler Juvenile Monitoring Facility (CJMF). FL, fork length; g, gram; mm, millimeter]

Tributary (Hatchery)	Release date	Number of tagged	Mean size at tagging (mm FL; range)	Mean weight at tagging (g; range)	Release site
9 mm					
Snake (Dworshak)	May 1	198	146.9 (140–208)	35.2 (26.9–117.5)	Kooskia NFH
Snake (Dworshak)	May 8	198	145.6 (140–192)	34.0 (27.4–83.7)	Kooskia NFH
Yakima (Cle Elum)	May 30	199	154.5 (140–173)	43.2 (30.0–64.2)	CJMF
Yakima (Cle Elum)	June 6	199	154.5 (140–168)	41.9 (28.8–59.2)	CJMF
7 mm					
Snake (Dworshak)	Apr 25	197	146.2 (130–159)	37.5 (23.3–55.5)	Kooskia NFH
Snake (Dworshak)	May 2	198	146.3 (131–159)	37.3 (23.9–52.7)	Kooskia NFH
Yakima (Cle Elum)	May 15	189	140.3 (129–158)	28.1 (22.0–10.9)	CJMF
Yakima (Cle Elum)	May 21	189	140.4 (131–157)	28.1 (22.1–37.2)	CJMF

Figure 1. Pacific Ocean Shelf Tracking (POST) acoustic array. Acoustic tagged smolts were detected in the Columbia River basin and at ocean sites at Willapa Bay, Lippy Point, and Graves Harbor. Inset shows the location of the hatcheries (DNFH, Dworshak National Fish Hatchery; CESRF, Cle Elum Supplementation and Research Facility), release sites (CJMF, Chandler Juvenile Monitoring Facility; KNFH, Kooskia National Fish Hatchery), acoustic detection sites (McG, McGowan's Channel, 10 km downstream of Bonneville Dam; LaC, Lake Celilo, 7 km downstream of John Day Dam; LaW, Lake Wallula, 10 km downstream of the confluence of the Snake and Columbia Rivers; LaB, Lake Bryan,14 km downstream of Lower Granite Dam); and dams (BON, Bonneville; TDA, The Dalles; JDA, John Day; MCN, McNary; ICH, Ice Harbor; LMO, Lower Monumental; LGO, Little Goose; LGR, Lower Granite) within the Yakima, lower Snake, and Columbia Rivers. The continental shelf (depths <200 m) is shaded.

In 2006 and 2008, spring Chinook salmon released from CESRF acclimation sites in the upper Yakima River were recaptured in the lower river at the Chandler Juvenile Monitoring Facility (CJMF) downstream of Prosser Dam and used in our captive and field studies. We chose to recapture fish downstream at CJMF because fish mortality from the acclimation sites to CJMF (approximately 200 km) was as high as 80% in recent years (Yakama Nation, 2008). All tagging and captive tag studies took place at Prosser Hatchery, Prosser, WA, which is directly adjacent to CJMF. In both years, ROR fish used in field studies were released into the Yakima River from the CJMF (fig. 1).

Tags and tagging.—We used Vemco (Halifax, Nova Scotia) V9-6L acoustic transmitters (9 mm × 21 mm, 3.1 g in air, 69 kHz) and V7-2L transmitters (7 × 20 mm, 1.6 g in air, 69 kHz) to estimate survival of migrating fish in 2006 and 2008, respectively (table 2). The larger, more powerful V9 transmitter has a detection radius ≤400 m, and the smaller V7 tag has a detection radius ≤300 m; however, detection range is location and time-dependent, and may vary with freshwater/estuarine/ocean conditions, local topography, river flow, and weather conditions. Each transmitter was uniquely coded so that individual fish were identified when detected by river and ocean receivers along their migration route. For captive tag effects studies, we used DATs that were identical in volume, weight, and shape to live transmitters used in respective years. DATs also were embedded with a PIT tag (12.5 × 2.07 mm, 0.1 g) at our request by the manufacturer, and all control fish were implanted with a PIT tag; therefore, each individual could be identified throughout the tag effects study (unless a tag was lost). DAT tagged fish and control fish were held in the same tank. We did not include a non-tagged group because it was necessary to identify all individuals for growth analyses.

We specified a minimum size limit of 140 mm fork length (FL) for smolts implanted with a 9 mm acoustic or dummy tag, and a minimum size of 130 mm FL for the 7 mm tag. The mean tag to body weight ratio for Yakima smolts implanted with live 9 mm transmitters was similar to the ratio of smolts implanted with DATs (7.4 and 7.7%, respectively, table 3); however, Dworshak smolts implanted with live 9 mm transmitters and released, were slightly smaller on average than the hatchery-held DAT tagged smolts, and the mean tag to body weight ratio was thus slightly higher for ROR smolts (ROR=9.3%, captive smolts=7.6%; table 3). Although the mean tag to body weight ratio was higher for ROR smolts,

Table 3. Tag burden (%) of spring Chinook salmon smolts implanted with 9 mm and 7 mm dummy acoustic transmitters (DAT) used in captive tag effects studies, and 9 mm and 7 mm live transmitters used to estimate run of river (ROR) survival estimates; mean (range).

Tag group	Tag weight : Body weight	Tag length : Fork length	Tag weight : Body weight	Tag length : Fork length
	9 mm		7 mm	
Dworshak DAT	7.6 (5.4–10.0)	13.6 (12.4–14.8)	4.2 (2.8–6.2)	13.5 (12.6–14.8)
Yakima DAT	7.7 (5.2–10.4)	13.6 (12.1–14.7)	5.9 (4.7–7.6)	14.3 (13.4–15.2)
Dworshak ROR	9.3 (2.6–11.5)	14.4 (10.1–15.0)	4.5 (2.9–6.9)	13.7 (12.6–15.4)
Yakima ROR	7.4 (4.8–10.8)	13.6 (12.1–15.0)	5.8 (3.9–7.3)	14.3 (12.7–15.5)

there were DAT tagged representatives within each size class (fig. 2). The mean tag weight to body weight ratio for fish implanted with live 7 mm transmitters was similar to the ratio for smolts implanted with DATs for both Yakima (5.8 and 5.9%, respectively) and Dworshak populations (4.5 and 4.2%, respectively; table 3).

Surgical procedures used to implant acoustic transmitters were reviewed annually by institutional animal care committees and met or exceeded the Canadian Council on Animal Care standards (www.ccac.ca). The same surgical protocol was used in 2006 and 2008 for fish tagged with live and dummy acoustic transmitters and PIT tags. Portable self-sustaining surgical units are assembled on site, and fish surgery was carried out by highly experienced, veterinarian-trained staff. Fish were not fed for 24 h prior to surgery. Fish were dip netted from their holding tank and lightly anesthetized, or sedated, with a low dose (20 ppm) of Tricaine Methane Sulphonate (MS-222) to reduce stress from handling. A mucous protectant (Vidalife) was added to all water baths and contact surfaces, and surgeons wore latex or nitril gloves while handling fish to reduce scale and mucous loss. All water baths were aerated, and dissolved oxygen (DO) and temperature were monitored approximately every 3 minutes. Fish were taken from the sedation bath once there was slight loss of equilibrium and were anesthetized one at a time in 70 ppm of MS-222. Induction time to total loss of equilibrium, loss of reflex reactivity, and slow and irregular opercular motion was <5 min. Each individual was removed from the induction bath, fork length was measured to the nearest millimeter and weight was measured to the nearest tenth of a gram. The fish was then placed ventral side up into a v-shaped trough and a maintenance dose of anesthetic (50 ppm) was pumped through the fish's mouth and over the gills. Tags were disinfected in an iodine solution (Ovadine) and rinsed in distilled water. An incision was made at the ventral midline midway between the pelvic and pectoral fins with a #12 curved blade on #3 scalpel and the tag was gently inserted through the incision into the peritoneal cavity. The transmitter was set in place directly below the incision with the tip of the scalpel blade. For ROR fish used in field studies, a PIT tag was inserted through the incision prior to transmitter insertion. This was to ensure that ROR fish were not collected at Snake and Columbia River dams for transport to the lower Columbia River. Two surgical-grade stainless steel cutting needle drivers and sterile, absorbable Monocryl 4-0 violet sutures with a swaged on reverse cutting needle (14 mm) were then used to set and tie sutures using a surgeon's knot covered by a square knot. Sutures were carefully tied to achieve edge apposition (i.e., no overlap of the incision edges). For a 9 mm live or dummy transmitter, the incision was 10–12 mm in length and was closed with two interrupted sutures; for a 7 mm live or dummy transmitter, the incision was 7–8 mm and was closed with one suture; for PIT tagged control fish in the captive, tag effects study, a 2 mm incision was made and no sutures were used. Two sets of instruments were rotated during surgeries so that one set soaked in the disinfectant solution (Ovadine and distilled water) during surgery. Instruments were rinsed with distilled water before use. Surgery time was <2 min for a 9 mm tag and about 1 min for a 7 mm tag. Immediately following surgery, fish were placed into a recovery bath and monitored. Within minutes fish regained equilibrium and reactivity; after several more minutes of recovery, fish were transferred into either the captive study holding tank or one of the field study tanks. At both hatcheries, captive fish were held in partially shaded outdoor tanks. Well water at Prosser Hatchery ranged from 13 to 16 °C, recirculated well water at Kooskia NFH was 11°C, and river water from the North Fork of the Clearwater River at Dworshak NFH increased from 4°C to 10°C as the captive study progressed.

To reduce bias during tagging (i.e., to reduce the chance that a surgeon might take more care in tagging a fish bound for the tagging study) DAT tagged fish were randomly tagged during the tagging of acoustic tagged fish intended for release. The surgeon was aware of the fate of the fish because transmitter identification must be verified before insertion (i.e., we could not conduct a truly blind study); however, intermingling dummy tagging with live acoustic tagging was intended to reduce any involuntary bias. Within each year, the same surgeons tagged all treatment groups at both hatcheries.

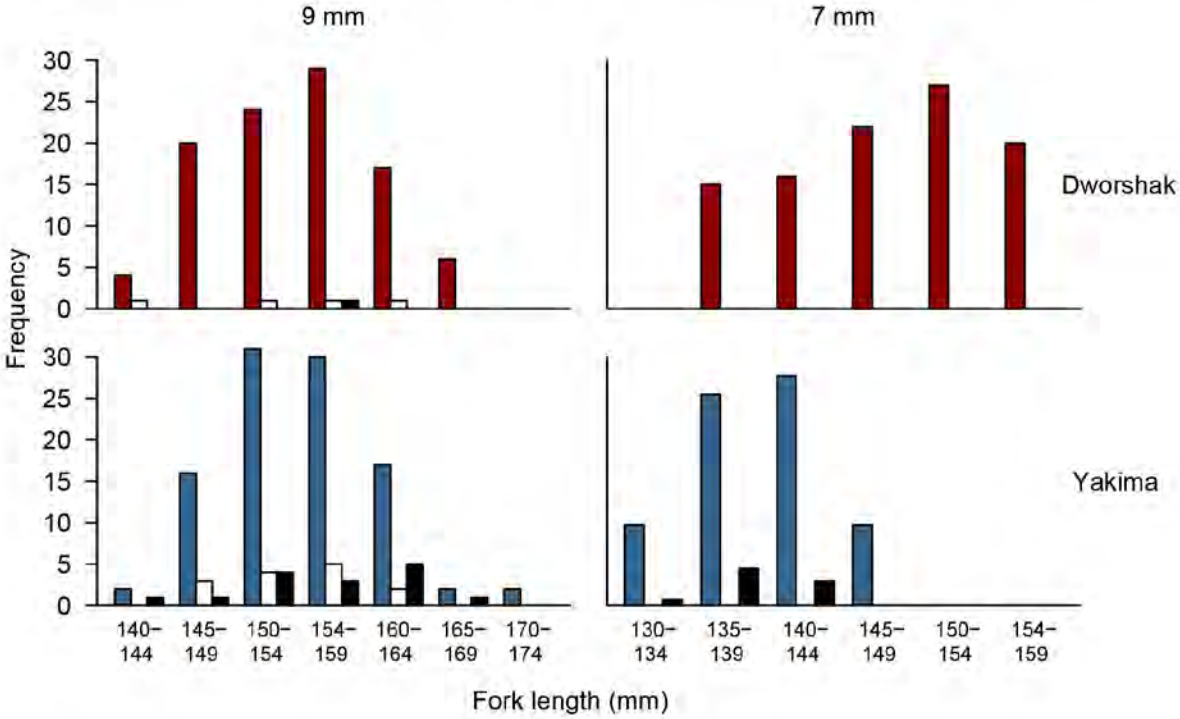

Figure 2. Size distribution of Dworshak (red bars) and Yakima (blue bars) spring Chinook salmon tagged with 9 mm and 7 mm dummy acoustic transmitters (2006 and 2008, respectively), initial size of smolts that expelled tags (white bars) and initial size of fish that died during the tag study (black bars). (Dworshak mortalities exclude deaths due to "ich" (a freshwater parasite) in 2006 and precocial male maturation in 2008). There was no tag loss in 2008.

Captive Study

Tanks were monitored daily for dead fish or expelled tags, and fork length and weight were recorded 1-3 times post-surgery (depending on the length of the study). All weights were adjusted by subtracting the average weight of the dummy tags. Tag retention was calculated each day as:

$$\frac{\text{N tags intact}}{\text{N tags implanted} - \text{N mortalities of tagged fish}},$$

and survival was calculated as:

$$\frac{\text{N live fish}}{\text{N fish initially tagged}}.$$

The percent of tags available for detection (K, i.e., live fish with tags) was calculated as:

$$\frac{\text{N tags implanted} - \text{N mortalities of tagged fish} - \text{N tags expelled}}{\text{N tags implanted}}.$$

Sample size.—Approximately 100 DAT tagged fish and 100 PIT tagged fish were tagged at each hatchery in each year. Mean fork lengths and mean weights were similar for both treatments (table 1).

Duration.—In 2006, the Dworshak captive tag study took place at Kooskia NFH from May 31 to Nov 17 (24 weeks) and fish were measured at weeks 5, 11, and 24. The study was terminated and fish were euthanized with a lethal dose of MS-222 after the final measurement during week 24. In 2008, the captive tag study took place from April 22 to Oct 3, 2008 (23 weeks). Approximately 1 week after tagging, the fish were transferred from Kooskia NFH back to Dworshak NFH for the duration of the study; mortality after transfer was zero. Fish were measured at weeks 7 and 23. During week 23, a dead DAT fish was found with fresh water fungus *Saprolignia* spp. In the following days, four PIT tagged and four DAT tagged smolts succumbed to the fungus, therefore we took final measurements and terminated the study before the fungus spread to all of the captive fish.

The Yakima captive tag study in 2006 took place at Prosser Hatchery from May 27 to August 21 (12 weeks) and fish were measured at weeks 6 and 12. In early September, a major mortality event occurred due to a disease outbreak at the hatchery, which killed approximately 60% of the study fish and therefore the tag study was effectively terminated after measurements were taken on August 21, 2006. In 2008, the tag study took place from May 7 to June 13 (5 weeks) and fish were measured at week 5. The study was inadvertently terminated during week 5 after nearly all of the fish died (DAT and PIT tagged) the day after we obtained growth measurements. Several of the fish that died just prior to this major mortality event were examined by a fish pathologist (Eric Pelton, U.S. Fish and Wildlife Service) because there had been a decline in survival of both DAT and PIT tagged fish during week 5 (prior to week 5 survival was 98% for DAT tagged fish and 100% for PIT tagged fish). There was no indication of disease or stress, however, and therefore we do not know the cause of the mass mortality that subsequently occurred the day after our growth measurements were collected.

Field Study

Sample size.—In each year, at each hatchery, approximately 400 fish were tagged with live acoustic transmitters and were released into their respective rivers as the ROR groups (table 2). We attempted to match mean sizes between both hatcheries; however, we were somewhat limited in size availability because we were collecting Yakima smolts at CJMF as they migrated through. Therefore the mean FL of Dworshak smolts was approximately 10 mm smaller than the mean FL of Yakima smolts in 2006 and 6 mm larger in 2008.

Release timing.—Dworshak smolts were released in the Snake River basin 349 km upstream of the confluence of the Snake and Columbia Rivers (RKM 522). We released Yakima smolts into the Yakima River, 76 km upstream of the confluence to the Columbia River (RKM 539), several weeks after the Dworshak smolts were released in order to have both populations arrive at the Columbia River mouth simultaneously so that they encountered similar ocean conditions.

Array Location.—The POST array is composed of individual Vemco omni-directional acoustic receivers (VR2s or VR3s) anchored to the river or ocean floor to form a component line or an "acoustic curtain" at each sub-array (Welch et al., 2002) and extends approximately 2,300 km from the Snake River to southeast Alaska (fig. 1). Each receiver records the date, time, and identification of uniquely coded acoustic tags passing near it. Oceanic receivers of the POST array at Willapa Bay (southern WA), Lippy Point (northwest Vancouver Island, BC), and Graves Harbor (southeast AK) were deployed approximately every 800 m and extend from near-shore to the edge of the continental shelf, a distance of up to 30 km.

Component sub-arrays relative to this study were deployed within the Columbia River at McGowan's Channel (10 km downstream of Bonneville Dam), in Lake Celilo (7 km downstream of John Day Dam in 2006, and upstream and downstream of John Day Dam in 2008), and in Lake Wallula (21 km downstream of the confluence of the upper Columbia and Snake Rivers). In the Snake River, receivers were installed in Lake Bryan (14 km downstream Lower Granite Dam; total distance from the ocean was 681 km). At each of these locations, receivers were deployed across the river as paired lines to evaluate the detection probability for each of the pairs, and to provide a survival measurement downstream of four of the major hydroelectric dams. In river receivers were deployed every 100–200 m to ensure high transmitter detection rates in the fast flowing rivers. In 2007, an additional line of receivers was deployed at the Astoria Bridge, 22 km from the mouth of the Columbia River. Therefore, survival was estimated to an additional point near the river mouth in 2008, but not in 2006.

Data Analyses

Captive Studies.—All data analyses for captive studies were performed in the statistical programming language R (R Development Core Team, 2008). We used chi-squared tests of homogeneity to test the null hypothesis that survival of PIT tagged fish is equal to survival of DAT tagged fish. This null hypothesis was tested for each population at those times when growth was measured. For example, in 2006, we compared the survival of each treatment group (PIT and DAT) of the Dworshak population at weeks 5, 11, and 24, and for the Yakima population, we compared survival at weeks 6 and 12. In 2008, it was only necessary to make a statistical comparison for Yakima smolts (at week 5), as no mortality occurred in DAT tagged Dworshak smolts. In the case where the expected cell count was less than five, we estimated the p-value using a Monte Carlo simulation. This simulation is based on 2,000 replicates, and as a result the degrees of freedom are reported as NA. We repeated this procedure with the tag retention data using the null hypothesis that tag retention of PIT tagged fish was equal to tag retention of DAT tagged fish; however, we only tested the 2006 data as there was no PIT tag or DAT tag loss in either population in 2008.

To determine whether DAT tag loss or mortality was a function of FL, we used logistic regression analyses with tag retention or survival as the dichotomous response variable (1= tag retained/survived, 0=tag lost/died) and fork length at tagging as the continuous independent variable. As mortality was low or zero for Dworshak smolts implanted with either 9 mm or 7 mm DATs, respectively, and tag loss was zero for 7 mm DATs for both populations, we only conducted three logistic regression analyses for Yakima smolts: (1) survival (with 9 mm DAT intact at death) as a function of FL; (2) retention of 9 mm DATs as a function of FL; and (3) survival with 7 mm DATs as a function of FL. A Wald X^2 test was used to assess significance of the FL coefficient.

We used t-tests to compare fork length and weight of PIT tagged to DAT tagged smolts after each measurement was obtained. ANCOVA analyses were used to compare specific growth rate. Specific growth rate (SGR, % weight/week) of PIT tagged and DAT tagged fish was calculated for each interval: from initial tagging to the second measurement, from the second measurement to the third measurement, etc. SGR in weight was calculated as SGR=100 $[(\ln(W_2)-\ln(W_1))/(t_2-t_1)]$, where W_2 is the weight at time t_2 and W_1 is the weight at time t_1. For the first interval, we compared SGR of the two treatment groups with initial fork length as the covariate; for subsequent intervals, we used the fork length from the previous measurement as the covariate.

In 2008, it was obvious at week 23 that a small percentage of the Dworshak smolts had become sexually mature males (13% DAT, 5% PIT). These precocious males were noticeably smaller, were olive green in color (not silvery smolts) and were swollen with milt. These fish were excluded from the 2008 growth analyses as they were not representative of a typical spring Chinook salmon smolt, and were unmistakable outliers in the study.

Field Studies.—Estimates of smolt survival (Φ) and detection probability (p) for each recapture occasion, i.e., acoustic detection line, in 2006 and 2008 were calculated using the Cormack-Jolly-Seber (CJS) model for live recaptured animals implemented in Program MARK (White and Burnham, 1999). This model jointly estimates survival and detection within a likelihood framework. Survival probabilities in both years were estimated to detection sites within the Columbia River and to an ocean detection site adjacent to Willapa Bay (Rechisky et al., 2009; Rechisky, 2010). Smolts were detected north of Willapa Bay at Lippy Point (both populations) and in Alaska (Dworshak only, in both years); however, it was not possible to estimate survival to Lippy Point with the CJS model due to small sample size on the Alaska detection line. Therefore, in order to examine medium-term tag effects, we present the percent of fish detected at Lippy Point, which represents the minimum survival of migrating fish and likely underestimates survival to this site.

For in-river lines, we recognized basic CJS model assumptions (equal survival probability, equal recapture probability, no tag loss, and instantaneous sampling); however, for oceanic lines that are not bounded on the offshore end (continental slope), we required two additional assumptions: (1) as fish migrate, they cross over the acoustic detection lines that span the length of the continental shelf; and (2) most fish departing the Columbia River swim north. These assumptions are supported by evidence from numerous ocean sampling programs (e.g., Fisher and Pearcy, 1995; Brodeur et al., 2004; Bi et al., 2007).

To estimate overdispersion in the data, we used a median $\hat{c}$ procedure (White and Burnham, 1999) to test the goodness of fit (GOF) of our global model ($\Phi_{population*line}\ p_{population*line}$, where line = acoustic detection site) and then corrected for this overdispersion across all candidate models. Because of the low number of fish detected at Vancouver Island and Alaska, we included in our models two additional treatment groups (each N=100) of spring Chinook salmon smolts from Dworshak NFH, tagged with the same acoustic tag, that were released downstream of Bonneville Dam during the spring out-migration, in order to better quantify the detection probability of the Willapa Bay detection line. (These two treatment groups were used in our transportation survival study, which is not reported here.) The survival estimate of this group was modeled in the same way across models (Φ_{line}) and did not influence survival estimates for ROR smolts. Recapture parameters were modeled to vary with population and line except at Willapa Bay where all populations were pooled.

To test the hypothesis that smaller fish have lower survival due to tag burden, we followed a similar procedure as described above, accept we modeled each population separately and then compared the global CJS survival model ($\Phi_{line}\ p_{line}$) to an additive model that included fork length as a covariate ($\Phi_{line+FL}\ p_{line}$), as well as a model that included the interaction between acoustic detection site and FL ($\Phi_{line*FL}\ p_{line}$). We used Akaike's Information Criterion (AIC) values to rank the performance of the models. In general, the model with the lowest AIC value (which accounts for the number of model parameters, n_{pars}) has more support in the data, and if the ΔAIC of the other candidate models is greater than 2, then these models (i.e., hypotheses) have little or no support. If the additive model has more support given the data (i.e., ΔAIC >2) then there is evidence that FL had a constant additive effect on survival at each detection site. If the interaction model has more support, then the effect of FL varies at each detection site.

Comparison with PIT Tag studies.—We obtained PIT tag survival estimates for out-migrating Dworshak [Steve Smith, National Oceanic and Atmospheric Administration (NOAA), personal commun., 2006 and 2008; Faulkner et al., 2008] and Yakima (David Lind, Yakama Nation, personal commun., 2006 and 2008) spring Chinook salmon to compare with our estimates of ROR survival using 9 mm and 7 mm acoustic tags in 2006 and 2008, respectively. PIT tagged Dworshak smolts were released at Dworshak NFH and survival was estimated to several dams in the lower Snake and Columbia Rivers to as far as Bonneville Dam (577 km). Acoustic tagged smolts were released at Kooskia NFH and survival was estimated to four (2006) or five (2008) detection sites in the lower Snake and Columbia Rivers and to coastal Washington (adjacent to Willapa Bay, 911 km). PIT tagged Yakima smolts were released from acclimation sites in the upper Yakima River; however, survival estimates were calculated only for those fish that were recaptured and released at CJMF. Survival was estimated to two dams in the lower Columbia River—McNary Dam and John Day Dam (268 km). Survival estimates for acoustic tagged Yakima smolts were from release at CJMF to three (2006) or four (2008) river detection sites and to Willapa Bay (655 km).

To statistically compare survival rates (S/km) we regressed the log-transformed cumulative survival estimates at the j-th detection site, $\ln\left(S_{i,j}\right) = bd_{i,j}$, for each of the i-th populations against migration distance from the respective release sites, $d_{i,j}$, resulting in a survival rate per kilometer, b_i. To estimate the uncertainty in the estimated regression coefficients (b_i), we used a Monte Carlo procedure to randomly generate 10,000 individual survival estimates at each of the detection sites for each population i (in each year) using the estimated survival proportions, $S_{i,j}$, and associated estimated variances that define the parameters of the binomial distribution. We then took the 10,000 sets of generated survival estimates with distance for each population, and calculated the log-transformed regression estimates to empirically define the distribution of survival rates, b_i, for each population. The null hypothesis that the survival rate of acoustic tagged smolts is equal to that of the PIT tagged smolts is equivalent to assuming that on average the difference in the regression coefficients, $b_{DAT} - b_{PIT}$, is zero. We tested this null hypothesis by evaluating whether the central 95% of the 10,000 survival rate differences included zero.

Survival estimates of ROR spring Chinook salmon corrected for tag loss in captive studies.—To correct for tag loss and mortality, we calculated the percent of tagged animals available for detection on day i, K_i, from the proportion of fish that were alive and retaining tags in captivity. We then used K_i to provide an estimate of survival in free-ranging smolts adjusted to account for tag loss and mortality due to surgical implantation of tags:

$$S_K(t,j) = \frac{\text{estimated survival to detection site j}}{\text{K for the median day of arrival, t, to detection site J}}.$$

For example, the median time to arrival at Willapa Bay for ROR Dworshak smolts in 2006 was 24 days, and so we calculated K on day 24 of the captive survival study and divided the ROR survival estimate at Willapa Bay by $K_{t=24}$ to obtain S_K.

Results

Tag Effects–Captive Studies

Tag Retention

9 mm DATs.—For the duration of the tag study in 2006 (24 weeks, fig. 3, table 4a), 100% of PIT tagged and 95% of DAT tagged Dworshak fish retained their tags. At weeks 5 and 11, there were no significant differences in tag retention of PIT tagged and DAT tagged smolts; however, at week 24, DAT tag loss was significantly greater than PIT tag loss (table 4a). The initial fork lengths of the four fish that expelled tags were distributed across the size range of DAT tagged fish (fig. 2); too few tags were expelled to warrant a significance test of whether some size classes had greater tag expulsion.

For the duration of the study (12 weeks; fig. 3), 100% of PIT tagged and 83% of DAT tagged Yakima fish retained their tags. Tag loss was significantly greater for DAT tagged smolts at week 6 and week 12 (table 4a). We believe that tag loss was greater in DAT tagged Yakima smolts because the sutures (most of which were present after 86 days) were observed tearing through the skin and muscle toward the incision (figs. 5b, 5c); Dworshak smolts also retained their sutures for several months; however, tearing was not observed (fig. 5a). The sutures, when completely ripped out, left a large open wound where the tag could be expelled. Often times the incision itself was well healed or completely healed but the sutures prevented complete recovery from the surgery. In some cases, the sutures were observed to have ripped toward the incision and completely out of the body but the DAT tag was still intact. Tag retention was not a function of initial FL (Wald $X^2 = 0.603$, df = 99, $p = 0.547$), therefore tag loss was not limited to smaller individuals (fig. 2).

7 mm DATs.—Retention of PIT tags and 7 mm DATs was 100% for the duration of the study for both Dworshak (23 weeks) and Yakima smolts (5 weeks; fig. 4).

Captive Survival

9 mm DATs.—Approximately 1 month into the Dworshak tag study, fish were treated with chloramine-T due to an *Ichthyophthirius* spp. ("ich") outbreak at Kooskia NFH. The death of 12 DAT tagged fish and eight PIT tagged fish was attributed to ich and/or treatment. Following the ich outbreak only one DAT tagged fish and two PIT tagged fish died during the remainder of the study (a total of 170 days). Total survival of DAT tagged fish was 87%, and survival excluding the mortalities associated with chloramine-T treatment was 99%.

Table 4. Summary of statistical analyses used in the captive tag study.

[Significant *p*-values are represented by **bold** type. Degrees of freedom (d.f.) for the X^2 tests for tag retention and survival are not available because *p*-values were estimated with a Monte Carlo simulation when some cells contained fewer than five data points. Significance tests were not applicable (NA) when tag retention or survival was 1. DAT=dummy acoustic tag, PIT=passive integrated transponder tag. (* excludes precocial males)]

a. Tag retention	Tag size	Population	Time since tagging	Proportion of tags retained		X^2	d.f.	*p*
				DAT	PIT			
	9 mm	Dworshak	week 5	0.98	1	2.1	–	0.25
			week 11	0.97	1	3.2	–	0.13
			week 24	0.95	1	5.3	–	**0.03**
		Yakima	week 6	0.91	1	7.5	–	**0.007**
			week 12	0.83	1	9	–	**0.002**
	7 mm	Dworshak	week 7	1	1	NA	NA	NA
			week 23	1	1	NA	NA	NA
		Yakima	week 5	1	1	NA	NA	NA

b. Survival	Tag size	Population	Time since tagging	Proportion of surviving fish		X^2	d.f.	*p*
				DAT	PIT			
	9 mm	Dworshak	week 5	0.88	0.93	1.5	–	0.35
			week 11	0.88	0.91	0.48	–	0.64
			week 24	0.87	0.90	0.44	–	0.65
		Yakima	week 6	0.93	0.99	4.2	–	**0.07**
			week 12	0.84	0.96	8.8	–	**0.005**
	7 mm	Dworshak	week 7	1	1	NA	NA	NA
			week 23	1	1	NA	NA	NA
		Yakima	week 5	0.89	0.96	3.8	–	0.06

c. Fork length (mm)	Tag size	Population	Time since tagging	DAT mean (SD)	PIT mean (SD)	*t*	d.f.	*p*
	9 mm	Dworshak	week 0	155.3 (6.5)	155.2 (5.6)	0.07	158	0.94
			week 5	167.6 (8.8)	173.8 (7.8)	4.8	159	**<0.001**
			week 11	182.1 (11.4)	189.6 (9.9)	4.6	157	**<0.001**
			week 24	202.8 (17.9)	212.9 (14.7)	3.9	153	**<0.001**
		Yakima	week 0	154.6 (5.9)	154.2 (5.9)	0.41	147	0.68
			week 6	163.5 (7.5)	166 (7.6)	2.2	148	**0.03**
			week 12	174.2 (7.8)	178.8 (7.7)	3.7	148	**<0.001**
	7 mm	Dworshak	week 0	148.3 (5.8)	147.9 (6.9)	0.33	195	0.74
			week 7	165.1 (6.3)	166.6 (5.6)	1.7	192	0.08
			week 23*	215.9 (9.5)	217.3 (8.9)	0.9	165	0.35
			week 0	139.9 (4.5)	139.9 (4.7)	0.03	177	0.98
		Yakima	week 5	150.5 (5.1)	151.2 (5.3)	0.9	177	0.36

d. Weight (g)	Tag size	Population	Time since tagging	DAT mean (SD)	PIT mean (SD)	*t*	d.f.	*p*
	9 mm	Dworshak	week 0	42.2 (6.4)	42.3 (5.8)	0.1	161	0.91
			week 5	59.7 (13.2)	67.6 (12.1)	4.1	161	**<0.001**
			week 11	72.6 (15.4)	81.2 (14.2)	3.7	161	**<0.001**
			week 24	93.6 (23.9)	107.2 (21.4)	3.8	160	**<0.001**
		Yakima	week 0	41.2 (6.1)	40.5 (5.9)	0.72	140	0.47
			week 6	51.1 (8.8)	54.4 (8.0)	2.3	137	**0.02**
			week 12	68.7 (11.8)	75.2 (11.1)	3.4	139	**<0.001**
	7 mm	Dworshak	week 0	39.2 (6.6)	38.1 (6.8)	1.15	195	0.25
			week 7	55.1 (8.2)	55.6 (8.3)	0.48	195	0.63
			week 23*	114 (18.4)	115.3 (16.2)	0.53	165	0.59
		Yakima	week 0	27.4 (2.9)	27.2 (3.3)	0.52	178	0.60
			week 5	37.6 (4.6)	38.2 (5.2)	0.84	178	0.40

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Table 4. Summary of statistical analyses used in the captive tag study.—Continued

[Significant *p*-values are represented by bold type. Degrees of freedom (d.f.) for the X^2 tests for tag retention and survival are not available (NA) because *p*-values were estimated with a Monte Carlo simulation when some cells contained fewer than 5 data points. DAT=dummy acoustic tag, PIT=passive integrated transponder tag. (* excludes precocial males)]

e. Specific growth rate (% g/week)	Tag size	Population	Time	DAT mean (SD)	PIT mean (SD)	*F*	d.f.	*p*
	9 mm	Dworshak	week 0 to week 5	5.84 (2.6)	8.12 (2.2)	37.5	165	**<0.001**
			week 5 to week 11	3.28 (1.7)	3.09 (1.7)	0.19	165	0.65
			week 11 to week 24	1.85 (1.2)	2.13 (0.74)	0.028	165	0.86
		Yakima	week 0 to week 6	3.33 (0.91)	4.61 (1.06)	62.3	144	**<0.001**
			week 6 to week 12	4.99 (2.02)	5.48 (1.62)	3.73	144	0.055
	7 mm	Dworshak	week 0 to week 7	4.87 (1.2)	5.45 (1.2)	13.19	169	<0.001
			week 7 to week 23*	4.59 (0.91)	4.57 (0.88)	0.16	169	0.69
		Yakima	week 0 to week 5	6.16 (1.3)	6.65 (1.6)	4.81	178	**0.029**

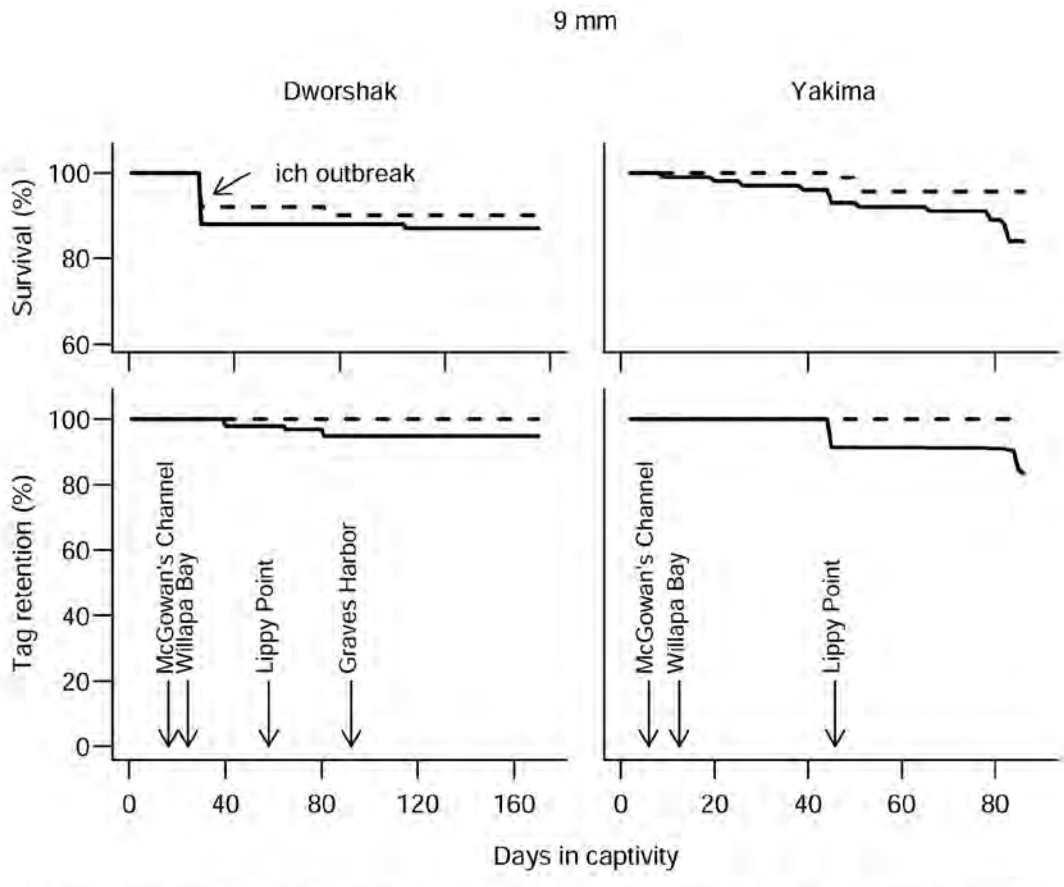

Figure 3. Tag retention and survival for Dworshak and Yakima spring Chinook salmon tagged with 9 mm dummy acoustic transmitters (solid lines) and passive integrated transponder tags (dashed lines) in 2006. The arrows on the tag retention plots are reference points that indicate the mean day of arrival of in-river migrants to each of the acoustic detection lines. Yakima smolts were not detected at Graves Harbor. Note the y-axis scale on the survival plot does not go to zero.

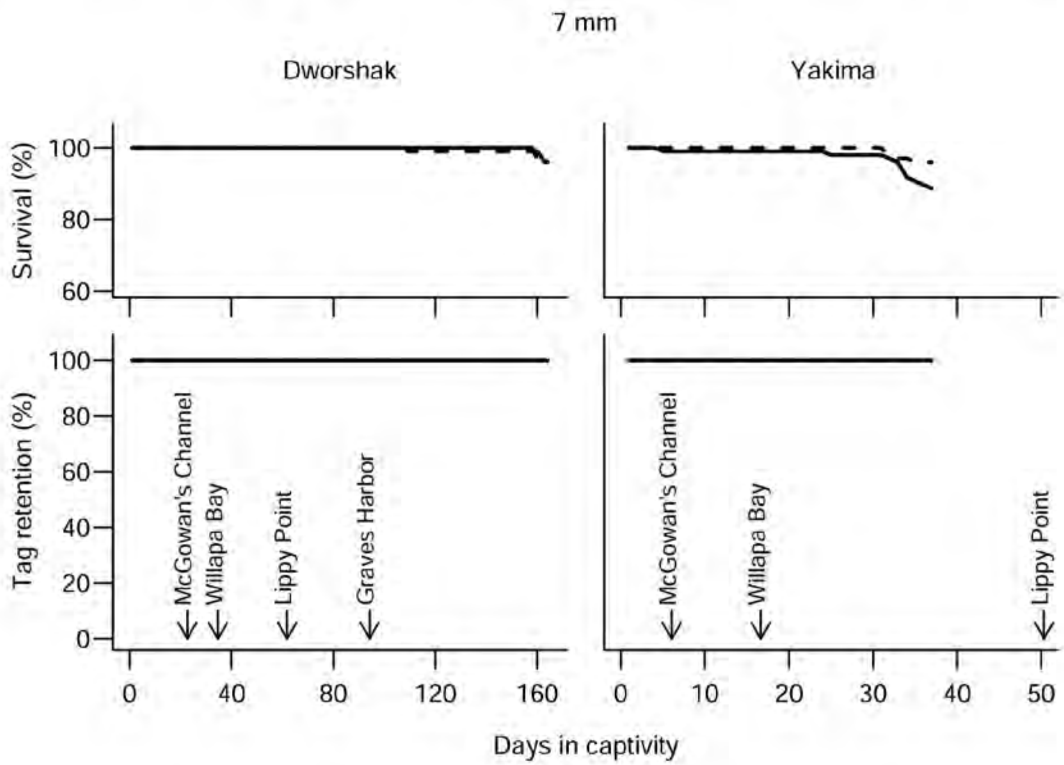

Figure 4. Tag retention and survival for Dworshak and Yakima spring Chinook salmon tagged with 7 mm dummy acoustic transmitters (solid lines) and passive integrated transponder tags (dashed lines) in 2008. The arrows on the tag retention plots are reference points that indicate the mean day of arrival of in-river migrants to each of the acoustic detection lines. Yakima smolts were not detected at Graves Harbor.Note the y-axis scale on the survival plot does not go to zero.

Survival of PIT tagged fish was similar; total survival was 90% and survival excluding chloramine-T mortalities was 98%. Because the ich parasite cannot survive in seawater and in-river migrants were released from the hatchery before the outbreak, it is likely that in-river migrants were not affected. At weeks 5, 11, and 24 there were no significant differences in survival of PIT tagged and DAT tagged smolts (table 4b; fig. 3). As only 1 fish died after the ich outbreak, a significance test for survival as a function of FL was not warranted.

Survival to day 86 (the final day of the study) was 84% for DAT tagged and 96% for PIT tagged fish. At week 6, there was no significant difference in survival of PIT tagged and DAT tagged smolts; however, at week 12 survival of PIT tag smolt was significantly greater than DAT tagged smolts (table 4b; fig. 3). As mortality was not limited to smaller individuals, survival was not a function of initial FL (Wald X^2= -0.309, df = 99, p = 0.757, fig. 2). Mortality of some DAT tagged fish may be attributed to the suture wound.

7 mm DATs.—Survival of PIT tagged and DAT tagged Dworshak smolts was 100% up to day 108 of the study. On day 108, one PIT tagged fish was found dead with no obvious cause of mortality. On day 159, a dead DAT tagged fish was found with fresh water fungus *Saprolignia* spp. In the following days, four PIT tagged and four DAT tagged smolts succumbed to the fungus. At that point, we terminated the tag study as it was obvious that the fungus was spreading throughout the fish in the tank and the tag study results would be compromised. Prior to the occurrence of the fungus (day 159), survival was 100% for DAT tagged fish and 99% for PIT tagged fish. If these fish had the opportunity to migrate, they would have reached the ocean in several weeks (median day of arrival of ROR smolts to the ocean was 35 days), and thus would likely not have been affected by this freshwater pathogen.

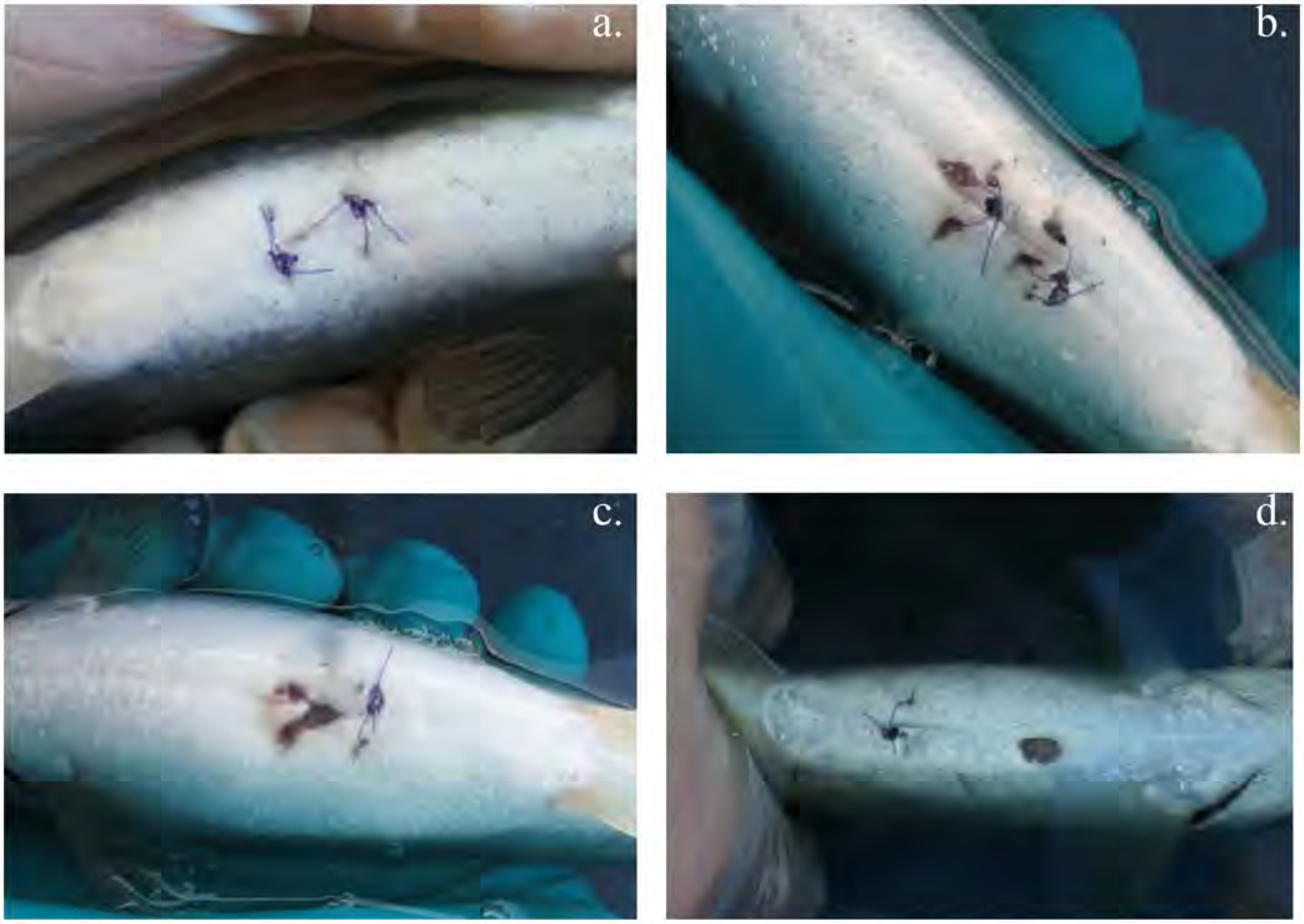

Figure 5. a. Typical Dworshak spring Chinook salmon smolt 11 weeks post-surgery with healed incision and 9 mm dummy acoustic transmitter (DAT) and sutures still intact. b. After 12 weeks in captivity, Yakima Chinook salmon implanted with a 9 mm DAT have a completely healed incision, although sutures have not dissolved and are tearing through the skin of some fish. c. Yakima spring Chinook salmon 12 weeks post-surgery with sutures torn to incision leaving wound for 9 mm transmitter to exit. The relatively delicate skin of Yakima Chinook may be an intrinsic trait; however, suture tearing also may plausibly be attributed to warmer water temperatures experienced at Prosser Hatchery. As run of river Yakima smolts migrated into the ocean only days after release, they would have experience cooler water temperatures within weeks of surgery. As well, it is likely that tag loss would have been minimal during the time when fish migrated over the array (see fig. 3). d. Yakima spring Chinook salmon implanted with a 7 mm DAT 5 weeks post-surgery; this fish is forming a pore anterior of the surgery site from which the transmitter might potentially be expelled. (Suture tearing and tag expulsion did not occur in Dworshak fish.)

Survival of Yakima smolts to day 31 was 98% for DAT tagged and 100% for PIT tagged fish. From day 32 to day 37, nine DAT tagged and four PIT tagged fish died. Although more DAT tagged fish died during the final week, the difference was not significant (table 4b). Because the study was inadvertently terminated on day 38 (see section “Methods”), we were not able to monitor fish in captivity beyond 5 weeks. Survival was not a function of initial fork length (Wald X^2= 1.075, df = 99, p = 0.283; fig. 2), therefore mortality was not limited to smaller individuals.

Growth

9 mm DATs.—The initial mean fork length (mm) and weight (g) of PIT tagged and 9 mm DAT tagged Dworshak smolts were not significantly different (table 4c,d, fig. 6). At 5 weeks post-surgery, the mean fork length and mean weight of PIT tagged smolts were significantly greater than DAT tagged fish. At 11 and 24 weeks post-surgery, the mean fork length and weight of PIT tagged smolts remained significantly greater than DAT tagged fish.

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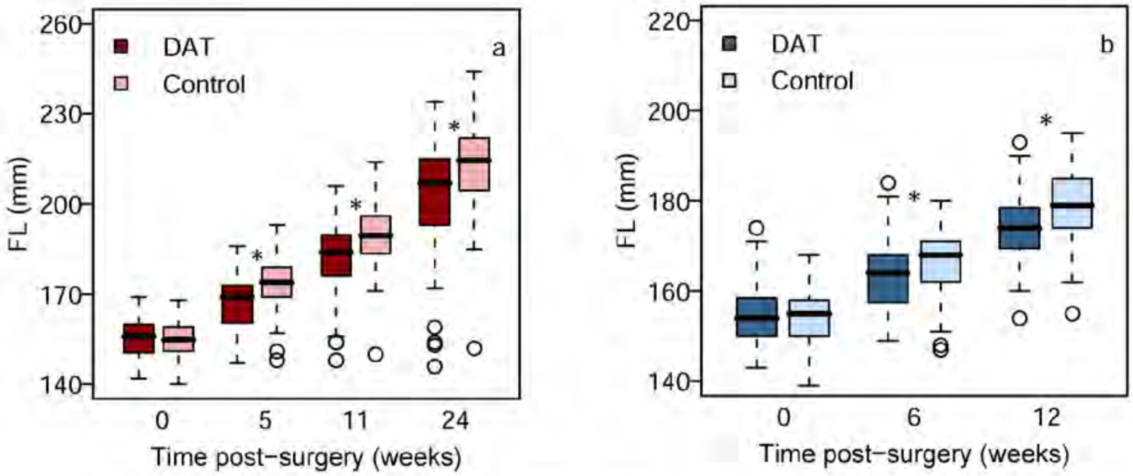

Figure 6. Boxplots (median, quartiles, and 95% confidence interval) of fork length (FL) for Dworshak (a) and Yakima (b) spring Chinook salmon tagged with 9 mm dummy acoustic transmitters (DAT) and passive integrated transponder tags (control) in 2006. Asterisks indicate a difference at a 0.05 level of significance. Open circles represent precocious fish that were not included in the analysis. Boxplots of weight are not shown, but see table 4d.

The specific growth rates (% weight/week) of PIT tagged smolts were significantly greater than DAT tagged smolts from week 0 to week 5 when we accounted for initial fork length (table 4e). During this initial 5 week period, PIT tagged fish grew 2.2% /week more than DAT tagged fish. From week 5 to the final week of the study (week 24), however, specific growth rate was not statistically distinguishable for the two treatments, demonstrating that DAT tagged smolts grew at the same rate as PIT tagged smolts and that recovery from an initial set back in growth (due to the DAT or the surgery, or the cumulative effects of both) occurred within 5 weeks post-surgery.

The initial mean fork length and weight of PIT tagged and DAT tagged Yakima smolts were not significantly different; however, by week 6, PIT tagged fish were significantly larger than DAT tagged fish (table 4c-d, fig. 6). At week 12, this difference was still significant.

The specific growth rates of PIT tagged smolts were significantly greater than DAT tagged smolts from week 0 to week 6 when we accounted for initial fork length (table 4e). During this initial 6-week period, PIT tagged fish grew 1.3%/week more than DAT tagged fish. From week 6 to the final week of the study (week 12), PIT tagged fish grew 0.58%/week more than the DAT tagged fish; however, this was not a significant difference for the two treatment groups. Therefore, Dworshak and Yakima fish tagged with a 9 mm DAT suffered an initial growth set back due either to the DAT or the surgery, or the cumulative effects of both, but this effect did not persist beyond the first growth measurements at weeks 5 and 6, respectively.

7 mm DATs.—The initial mean fork length and weight of PIT tagged and 7 mm DAT tagged Dworshak smolts were not significantly different (table 4c,d, fig. 7). The mean fork length and weight of PIT tagged smolts 7 and 23 weeks post-surgery also were not significantly greater than DAT tagged fish (table 4c, d). Therefore, the 7 mm DAT did not have an initial impact on fork length or weight, as was observed for the 9 mm tag (which was implanted into slightly larger fish).

The specific growth rate analyses indicated that PIT tagged Dworshak fish grew 0.52%/week more than DAT tagged fish during the first 7 weeks, which was significantly greater (table 4e), despite the non-significant finding for the fork length and weight comparisons during the same time interval. From week 7 to week 23, however, specific growth rates were not statistically distinguishable for the two treatments, and both groups grew at approximately the same rate; thus recovery from the initial set back in growth occurred in less than 7 weeks post-surgery.

The initial mean fork length and weight of PIT tagged and DAT tagged Yakima smolts were not significantly different (table 4c-d, fig. 7). The mean fork length and weight of PIT tagged smolts 5 weeks post surgery also were not significantly greater than DAT tagged fish.

The specific growth rate analyses indicated that PIT tagged Yakima fish grew 0.48%/week more than DAT tagged fish during the first 5 weeks, which was significantly greater, despite the non-significant finding for the fork length and weight comparison during the same time interval (table 4e). As the study ran for only 5 weeks, we were unable to monitor growth for a second interval. However, compared to the 9 mm tag, the initial set back in growth rate was not as large for the 7 mm tag (1.3% vs. 0.48%).

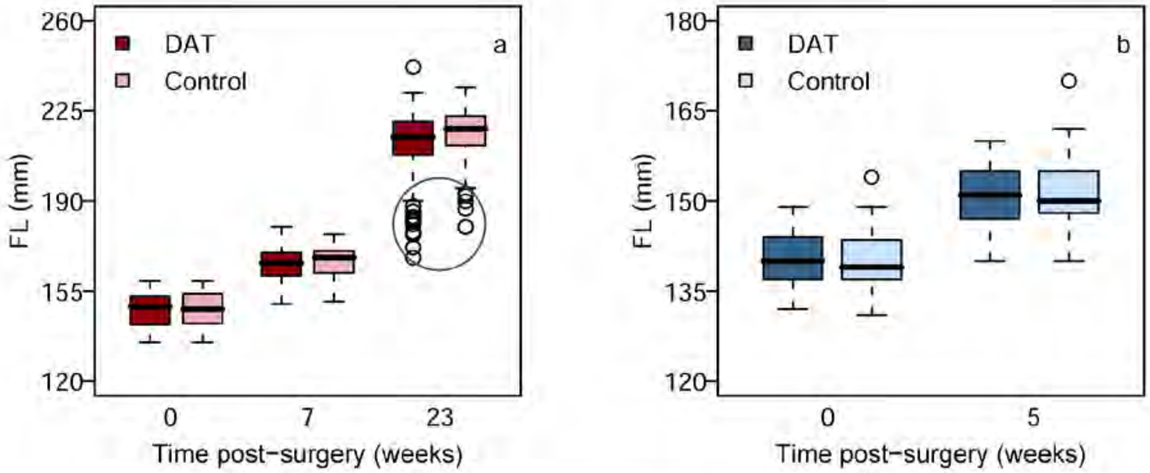

Figure 7. Boxplots (median, quartiles, and 95% confidence interval) of fork length (FL) for Dworshak (a) and Yakima (b) spring Chinook salmon tagged with 7 mm dummy acoustic transmitters (DAT) and passive integrated transponder tags (control) in 2008. There was no significant difference in FL of DAT and control groups for either population during the study. The circle in (a) shows the FL's of precocial males which were excluded from the significance test. Open circles represent precocious fish that were not included in the analysis. Boxplots of weight are not shown, but see table 4d.

Tag Effects–Field Study

In 2006 and 2008, Columbia River basin spring Chinook salmon smolts were tagged with 9 mm (minimum size 140 mm FL) and 7 mm (minimum size 130 mm FL) acoustic tags, respectively, released into the river, and tracked as far north as Alaska. Although smolts were detected on the Vancouver Island line (at Lippy Point), survivorship for these ROR groups was estimated to coastal Washington (the Willapa Bay detection site, fig. 8). To determine if tags may have affected survival we: (1) plotted the estimated survival of 5 mm size classes at each detection site for each population in each year for a visual comparison of survival by size; (2) used initial fork length as an individual covariate within a linear model framework in Program MARK to statistically test the hypothesis that smaller fish have lower survival due to tag burden; and (3) compared our in-river survival estimates obtained with acoustic tags to other studies that obtained survival estimates with PIT tags.

Survival by Size Class

9 mm transmitter.—Survival of Dworshak ROR smolts tagged with 9 mm transmitters was variable across all size classes at each detection site, and smaller size classes did not appear to have lower survival (fig. 9). Similarly, survival of Yakima ROR smolts was variable across all size classes at each detection site as well (fig. 9). The smallest Yakima size class had the lowest survival; however, it was made up of only six fish. It is possible that fish at the lower limit of our size requirements of 140 mm may have suffered from tag induced mortality (Welch et al., 2007); however, it is difficult to draw conclusions about this size class because of the low sample size. If smaller fish had reduced survival then we would have expected survival to increase with increasing body size, however, the largest groups did not have the highest survival. Thus, the 9 mm acoustic transmitter did not appear to differentially affect survival over the size range tested.

7 mm transmitter.—Survival of Dworshak ROR smolts tagged with 7 mm transmitters was variable across all size classes at each detection site (i.e., there was no general trend in survival), with the exception that the largest size class (155–159 mm) appeared to have consistently higher survival than all other size classes (fig. 10). Survival of Yakima ROR smolts was variable across all size classes at each detection site; however, the largest Yakima size class had the lowest survival, in contrast to Dworshak (fig. 10). The sample size of the largest Yakima size class was low, however, and therefore it is difficult to draw conclusions about this size class. In general, survival did not increase with increasing body size, and thus the 7 mm acoustic transmitter did not appear to differentially affect survival across the size range tested.

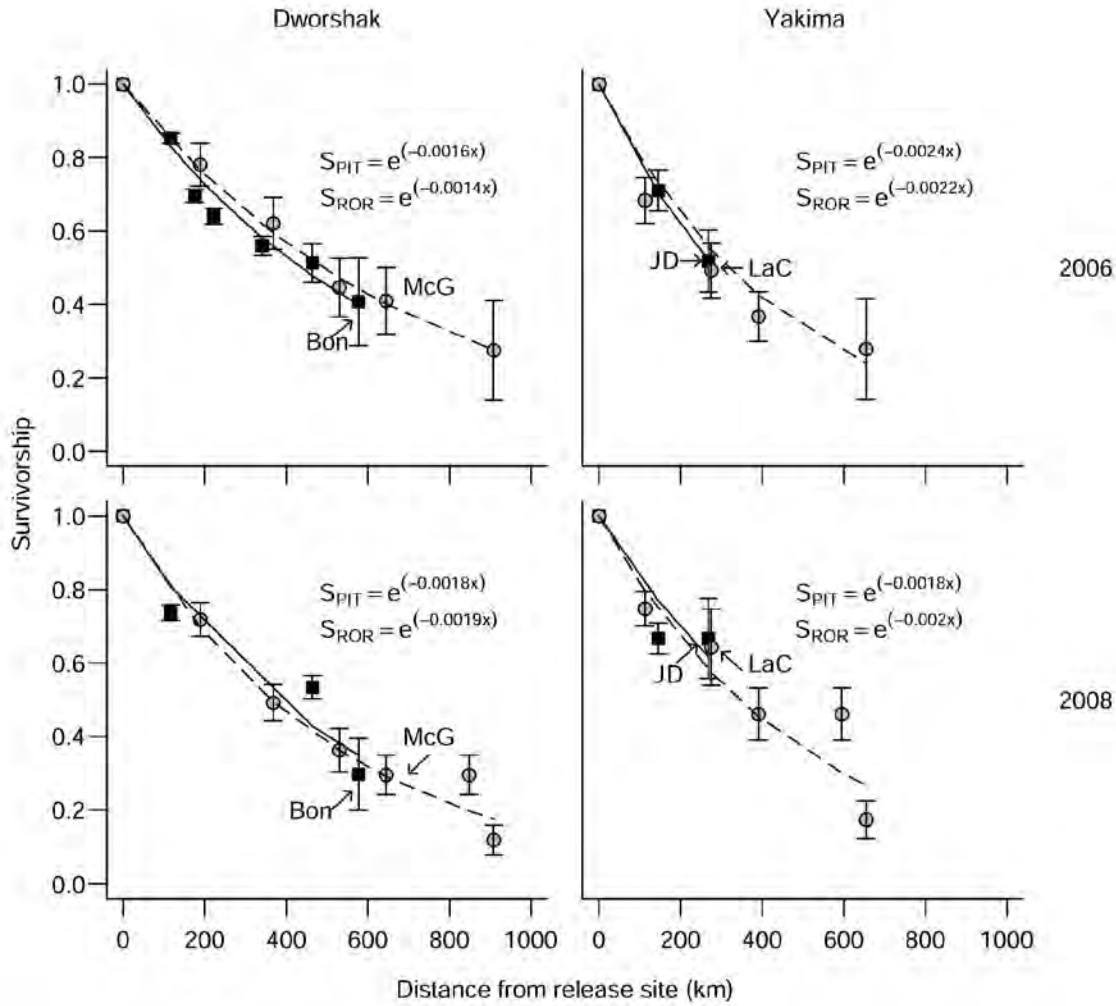

Figure 8. Survivorship of Dworshak and Yakima spring Chinook salmon in 2006 and 2008. Survivorship of acoustic tagged smolts (grey circles, dashed line) was estimated to coastal Washington (Willapa Bay). Survivorship of passive integrated transponder (PIT) tagged smolts (black squares, solid line) was estimated to Bonneville Dam (Bon) and John Day (JD) for Dworshak and Yakima smolts, respectively. Survivorship curves are calculated by fitting the log-transformed regression $S(x)=e^{-bx}$, where x is distance from release site. (PIT tag survival estimates for Dworshak are from Steve Smith at NOAA/National Marine Fisheries Service/Northwest Fisheries Science Center and Faulkner et al., 2008, and Yakima PIT tag estimates are from David Lind at Yakama Fisheries). ROR =run of river treatment groups presented in this study, McG=McGowan's Channel (10 km downstream of Bon), LaC=Lake Celilo (7 km downstream of JD). Error bars are 95% confidence intervals.

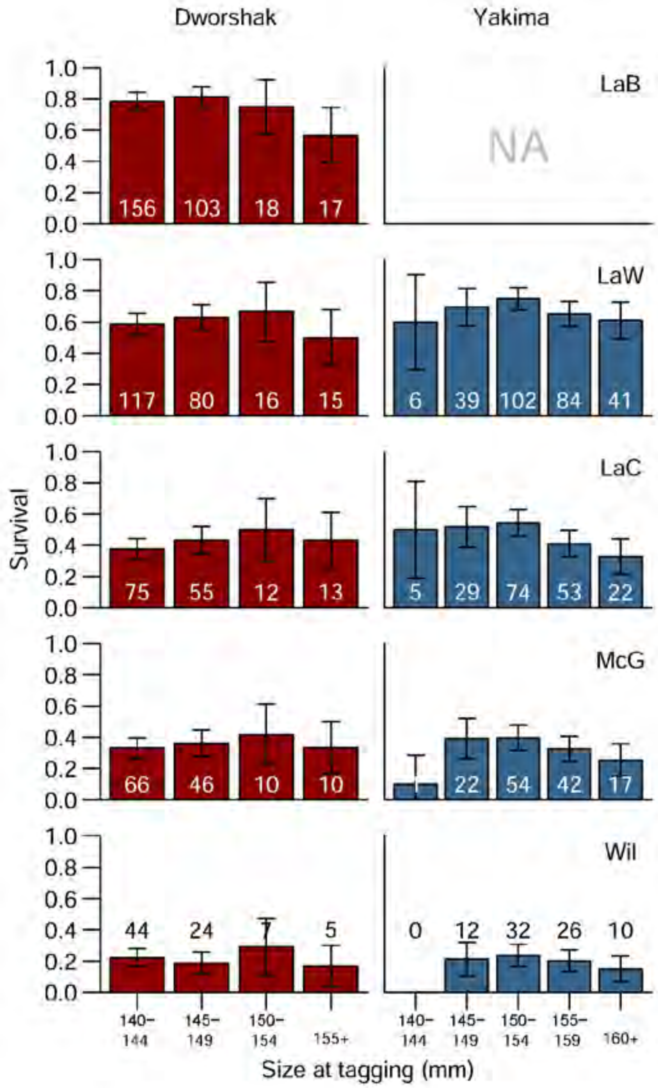

Figure 9. Survival in 2006 by size class (fork length) of migrating Dworshak (red) and Yakima (blue) spring Chinook salmon tagged with 9 mm acoustic transmitters. The numbers on or above the bars indicate the estimated number of fish detected within each size class at each detection site. NA=Not applicable to Yakima smolts. LaB=Lake Bryan, LaW=Lake Wallula, LaC=Lake Celilo, McG=McGowan's Channel, Wil=Willapa Bay. Error bars are 95% confidence intervals.

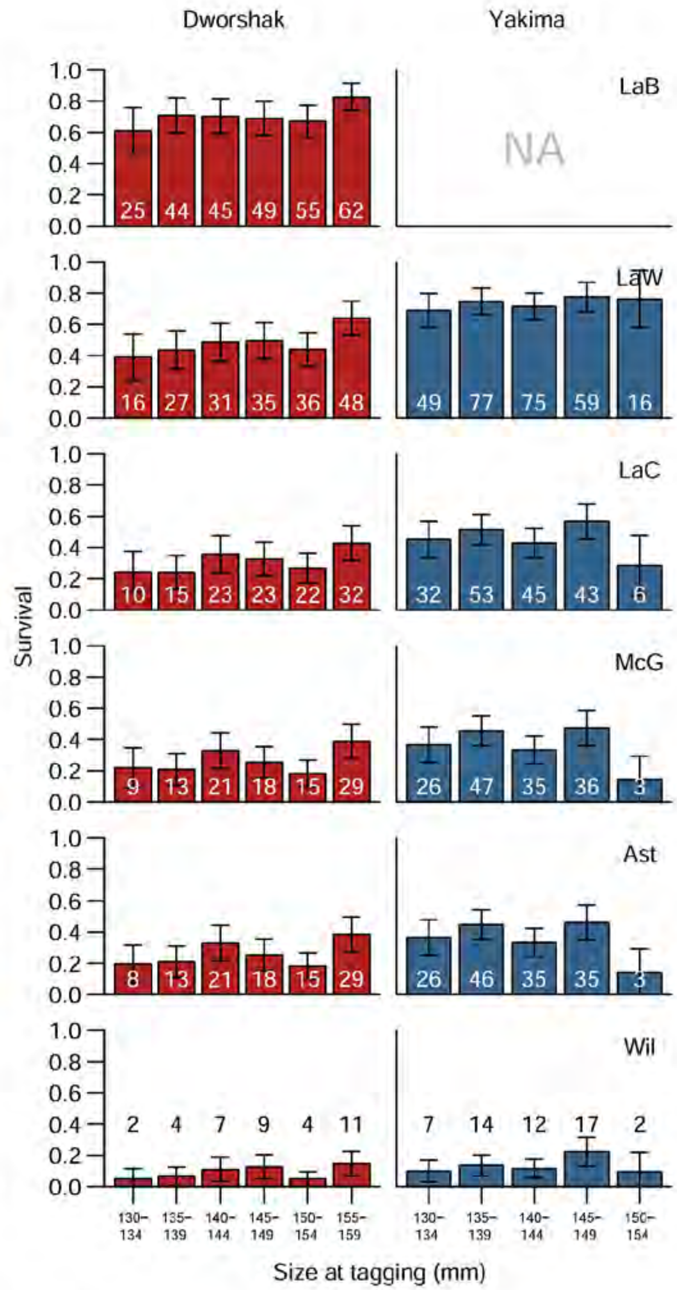

Figure 10. Survival in 2008 by size class (fork length) of migrating Dworshak (red) and Yakima (blue) spring Chinook salmon tagged with 7 mm acoustic transmitters. The numbers on or above the bars indicate the estimated number of fish detected within each size class at each detection site. NA=Not applicable to Yakima smolts. LaB=Lake Bryan, LaW=Lake Wallula, LaC=Lake Celilo, McG=McGowan's Channel, Ast=Astoria Bridge, Wil=Willapa Bay. Error bars are 95% confidence intervals.

Fork Length as a Covariate in Survival Models

To test the hypothesis that smaller ROR fish have lower survival due to tag burden, we used an information theoretic approach to compare the fully time-varying CJS survival models to additive and interaction models that included fork length as a covariate.

9 mm transmitters.—For Dworshak ROR smolts, the most parsimonious survival model was the fully time (i.e., line) varying CJS model (table 5). The ΔAIC of the additive model with fork length as a covariate was approximately 2, and the deviances of the models were nearly identical, which implies that there was no difference in the models. For Yakima ROR smolts, there was some support for the additive survival model with fork length as a covariate (ΔAIC=0.83); however, the most parsimonious model was the fully time varying CJS model (table 5). Therefore, there is no support that smaller smolts suffered higher mortality.

7 mm transmitters.—For Dworshak smolts implanted with 7 mm transmitters, the most parsimonious survival model was the additive model with fork length as a covariate, which provided support that as fork length increased survival increased; however, figure 10 demonstrates that the largest size class had consistently higher survival, and therefore we re-ran the analysis and excluded smolts that were 155–159 mm FL to determine if size was a factor across all other sizes (from 130–154 mm FL). When we excluded the largest size class, the fully time varying CJS model was the most parsimonious model (table 5). The AIC of the additive model with fork length as a covariate was <2, and the deviances of the models were nearly identical, which implies that there was no additional support for a model with FL as a covariate.

For Yakima ROR smolts, there was little support for the additive model with fork length as a covariate; the most parsimonious model was the fully time varying CJS model (table 5). There is no statistical support that smaller smolts suffered higher mortality.

Table 5. Model selection for fork length (FL) analyses using Akaike's Information Criterion (AIC).

[QAICc=quasi-AIC corrected for overdispersion and effective sample size. Φ = survival probability, line = acoustic detection site. Recapture parameters were held constant for all models ($p_{population*line}$)]

	Model	QAICc	ΔQAICc	Num. Par	QDeviance
2006					
Snake	Φ_{line}	592.37	0	11	570.14
	$\Phi_{line+FL}$	594.35	1.98	12	570.08
	$\Phi_{line*FL}$	600.97	6.62	17	566.44
Yakima	Φ_{line}	1,281.24	0	9	1,263.06
	$\Phi_{line+FL}$	1,282.07	0.83	10	1,261.85
	$\Phi_{line*FL}$	1,282.71	0.65	14	1,254.30
2008					
Snake	$\Phi_{line+FL}$	1,765.71	0	14	1,737.31
	Φ_{line}	1,769.53	3.82	13	1,743.18
	$\Phi_{line*FL}$	1,775.38	5.86	20	1,734.59
Snake (FL=130–154)	Φ_{line}	1,381.77	0	13	1,355.32
	$\Phi_{line+FL}$	1,383.56	1.79	14	1,355.05
	$\Phi_{line*FL}$	1,388.66	5.10	20	1,347.62
Yakima	Φ_{line}	1,683.99	0	11	1,661.70
	$\Phi_{line+FL}$	1,685.12	1.13	12	1,660.78
	$\Phi_{line*FL}$	1,687.51	2.39	17	1,652.84

Comparative Survival of In-River Migrants Using Acoustic Tags and PIT Tags

9 mm transmitter.—Survival of acoustic tagged smolts was similar to PIT tagged smolt survival (fig. 8). We compared our Dworshak spring Chinook salmon acoustic survival rate (S/km) to the Pacific Ocean with NOAA's PIT tag survival rate from Dworshak NFH to Bonneville Dam in 2006. We chose to compare survival rate rather than survivorship estimates because distances to detection sites for each tag type vary, but we present the estimates of apparent survivorship in parentheses to inform the interpretation. We found no difference in estimated survival rate (p>0.05; fig. 8) between acoustically tagged smolts to the Pacific Ocean (survivorship to Willapa Bay, 911 km from the release site, was 27.5%, SE=6.9%) and PIT tagged smolts to Bonneville Dam (survivorship from release, a distance of 577 km, was 40.8%, SE=6.1%). Due to tag limitations, we could only tag smolts >140 mm FL (i.e., we could not tag the entire size range) and our release dates were during the latter part of the spring Chinook migration. Further, we released Dworshak smolts from Kooskia Hatchery 60 km upstream (purely for logistical reasons); however, comparing results from the two studies provided a second approach to assessing the reasonableness of our survival estimates by assessing whether our acoustically tagged smolts had lower survival than smolts tagged with PIT tags, a much smaller tag.

PIT tag survival estimates of Yakima spring Chinook salmon released from Cle Elum Hatchery and recaptured at CJFM in Prosser, WA, were available to McNary Dam and John Day Dam in the lower Columbia River. Although survival of PIT tagged fish could only be estimated to as far as John Day Dam (survivorship to John Day, 268 km from the release site, was 51.8%, SE= 4.3%), the estimated survival rate calculated from acoustic tag estimates for the entire lower Columbia River and into the ocean (survivorship to Willapa Bay, 655 km from release, was 27.9%, SE=7.0%) is consistent with the estimated PIT tag survival rate to John Day Dam (p>0.05; fig. 8).

7 mm transmitter.—We compared our Dworshak spring Chinook salmon acoustic survival estimates to the river mouth and to Willapa Bay (survivorship to Willapa Bay was 11.8%, SE=2.1%) to NOAA's PIT tag survival estimates in the river to as far as Bonneville Dam (survivorship to Bonneville Dam was 29.7%, SE=5.0%) in 2008 and found no difference in estimated survival rate (p>0.05; fig. 8). Because we used the smaller 7 mm tag, we were able to tag smolts as small as 130 mm FL, and we were able to tag and release fish approximately 1 week earlier than in 2006. Therefore, our release dates coincided with the peak of the Snake River spring Chinook salmon run but were still several weeks after NOAA PIT tagged smolts were released from Dworshak NFH.

PIT tag survival estimates for Yakima spring Chinook salmon were available to McNary Dam and John Day Dam in 2008. The estimated survival rate from release to John Day Dam (survivorship was 66.7%, SE=5.5%) was not significantly different than the estimated survival rate of acoustic tagged Yakima spring Chinook salmon smolts from release to Willapa Bay (survivorship of acoustic tagged smolts to Willapa Bay was 17.3%, SE= 2.6%; p>0.05; fig. 8).

Survival Estimates of ROR Spring Chinook Salmon Corrected for Tag Loss in Captive Studies

How much does tag loss and mortality due to the surgical procedure affect survival estimates for ROR smolts? All estimates of K (live, tagged animals in the captive study) were >98% at the time when migrating ROR smolts would have passed the Willapa Bay detection line. K was greater than >97% when Dworshak smolts migrated passed Lippy Point (in 2006 and 2008), and 85% when Yakima smolts passed Lippy Point in 2006 (in 2008 the Yakima tag study was only held for 5 weeks, which was insufficient time to estimates K to Lippy Point). Figure 11 shows ROR estimated survival and S_K. In general, the difference between adjusted and unadjusted survival estimates is negligible and well within the 95% confidence interval of the unadjusted survival estimates for both populations in both years. Dworshak smolts had zero mortality and tag loss in captivity within the first month in 2006 and 2008, and thus the survivorship estimates to Willapa Bay are not altered (28.5% in 2006, 11.8% in 2008). Beyond 1 month, there was minor tag loss and mortality of captive Dworshak smolts in 2006 and therefore, minimum survival of migrating smolts would increase 2%, from 1.49 to 1.52% at the Lippy Point detections site. In 2008, there was no tag loss or mortality in captive smolts at the time when migrating smolts were passing Lippy Point and no adjustment is necessary (minimum survival to Lippy Point was 3.1%).

For Yakima smolts in 2006 and 2008, the percent of fish available for detection based on captive studies was 99% at Willapa Bay. If we account for this slight reduction in detectability, survivorship would increase from 27.9 to 28.1% at Willapa Bay in 2006, and from 17.4 to 17.6% in 2008. Although combined tag loss and mortality was 15% after 45 days in captivity for Yakima smolts in 2006, the minimum survival of free ranging smolts to Lippy Point would only increase from 0.7 to 0.8% (we could not assess medium-term tag loss for Yakima smolts in 2008).

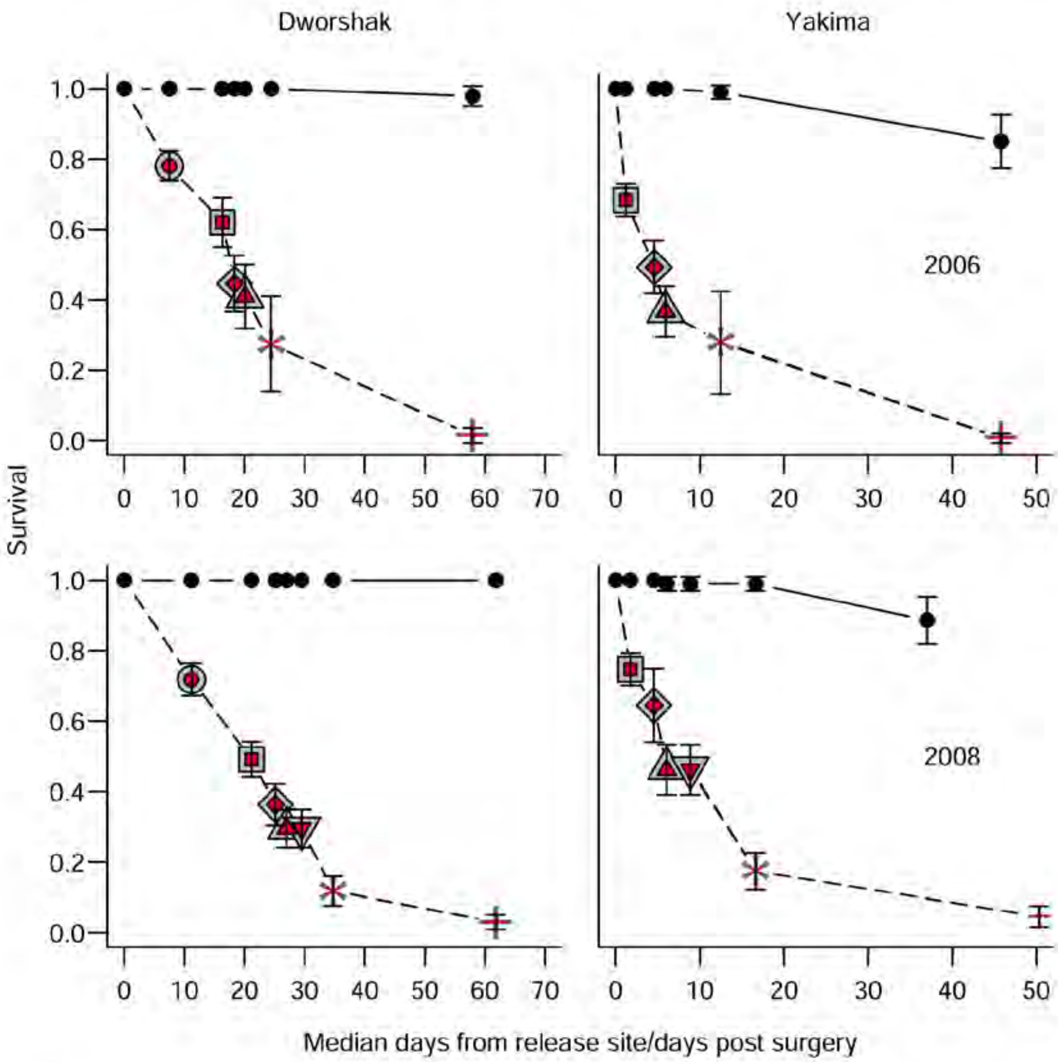

Figure 11. Proportion of tagged animals available for detection from the captive tag study (K; black circles), estimated in river survival with 95% confidence intervals (red symbols), and estimated ROR survival corrected for tag effects (S_K, larger, grey symbols). The correction for potential mortality and tag loss as a result of surgical implantation had no material effect on the measured survival of free-ranging smolts. Note that the corrected survival falls almost perfectly on top of the survival estimates. ○ = Lake Bryan, □ = Lake Wallula, ◊ = Lake Celilo, Δ = McGowan's Channel, ∇ = Astoria Bridge, * = Willapa Bay, + = Lippy Point.

Discussion

Overall, short term (<1 month) mortality and tag loss following surgical implantation was minimal for 9 mm dummy acoustic transmitters implanted into smolts ≥140 mm FL and weighing 5.2–10.4% of the body weight. The short-term effects of the smaller 7 mm transmitter on tag retention and mortality were negligible for smolts ≥130 mm FL implanted with 7 mm dummy transmitters, and weighing 2.8–7.6% of the weight of the fish. Therefore, estimates of survival of migrating smolts over long distances and up to 1 month are reasonable within these size limitations.

Medium-term (30–90 d) mortality and tag loss was minimal for Dworshak smolts tagged with both transmitter sizes. Yakima smolts tagged with 9 mm transmitters were more susceptible to medium-term tag loss, but nearly 3 months post-implantation 84% of the tags were still retained. We believe that the 16% tag loss may have been due to the sutures tearing through the skin, leaving a large open wound through which the transmitter could escape. While conducting surgeries, we noticed that the skin and musculature of the body wall of Yakima smolts was much thinner and more delicate than what we observed in the more robust Dworshak population, and this may have made fish more susceptible to chafing by the sutures. Further, we noted that 60% of the Yakima DAT tagged fish had one suture that had either ripped out or was visibly ripping through the skin 86 days post-surgery. Tag loss and mortality, however, were not a function of size (i.e., smaller fish no more susceptible than larger fish), and damage did not appear to be caused by the transmitter pushing against sutures (see fig. 5b-c).

Water temperature may contribute to the more fragile skin of the Yakima smolts, as Dworshak smolts were held in colder water than Yakima smolts and showed only minor medium-term effects from the 9 mm tag. Both populations were, however, held at water temperatures that were comparable to their respective river temperatures; therefore, it is possible that the Yakima population has inherently more delicate skin. It has been demonstrated that fish implanted with transmitters have significantly higher occurrence of tag loss at higher temperatures (Knights and Lasee, 1996; Bunnell and Isely, 1999). In bluegills (*Lepotnis macrochirus*), transmitters were expelled through necrotic muscle tissue for fish held at 20°C (Knights and Lasee, 1996), and in rainbow trout (*O. mykiss*) held at the same temperature, transmitters were expelled through the incision (Bunnell and Isely, 1999). There is, however, contrasting evidence that fish held in warmer water heal faster after injury (Anderson and Roberts, 1975). As we observed transmitter expulsion at the torn suture site, it is difficult to discern whether warmer temperatures caused the musculature to become more delicate and susceptible to chafing by sutures.

Ideally, the use of a more rapidly dissolving suture would likely address this issue, but commercially available absorbable sutures are designed for use in mammals. In mammals, these sutures rapidly lose their strength; however, the sutures do not readily degrade in fish held in cold water. If the sutures degraded as desired, the tearing we observed in Yakima fish would likely not have occurred and tag loss would have been lower. This does not appear to be a common problem among researchers that use surgical implantation as a method of transmitter attachment (Wagner and Cooke, 2005). We suspect that the wound caused by the sutures may have also contributed to mortalities, as we witnessed several fish with the pyloric caeca or liver protruding through the wound. We also witnessed several live fish that had lost transmitters and had well healed wounds where the transmitter exited; therefore, transmitter expulsion did not always kill the fish.

We were unable to assess medium- or long-term tag effects of the 7 mm transmitter on Yakima smolts, as the tag study was inadvertently terminated on day 37. Although survival and tag retention was >98% for the first month of the study, nine DAT and four PIT tagged fish died during the last week. Because PIT tagged fish also died in the final days of the study, we hesitate to attribute the death of DAT tagged fish (in the last 5 days) to the transmitters or the surgical procedure. On the final day of the study, we also observed potential tag expulsion. Unlike the 9 mm DAT, tag expulsion of the 7 mm DAT in Yakima smolts was beginning to occur at a location away from the incision site (a pore had started to form in the body wall). This mechanism of tag expulsion has previously been reported by Lucas (1989), Moore et al. (1990), Welch et al. (2007), and others (see Jepsen et al., 2002). We were unable to quantify tag loss through the body wall in 2008 to compare to the 2006 tag study results.

Although we were not able to observe medium- and long-term tag effects, there is support that 7 mm transmitters had less of an effect on the Yakima population than 9 mm transmitters. For example, the mean FL of PIT tagged and 9 mm DAT tagged fish differed significantly after 6 weeks, whereas mean FL 5 weeks post-implantation with the 7 mm tag was not significantly different. Further evidence that 7 mm transmitters had less of an effect is reflected in the growth rates; during the first interval after tagging, PIT tagged smolts grew 1.3% per week more than 9 mm DAT tagged smolts and only 0.48% per week more than 7 mm DAT tagged fish.

In Dworshak smolts tagged with both tag types, growth rate rebounded for DAT tagged fish after an initial period of slower growth following surgery. An initial period of impaired growth followed by growth at the same rate as control fish was also observed in fall Chinook salmon smolts implanted with radio transmitters that weighed up to 5.5% of the body weight of the fish (Adams et al., 1998a). Tag loss may thus have the potential to have some relatively small effects on long-term tracking studies (>3 months), when we consider only tag effects in captivity. It is possible that tag loss and mortality are higher in the wild, but the contribution of this source of error needs to be put in perspective relative to the size of the survival decline being measured in free-ranging smolts. Our results indicate that short- or medium-term studies would be minimally affected by tag loss or tag induced mortality even for Yakima smolts tagged with 9 mm transmitters.

Survival by Size of Migrating Smolts

We found no strong evidence for a relationship between size and survival for ROR smolts. Survival by 5 mm size class was variable for both transmitter types and for both populations and there was little support for survival models that incorporated body length as a covariate. There was only one exception to this general observation that did show some evidence for larger tagged smolts surviving better: in Dworshak smolts implanted with 7 mm tags in 2008, the largest size class (155–159 mm FL) had higher survival than all other size classes. The survival model results were consistent with this finding: when we included body size as a covariate and used all size classes tagged, this model had more support; however, when we excluded fish in the 155–159 mm FL size range, there was little support for the fork length model. This indicates that size did not affect survival of fish between 130 and 154 mm FL.

This survival difference (the largest size class with the highest survival) appeared to develop in the first migration interval between the release site and Lake Bryan (downstream of Lower Granite Dam) and persisted as fish migrated downstream. It is possible that larger fish escaped post-release predation or migrated more quickly resulting in higher survival; however, we did not see this trend in 2006 with the 9 mm tag where the largest smolts had the lowest survival in the same migration segment. In summary, only one of four comparisons showed evidence for larger fish having improved survival, and this result was restricted to the largest size class tagged. We thus have little evidence that the surgically implanted tags of the size we used were imposing a substantial burden on smolts above our specified size thresholds.

Effect of Tag Loss and Tag-Induced Mortality on ROR Survival Estimates

Although captive fish do not encounter the stressors that ROR fish must contend with in the wild, captive studies are the most practical method available for quantifying tag loss and mortality following surgical implantation of a transmitter. We used captive data to infer tag loss and tag mortality in actively migrating smolts and found that survival estimates of ROR smolts to Willapa Bay (40 km north of the Columbia River mouth) were unlikely to be affected by tag loss or tag mortality because tag retention and survival of captive groups was near 100% during the first month. Nearly all (96% in 2006 and 92% in 2008) of the Yakima smolts had migrated rapidly down the river and across the Willapa Bay line by day 30. Dworshak fish had farther to travel to reach the Willapa Bay line; however, by day 45, most fish had passed Willapa Bay (97% in 2006 and 88% in 2008).

In 2006 by day 60, all Dworshak fish had passed Lippy Point on northern Vancouver Island. The proportion of live, tagged, captive fish was 95% at day 45 and day 60, indicating that only 5% of ROR fish may not have been available for detection (combined smolt mortality and tag loss) at both ocean lines. In 2008 by day 70, 88% of Dworshak smolts had reached Lippy Point, and 100% of the captive fish were alive and tagged; therefore, all fish migrating past these detections site were presumably detectable.

In 2006, two Yakima fish were detected at Lippy Point and had passed by day 50. The proportion of live, tagged, captive fish was 85% at day 50, indicating that 15% of ROR fish may not have been available for detection at Lippy Point. In 2008, the mean travel time of Yakima smolts to Lippy Point was 56 days; however, we are unable to estimate potential nondetection because the captive tag study was terminated on day 37.

ROR Survival Compared With PIT Tag Studies.

Although it was not possible to directly measure tag loss or tag-induced mortality in free ranging salmon smolts (i.e., ROR), it was possible to further assess tag effects by comparing the survival estimates for ROR fish with that of PIT tagged smolts. As PIT tags have become the standard method for measuring salmon survival in the Columbia River, it is reasonable to compare acoustic tag performance to PIT tag performance. For instance, a short-term comparative survival study that used acoustic tags (similar in size to the 7 mm tag) and PIT tags found no difference in survival through a major hydropower dam in the Columbia River (Steig et al., 2005). The authors also noted that the sample size of PIT tagged fish used to achieve the same precision was two orders of magnitude greater than acoustic tagged fish (90,000 vs. about 800). Therefore, for our study, we used PIT tag survival estimates estimated independently for the same populations in the same migration year (see section "Methods"). Although release times and mean fish size were not identical for the two groups, the PIT tag estimates offer an alternative method for estimating survival within the Snake and Columbia Rivers using a much smaller tag that does not require surgical implantation (PIT tags generally are injected using a large-gauge hypodermic needle). We can thus use PIT tags as a benchmark of survival using very small tags. As our estimated decline in smolt survival with distance are consistent with the decline in survival of PIT tagged smolts with distance (see fig. 8), the negative effects of surgical implantation of our tags appear to be very minimal in ROR smolts, at least to the last dam where PIT tag-based estimates of survival can be obtained for Dworshak smolts (Bonneville) and to John Day Dam for Yakima smolts. Downstream of Bonneville Dam, no comparison of PIT and acoustic tagged smolts is possible, but the smooth decline in survival obtained with acoustic tags with distance downstream of Bonneville Dam does not suggest that there was a sudden decrease in survival for acoustically tagged smolts.

Other means of quantifying tag effects include measures of swimming performance, predator avoidance, and physiological indices. Swimming performance (critical swim speed, U_{crit}) has been tested in several species of salmonids and results indicate that juvenile salmon tagged with acoustic transmitters (representing various tag burdens) are capable of attaining U_{crit} values comparable to control groups (Moore et al. (1990), species: Atlantic salmon, tag burden: about 2.2% of fish weight; Brown et al. (2006) fall Chinook salmon, 10.7%; Anglea et al. (2004) juvenile fall Chinook salmon, 6.7%; Chittenden et al. (2009), coho *O. kisutch*, 8%). Predator avoidance experiments also were conducted by Anglea et al. (2004), which demonstrated that juvenile fall Chinook salmon tagged with acoustic transmitters and exposed to adult rainbow trout were not consumed in significantly higher proportions than the untagged control group. Adams et al. (1998b), however, found that juvenile fall Chinook salmon of similar size, implanted with radio transmitters resulting in similar body burden by weight, were eaten by smallmouth bass *Micropterus dolomieu* in greater numbers. These contrasting results could be due to different experimental design, different predators, or the presence of the 31 cm antenna trailing behind the radio tagged fish in Adams et al. (1998b), which may have aided in prey detection and subsequent capture.

To measure physiological response to surgery and tag presence, blood samples of tagged and control fish are often taken following a specified period of time (e.g., soon after tagging and at the end of a study) or post-exercise. Hematocrit level is a common metric used to evaluate stress response, and several studies have shown that after 2–3 weeks hematocrit levels of tagged juvenile salmon were within normal ranges found in salmonids and were comparable to control fish (Chittenden et al., 2009; Martinelli et al., 1998; Moore et al., 1990). As the smolts tagged in these studies had similar tag burdens to smolts presented in this study, these earlier studies suggest that stress due to tagging may subside within several weeks after surgery.

Tag Size Tradeoffs

The use of different acoustic tags represents a trade-off between biological and technical limitations on any telemetry system designed to study fish movements and survival. Generally speaking, smaller tags impose less of a burden on the animal that they are implanted in, but smaller tags also are harder to detect, for several reasons: (1) smaller transducers will not as efficiently convert electrical power from the battery into sound waves at the frequencies of primary interest for marine telemetry systems (as they are farther off-resonance), so the acoustic power output (loudness) will drop; and (2) smaller tags necessarily have smaller batteries, which means that tag lifespan also is reduced relative to what could be obtained with a tag containing larger batteries, unless transmission frequency is reduced to compensate.

Shrinking the tag size makes it harder to detect tags and also tags are detectable for a shorter period of time. To achieve the same probability of detecting the passage of a tagged fish means that additional economic investments must be made in receivers to use in constructing the individual sub-arrays forming the telemetry system in order to compensate for the reduced signal strength (range) of the tags. Similarly, smaller tags place greater physical limits on the geographic range that migrating salmon smolts can be successfully studied over. Our current results indicate that dummy V7 and V9 Vemco acoustic tags do not have a substantial influence on survival rates for free-ranging or hatchery-reared smolts ≥130 and ≥140 mm, respectively, relative to the other sources of mortality, and that these tags can be used in studies potentially lasting for 5 months or more in duration. Similar survival trials have shown that salmon smolts down to 100 mm FL (Chittenden et al., 2008) can be tagged with Vemco V6-sized tags; this, combined with our results, suggests that telemetry arrays capable of effectively measuring salmon survival are now technically feasible for many stocks and species of wild Pacific salmon, and not just for hatchery smolts ≥130 mm FL. However, consideration of the increased cost of such systems means that researchers need to carefully design these systems in order to make them as economical as possible.

In conclusion, tagging salmon smolts to measure survival beyond rivers and into the ocean requires both successful surgical implantation of transmitters and medium to long-term (>1 month) retention of tags. A critical requirement is that the combined effect of surgery and tag size does not affect growth and survival. We used multiple approaches to quantify the effect of tag implantation on survival for Columbia River spring Chinook salmon smolts, including captive smolt studies at hatcheries, a comparison of the statistical fit of an alternative survival model (FL as an individual covariate) for free-ranging smolts, and a comparison with independent survival estimates obtained from PIT tags. Overall, tagging effects were minimal for the size range of fish that we tagged (7 mm tag: ≥ 130 mm; 9 mm tag: ≥ 140 mm). We also found that different populations within the same river basin may not have a completely equal response to tag implantation, with the Yakima smolts having a greater incidence of sutures tearing through the skin and subsequent tag loss over time. Finally, adjusted survival estimates (S_K) for ROR smolts to reflect tag loss and smolt mortality observed in captive populations are well within the 95% confidence intervals of unadjusted survival estimates, indicating that these sources of uncertainty are likely very small relative to the overall mortality we have measured.

Our results indicate that acoustic telemetry appears to be a reliable method for measuring survival of free-ranging smolts and testing alternative hypotheses concerning the cause of the poor ocean survival of some populations of smolts originating from the Columbia River basin (Schaller et al., 1999). Measurement of Chinook salmon smolt movement or survival over periods of many months appears to be quite feasible when smolts are implanted with 9 mm transmitters <11.5% of body weight and 7 mm transmitters <7.3% of body weight. Although movement measurements do not require precise estimation of the proportion of tagged animals reaching a sub-array, the more demanding task of estimating smolt survival over time periods up to at least 3 months post-surgery appears to be feasible, with estimates of survival apparently not substantially compromised by tagging-induced mortality or tag loss, compared to the smaller PIT tag. Future, long-term, survival studies (> 6 months) that are intended to quantify ocean survival beyond the three-month time period should also include long-term tag retention studies in hatcheries to establish whether smolt survival and tag retention on longer time scales is also feasible; recent work on coho salmon (Chittenden et al., 2009) indicates that high survival and tag retention out to at least 8 months post-surgery is feasible.

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Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean

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Multiple dam passage during seaward migration is thought to reduce the subsequent survival of Snake River Chinook salmon. This hypothesis developed because juvenile Chinook salmon from the Snake River, the Columbia River's largest tributary, migrate >700 km through eight hydropower dams and have lower adult return rates than downstream populations that migrate through only 3 or 4 dams. Using a large-scale telemetry array, we tested whether survival of hatchery-reared juvenile Snake River spring Chinook salmon is reduced in the estuary and coastal ocean relative to a downstream, hatchery-reared population from the Yakima River. During the initial 750-km, 1-mo-long migration through the estuary and coastal ocean, we found no evidence of differential survival; therefore, poorer adult returns of Snake River Chinook may develop far from the Columbia River. Thus, hydrosystem mitigation efforts may be ineffective if differential mortality rates develop in the North Pacific Ocean for reasons unrelated to dam passage.

delayed mortality | marine survival | acoustic telemetry

The Columbia River basin has the fourth largest virgin mean annual discharge in North America and has been classified as "strongly affected" by high fragmentation of the river resulting from the construction of many large dams and from major irrigation consumption (1). Flooding, fish habitat loss, proliferation of nonindigenous aquatic species, and extensive modification of the riparian zone resulted from the river fragmentation; however, this altered river system provides electricity, irrigation, flood control, transportation, and recreation to people in the region. For salmon, dams alter migration routes and speeds and act as large obstacles that adults must navigate around during their migration to upstream spawning grounds (via fish ladders) and that juveniles must pass through (via spill over the dam, fish bypasses, or turbines) during their seaward migration.

Before dam construction, Columbia River basin spring Chinook salmon, *Oncorhynchus tshawytscha,* abundance declined dramatically because of overharvesting (2). Several decades later, populations began to rebound, likely as a result of strict harvest regulations (3) and improved ocean conditions (4). However, salmon populations were further affected by the construction of hydroelectric dams on both the Columbia River and its largest tributary, the Snake River (5–7). Just as construction of the last of four major dams in the lower Snake River was being completed in the late 1970s, an unfavorable change in ocean climate also contributed to the reduced survival of many salmon stocks in southern parts of their range (4, 8). In 1992, Snake River spring Chinook salmon were listed as threatened under the US Endangered Species Act.

Since that time, billions of dollars have been spent on programs to improve smolt (seaward-migrating juvenile salmon) survival through dams and turbines, in tributary habitats, and in the Columbia River estuary (9). As a result, direct smolt mortality at the dams has been successfully reduced (10–12), and survival of Snake River spring Chinook salmon smolts that migrate through the eight-dam, 460-km hydrosystem (a series of four dams in the lower Snake River and four dams in the lower Columbia River) is now typically 50% (13), which is higher than that observed for Chinook salmon populations that migrate a similar distance in the adjacent undammed Fraser River (14). However, despite increases in freshwater smolt survival, smolt-to-adult return rates (SARs) of the aggregate wild Snake River spring Chinook salmon run averaged only 1.1% over the last decade (15), which is well below the recovery target of 4% and the minimum target of 2% (16). Therefore, approximately one in two smolts survive the hydrosystem, but only one in 50 of these survivors then survives the Columbia River estuary and North Pacific Ocean to return as adults 2–3 y later.

In contrast, the SAR of wild spring Chinook salmon from two mid–Columbia River tributaries (the John Day and Yakima rivers) was 4.3% and 3.1%, respectively, during the same period (15). These smolts only migrate through the lower Columbia River dams and are not exposed to Snake River dam passage. Thus, the lower productivity of the Snake River population was attributed to their combined exposure to the four lower Snake River dams and the four lower Columbia River dams during seaward migration (6, 17). Budy et al. (18) reviewed the possible stressors that Snake River spring Chinook salmon may encounter during their downstream migration and concluded that the accumulation of multiple stressors results in hydrosystem-induced delayed mortality (henceforth, "delayed mortality") that occurs in the estuary and coastal ocean.

The marine phase, however, may also differentially affect the survival of spring Chinook salmon stocks. Populations may migrate at different speeds or times or to different parts of the ocean, where they are exposed to different conditions, or they may migrate concurrently but respond differentially to ocean conditions (19). Catches of salmonids on the continental shelf during research surveys indicate that Columbia River basin spring Chinook salmon (including the Snake River populations) are widely distributed between Vancouver Island and southeast Alaska during their first summer at sea (20). Recoveries of mature Columbia River spring Chinook salmon from the commercial fishery also indicate that ocean distributions vary considerably (21). Coastal migration patterns appear to be consistent between years, regardless of changes in ocean conditions, and this lack of plasticity suggests a genetic control that may prevent populations from migrating away from poor-quality marine areas (20).

Such behavior could also explain why, despite improved ocean conditions since 1998–1999 and correlating higher adult return rates, Snake River spring Chinook salmon SARs covary with, but remain lower than, mid-Columbia populations (22). In contrast, river conditions (such as faster river velocity during smolt migration) were associated with improved adult returns, in addition to cold sea temperatures and increased coastal upwelling (23). Freshwater smolt survival during seaward migration and subsequent SARs were also positively correlated, supporting the

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Conflict of interest statement: D.W.W. 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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hypothesis that difficult or slow migration through the hydrosystem results in delayed mortality in the estuary and ocean (24).

These analyses, however, are based on mark-recapture data from fish that were tagged as juveniles and were then captured or detected as returning adults, rather than direct measurements of survival during the critical weeks in the estuary and coastal ocean immediately after dam passage. Stressful freshwater passage subsequently manifesting itself as mortality in the ocean, and the direct effects of the ocean on survival (both soon after ocean entry and for the rest of the marine phase), are confounded when using adult return rates. The only way to discriminate between these sources of mortality is to directly estimate survival downstream of the final dam during estuarine and early marine migration.

The development of acoustic tags small enough to surgically implant into salmon smolts, and the large-scale telemetry arrays with which to track them, provides a technique for directly estimating survival in the lower reaches of large rivers (14, 25–27) and into the coastal ocean (28–32), making it unnecessary to wait 2–3 y for the adults to return before evaluating delayed mortality. Using a continental-scale acoustic telemetry array (Fig. 1), we tracked the movements and estimated survival of size-matched groups of acoustic-tagged, 1-y-old hatchery spring Chinook salmon smolts from the Snake River and from a downstream population from the Yakima River to northern Vancouver Island, a distance of 750 km beyond the final dam. SARs for the Yakima River population, which migrates through half the number of dams, were, on average, 3.4 times higher than for the Snake River population (15) during this study. We then used an information theoretic approach (33) to investigate whether survival of Snake River smolts was lower than that of Yakima River smolts. Our results substantially extend the period of life history during which is it possible to address whether delayed mortality occurs in juvenile salmon from the Columbia River basin and expand and further support the findings of our first-year pilot study in 2006 (28).

Results

Estimated survival in each of the migration segments in the area of comigration was similar for Snake and Yakima River spring Chinook salmon (Fig. 2). From Lake Wallula to Lake Celilo, survival ranged between 0.72–0.75 for Snake River smolts and 0.63–0.87 for Yakima River smolts (Table 1; see Table S1 for the number of fish detected on each subarray). From Lake Celilo to McGowans Channel, survival ranged between 0.8–1.0 for Snake River smolts and 0.71–1.0 for Yakima River smolts. In 2006, survival from below Bonneville Dam to Willapa Bay (which included the lower Columbia River, estuary, and plume) was 0.78 (SE = 0.19) for Snake River smolts and 0.77 (SE = 0.18) for Yakima River smolts.

In 2008, following the installation of the Astoria subarray, we were able to partition survival between the lower Columbia River and estuary (LRE) and the plume. We found that survival in the LRE was consistently very high and ranged between 0.82 and 1.0 for both populations in 2008 and 2009. Survival in the plume during those years ranged between 0.34 and 0.48 for both populations. This was surprisingly low, given the short migration distance of only 63 km between subarrays and given that joint survival in the LRE and plume was substantially higher in 2006, at 0.77 and 0.78 for the two populations, indicating that plume survival must have been much higher in 2006. Thus, we observed substantial interannual variability in plume survival and strong covariation between populations.

We also observed interannual variability and covariation in estimated survival during the 485-km, 1-mo-long migration beyond the plume in the coastal ocean to Lippy Point, BC, Canada. In 2006, a year of poor to intermediate ocean conditions (34), coastal ocean survival was lowest for both populations (only 0.04 for Snake River smolts and 0.02 for Yakima River smolts). In 2008, a year of much improved ocean conditions, coastal survival was an order of magnitude higher for both populations (0.29 and 0.30). In 2009, when ocean conditions were intermediate, coastal survival estimates were intermediate as well (0.12 and 0.04).

Accordingly, when all migration segments in the area of comigration are taken together, cumulative survival for both populations from Lake Wallula to Lippy Point covaried (Fig. 3). In 2006, cumulative survival ranged between 0.01 and 0.02. With improved ocean conditions, cumulative survival increased to 0.07 for both populations in 2008 and then declined in 2009, to 0.01–0.03.

After approximately 2 mo in the ocean, several smolts were detected on the acoustic subarray in Alaska; however the low numbers detected on this subarray (>1,000 km north of Lippy Point) prevented us from estimating survival to this location (*Materials and Methods*). The estimated detection probabilities, *p*, of other subarrays are presented in Table S2.

Model selection results indicated that in individual years, there was little to no support for the delayed mortality (DM) model in which survival was parameterized separately in each of the post–Bonneville Dam migration segments (Table 2). The common model, which estimated survival in each migration segment for both populations combined, was the highest-ranked model and had higher Akaike's Information Criteria (AIC) weights in all years. The ΔAICc scores of the DM model ranged between 0.8 and 3.9, and ΔAICc scores of the base model ranged between 2.2

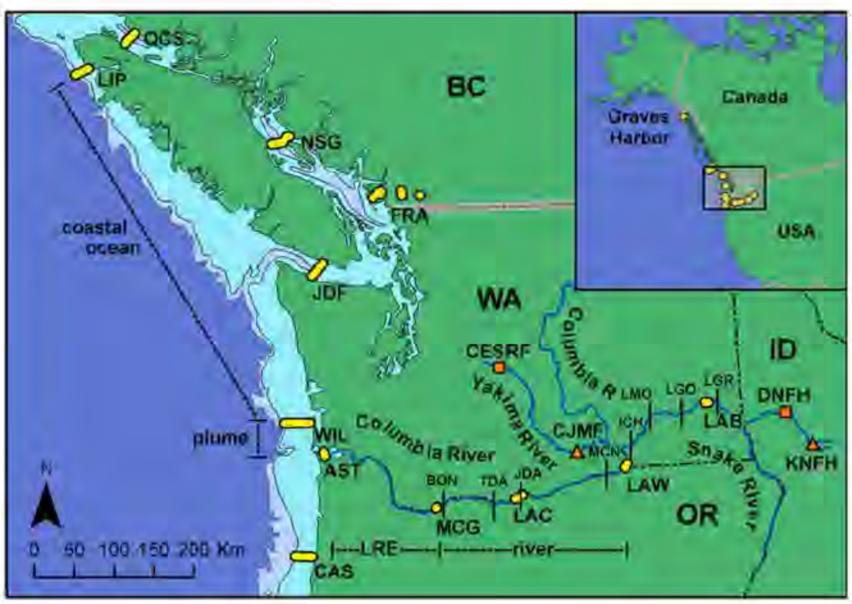

Fig. 1. Study area with acoustic tracking array (yellow dots and lines) and habitat designations. Hatcheries are represented by orange squares and release sites by orange triangles. Subarrays were deployed in Lake Bryan, Lake Wallula, Lake Celilo, McGowans Channel, Astoria, and Willapa Bay, WA; Lippy Point, BC, Canada; Cascade Head, OR; and Graves Harbor, AK. No smolts were detected on Pacific Ocean Shelf Tracking subarrays in the Juan de Fuca Strait, Northern Strait of Georgia, or Queen Charlotte Strait or on the Fraser River subarrays. Snake and lower Columbia River dams are indicated with vertical lines. Isobaths show the continental shelf edge at 200 and 500 m depth. AST, Astoria; BON, Bonneville; CAS, Cascade Head; CESRF, Cle Elum Supplementation and Research Facility; CJMF, Chandler Juvenile Monitoring Facility; DNFH, Dworshak National Fish Hatchery; FRA, Fraser River; ICH, Ice Harbor; JDA, John Day; JDF, Juan de Fuca Strait; KNFH, Kooskia NFH; LAB, Lake Bryan; LAC, Lake Celilo; LAW, Lake Wallula; LGO, Little Goose; LGR, Lower Granite; LIP, Lippy Point; LMO, Lower Monumental; MCG, McGowans Channel; MCN, McNary; NSG, Northern Strait of Georgia; QCS, Queen Charlotte Strait; TDA, The Dalles; WIL, Willapa Bay.

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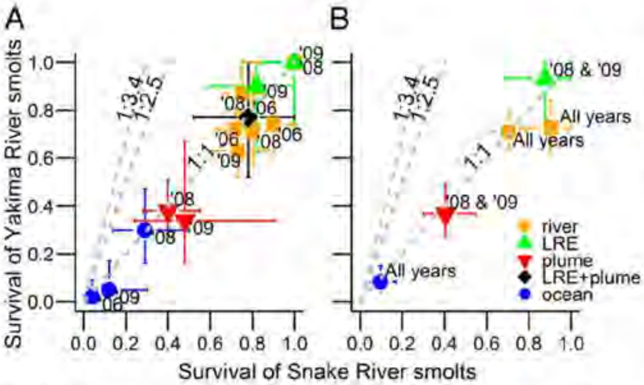

Fig. 2. Comparative survival of acoustic-tagged Snake River and Yakima River spring Chinook salmon smolts in each migration segment (*A*) in 2006, 2008, and 2009 and (*B*) in all years combined. The dashed 1:1 line represents equal survival of both treatment types; data points above the line indicate lower survival of Snake River fish. The 1:2.5 line indicates the survival disparity predicted by the delayed mortality hypothesis, using the ratio of Snake:Yakima adult return rates averaged over 2000–2009. The 1:3.4 line indicates the average survival disparity predicted over the years of our study. "River" estimates are from Lake Wallula to Lake Celilo and from Lake Celilo to McGowans Channel. The Astoria subarray was not deployed in 2006; therefore, LRE survival was combined with plume survival in that year. Error bars, 95% confidence intervals.

and 6.0. With all years combined, the weights of the three competing models were very similar; however, the common model still performed best. Thus, our data do not provide evidence that delayed mortality occurred in the estuary or coastal ocean in the first 5–6 wk after migrating out of the hydropower system, let alone the 3.4-fold increase in relative survival of the Yakima River population (Fig. 2).

Discussion

Before the initiation of this proof-of-concept acoustic telemetry project, the survival of Columbia River salmon smolts in estuarine and coastal ocean environments was the subject of intense speculation, but virtually no direct information was available. Hatchery-reared Yakima spring Chinook salmon smolts typically survive to return as adults at 2.5 times the rate of Dworshak National Fish Hatchery (NFH) smolts, and during the years of our study, they returned at 3.4 times the rate (15). If delayed mortality of Snake River smolts caused by stressful dam passage is expressed in the estuary or within the first month of life in the coastal ocean, we would expect to see reduced posthydrosystem survival of the Snake River population compared with smolts migrating from the Yakima River. Despite tracking size-matched groups with similar ocean entry timing as far as northern Vancouver Island, 750 km beyond the last dam, and for approximately 1 mo after ocean entry, we did not observe lower survival for Snake River smolts. Thus, our results do not support the hypothesis that hydrosystem-induced stress leads to higher mortality of hatchery-reared Snake River spring Chinook salmon in the estuary and early marine period. If our results are accurate, the survival difference to adult return likely occurs sometime beyond the first month at sea and may not be hydrosystem-related. This is an important finding because mitigation efforts in the Columbia River basin, which are partially based on the assumption that "latent" effects of the dams in the ocean are large, may be ineffective if differential mortality occurs in the North Pacific Ocean for reasons unrelated to dam passage.

Several limitations remain on our finding that Snake River fish did not experience reduced mortality relative to the Yakima controls. All smolts in the study were grown to a larger size to accommodate the acoustic transmitters, and as a result, size at release was in the upper fraction of the untagged population (however, see Fig. S1, which illustrates how the smaller transmitter used in 2008 and 2009 enabled us to tag ~70% of the size distribution). Although there is evidence that larger smolt size may lead to higher SARs for hatchery Chinook (35), within the size range we tagged, survival was not a function of fork length in any year (36, 37). Furthermore, John Day River wild spring Chinook are among the smallest smolts at the onset of seaward migration, yet their return rates are among the highest (15, 38). Thus, it is unclear whether larger body size compensated for hydrosystem-induced stress.

The extra holding time also meant that timing of release was later than what is typical for both populations. Because migration timing may also play a role in determining SARs (39), later ocean entry timing might have either reduced survival prospects for both populations or differentially affected survival.

In all years, we attempted to match ocean entry timing and mean body size of the two populations. We did this successfully in 2008 and 2009; however, in 2006 there was some difference in ocean entry timing, with Snake River smolts arriving at Bonneville Dam 2–3 wk earlier than the Yakima River smolts (owing to high river flows). In addition, Yakima River smolts were larger on average than Snake River smolts in that year. Nevertheless, survival was similar for both populations in 2006 and was not a function of body size (36, 37).

We have some evidence that smolts may have migrated past the ocean subarrays undetected. Several of the tagged smolts that returned to the Columbia River as adults 2 y later (which were detected by passive integrated transponder tag detectors at the dams) were not detected as smolts on all of the ocean subarrays. Therefore, a few individuals may have migrated around the coastal ocean subarrays or swum undetected over subarrays or in locations where receivers were lost, or tag acoustic power may have degraded with time. Provided these factors affected both populations equally, the comparison of relative survival would remain unchanged. In addition, smolts from both populations were widely distributed across the Willapa Bay subarray (Fig. S2); however, because smolts appeared to be confined to the shelf at Lippy Point, our survival models account for any undetected or off-shelf migrant smolts at Willapa Bay, and thus

Table 1. Estimated survival (standard error) of acoustic-tagged Snake and Yakima River spring Chinook salmon smolts by habitat

		Snake River				Yakima River			
Habitat	Migration segment	2006	2008	2009	All years	2006	2008	2009	All years
Tributary	Release–LAW*	0.62 (0.04)	0.49 (0.03)	0.57 (0.03)	0.54 (0.02)	0.68 (0.03)	0.75 (0.02)	0.84 (0.02)	0.75 (0.02)
Mainstem	LAW–LAC	0.72 (0.05)	0.75 (0.05)	0.73 (0.07)	0.70 (0.04)	0.72 (0.05)	0.87 (0.07)	0.63 (0.06)	0.71 (0.04)
Mainstem	LAC–MCG	0.90 (0.08)	0.80 (0.07)	1 (0)	0.90 (0.08)	0.74 (0.06)	0.71 (0.07)	1 (0)	0.73 (0.06)
LRE + plume†	MCG–WIL	0.78 (0.19)	NA	NA	NA	0.77 (0.18)	NA	NA	NA
LRE	MCG–AST	NA	1 (0)	0.82 (0.15)	0.88 (0.1)	NA	1 (0.01)	0.90 (0.19)	0.93 (0.09)
Plume	AST–WIL	NA	0.40 (0.07)	0.48 (0.17)	0.41 (0.06)	NA	0.38 (0.06)	0.34 (0.13)	0.37 (0.05)
Coastal ocean	WIL–LIP	0.04 (0.03)	0.29 (0.09)	0.12 (0.06)	0.10 (0.03)	0.02 (0.02)	0.30 (0.08)	0.05 (0.04)	0.08 (0.03)

Counts of fish detected on each subarray are reported in Table S2. AST, Astoria, WA; LAC, Lake Celilo, WA; LAW, Lake Wallula, WA; LIP, Lippy Point, BC, Canada; MCG, McGowans Channel, WA; WIL, Willapa Bay, WA.

*Note that distance to Lake Wallula was ~3 times longer for Snake River smolts.

†We could not separate estuary and plume survival in 2006 because the Astoria subarray was not deployed that year.

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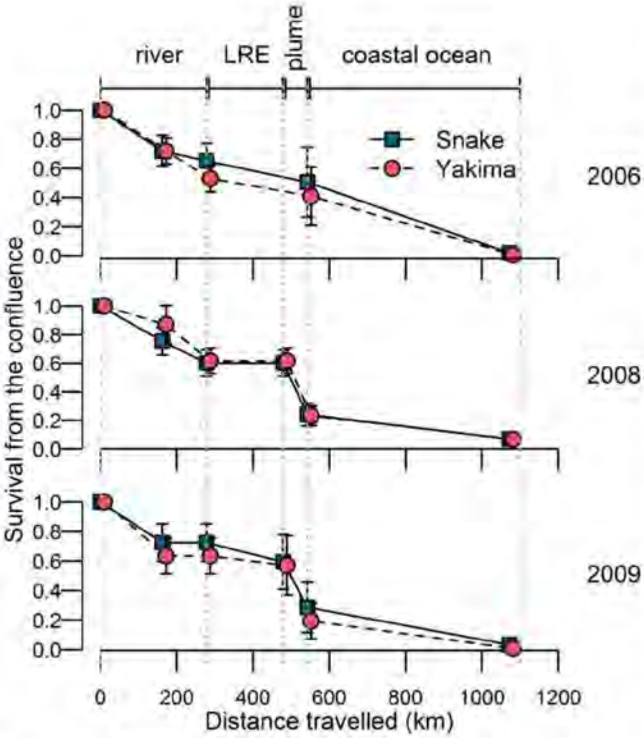

Fig. 3. Cumulative survival of Snake and Yakima River spring Chinook salmon smolts in the comigration pathway. Kilometer 0 is the location of the Lake Wallula subarray (below the confluence of the Snake, Yakima, and upper Columbia rivers). The Astoria subarray was not installed in 2006. Data points were adjusted to prevent overlap of 95% confidence intervals.

the survival estimates would not be affected. This statement holds true as long as the same proportion of both populations migrated around the Willapa Bay subarray (*SI Text*).

We have some concern that medium-term (>30 d) tag loss may be greater for the Yakima River population. Our studies of tagged smolts retained and held in freshwater tanks for up to several months at the release sites found that Yakima smolts had greater rates of transmitter expulsion (36). We also found, however, that the effect of tag loss during the first 5–6 wk after release relative to natural mortality in the coastal ocean is likely negligible (*SI Text*).

Finally, other studies have demonstrated that some Columbia River yearling Chinook salmon smolts may migrate south on ocean entry. Coded wire–tagged and acoustic-tagged yearling spring Chinook salmon were recaptured (40) or detected (41) south of the river mouth when surface ocean currents were southerly; however, in the case of the coded wire–tagged fish, nearly all recaptures occurred to the north of the river mouth 1 mo later, indicating that northward migration soon occurs (acoustic-tagged fish could not be detected beyond the plume). This was further demonstrated by Trudel et al. (42): only 1.6% (1/64) of mid–Columbia River spring run smolts, 2.3% (3/132) of upper–Columbia River springs, and 0% (0/116) of Snake River spring–summer smolts were captured south of the Columbia River mouth along the Oregon shelf. In the present study, we deployed an additional subarray to test the assumption that smolts did not migrate south; none were detected.

If these factors differentially affect survival, the effect would have to be large enough to mask a 3.4-fold difference in apparent survival to Lippy Point (assuming that all delayed mortality caused by prior hydrosystem experience is expressed by the end of the first month at sea). As we found no survival difference within the comigration corridor, the difference likely develops farther north. This suggests either that hydrosystem-induced mortality of hatchery-origin Snake River spring Chinook is greatly delayed or that differences in the subsequent ocean life histories influence survival of these genetically distinct population groupings. It remains unclear whether smaller, wild smolts have similar survival as the smolts reported here, although recent advances in transmitter miniaturization mean that it is now feasible to repeat these experimental tests using wild smolts.

Very little stock-specific distribution information is available for Columbia River spring Chinook from the time they migrate north of British Columbia to the time they return to the Columbia River, a period of more than 1.5 y. In a synthesis of juvenile Chinook salmon coded wire–tagged recoveries from US and Canadian research surveys, Trudel et al. (42) provide distribution information for Dworshak NFH and Yakima River hatchery spring Chinook recaptured over a 12-y sampling period. Although few tagged fish were recovered (Dworshak, $n = 11$; Yakima, $n = 8$), their capture locations provide some insight into stock-specific differences in survival. Juveniles from both populations were captured between the Columbia River and central British Columbia; a Dworshak fish was captured as far north as central Alaska, but no Yakima River fish were captured in

Table 2. Model selection results for survival models investigating whether survival of Snake River spring Chinook salmon is lower than Yakima River spring Chinook salmon

Year	Name	Model*	QAICc[†]	ΔQAICc	QAICc weights	Model likelihood	Number of parameters	QDeviance
2006	Common	ϕ (gr:seg:trib + seg:WAL–LIP) p	1,914.5	0	0.54	1	15	1,884.3
	DM	ϕ (seg:river + gr:seg:LREO) p	1,915.8	1.3	0.28	0.53	16	1,883.6
	Base	ϕ (gr:seg) p	1,916.7	2.2	0.18	0.34	18	1,880.4
2008	Common	ϕ (gr:seg:trib + seg:WAL–LIP) p	4,036.6	0.0	0.84	1.00	20	3,996.2
	DM	ϕ (seg:river + gr:seg:LREO) p	4,040.5	3.9	0.12	0.14	22	3,996.1
	Base	ϕ (gr:seg) p	4,042.5	6.0	0.04	0.05	24	3,994.0
2009	Common	ϕ (gr:seg:trib + seg:WAL–LIP) p	3,853.4	0.0	0.55	1.00	20	3,813.0
	DM	ϕ (seg:river + gr:seg:LREO) p	3,854.1	0.8	0.37	0.68	22	3,809.8
	Base	ϕ (gr:seg) p	3,857.3	3.9	0.08	0.14	24	3,808.8
All	Common	ϕ (gr:seg:trib + seg:WAL–LIP) p	5,620.6	0.0	0.39	1.00	31	149.8
	DM	ϕ (seg:river + gr:seg:LREO) p	5,621.0	0.4	0.32	0.81	32	148.2
	Base	ϕ (gr:seg) p	5,621.2	0.6	0.28	0.73	34	144.4

ϕ, survival probability; AICc, Akaike's Information Criteria with low sample size; DM, delayed mortality model; gr, treatment group (population); LREO, lower river, estuary, and ocean; p, detection probability; Q, correction for overdispersion was made; river, river upstream of Bonneville Dam; seg, migration segment; trib, tributary; WAL–LIP, Lake Wallula, WA to Lippy Point, BC, Canada; All, all years combined. See *SI Materials and Methods* for model name descriptions.

*In all models, detection probability (p) was estimated identically (*Methods*).

[†]AICc is presented for 2008.

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southeast or central Alaskan waters. This is consistent with our telemetry data, which show that only Dworshak fish were detected in southeast Alaska. Although both studies are based on few Alaskan observations, life history differences may lead to different ocean distributions, and thus potentially large differential survival rates.

There is evidence that increasing conservation actions and technological fixes within the Columbia River basin may not increase salmon population growth rates to sustainable levels. First, there is a significant correlation between ocean conditions that juvenile spring Chinook salmon encounter after ocean entry and the number of adults subsequently returning to the Columbia River (34, 43). For example, in 2005, ocean conditions were ranked lowest in a 14-y time series and the wild Snake River spring Chinook SAR from that outmigration year was also lowest, whereas in 2008, ocean conditions were ranked highest and subsequent adult returns reached the conservation goal of 4% for the first time. Second, our early marine survival estimates also correlate with ocean conditions: In 2008, smolt survival was an order of magnitude greater than in 2006, and 2009 was intermediate, consistent with mean rank scores of ocean conditions. Finally, modeling exercises demonstrated that even if hydrosystem survival were 100%, population growth rates would continue to decline unless reductions in first-year mortality, particularly early ocean and estuarine mortality, occurred (44).

Recent fluctuations and collapses of Chinook populations are not unique to the Columbia River basin. The collapse of the Sacramento River fall Chinook salmon run prompted complete closure of the California Chinook fishery in 2008 (45). Poor returns persisted for several years, but 2012 return rates are predicted to be some of the largest in decades, according to the Pacific Fishery Management Council. In British Columbia, west coast Vancouver Island Chinook populations are a stock of concern, and despite relatively pristine freshwater habitat and harvest reductions, the stock shows no sign of rebuilding (46). In 2012, the governor of Alaska requested disaster relief funds after severe restrictions or closures of Chinook salmon fisheries in the Yukon, Kuskokwim, and Kenai rivers, according to a State of Alaska news release. In all cases, marine survival was considered one of the most important factors leading to these declines. As our results indicate that the large difference in survival of hatchery-reared Snake and mid–Columbia River spring Chinook appears not to be caused by hydrosystem-induced delayed mortality, Columbia River salmon managers will need to recognize that the survival problem may be on a scale far larger than that of the Columbia River basin. Similar findings have also been reported for sockeye salmon, with large and persistent differences in long-term productivity of populations from even nearby river systems (47). Given the possibility of persistent differences in salmon production, managers may need to adopt a more pragmatic view of what level of technical "fix" to compensate for poor ocean conditions is both appropriate and possible within the Columbia River basin.

Materials and Methods

Populations Studied. The Snake River population of spring Chinook salmon used in this study was reared at the Dworshak NFH on the Clearwater River (a tributary of the Snake River); however, for logistical purposes we transferred smolts to Kooskia NFH for tagging (*SI Materials and Methods*). For the juvenile migration years used in this study, the geometric mean $SAR_{Dworshak}$ was 0.78 (2006, 0.68; 2008, 1.33; and 2009, 0.52), which is slightly higher than the average over the last decade (from 2000 to 2010, the geometric mean SAR was 0.66%) (15). This population migrates through eight dams before reaching the Columbia River estuary, and distance from release to the Columbia River mouth was 870 km (Fig. 1).

The Yakima River population was reared at the Cle Elum Supplementation and Research Facility on the upper Yakima River and is part of the mid-Columbia evolutionarily significant unit (ESU). Smolts were released from Cle Elum Supplementation and Research Facility acclimation sites and then collected from the lower Yakima River at the Chandler Juvenile Monitoring Facility in Prosser, WA, 194–249 km downstream of the acclimation sites, and held for tagging. We collected fish at the Chandler Juvenile Monitoring Facility to maximize our sample size, as mortality in the Yakima River has been as high as 80% in recent years (48). For the juvenile migration years used in this study, the geometric mean SAR_{Yakima} was 2.62 (2006, 1.65; 2008, 4.98; and 2009, 2.23; 3.4 times the Dworshak SAR), which is considerably higher than the average over the last decade (from 2000 to 2010, the geometric mean SAR was 1.6%). This population migrates through four dams, and the distance to the Columbia River mouth from release was 615 km.

Tagged Dworshak smolts were released from the Kooskia NFH 2–4 wk earlier than Yakima smolts to allow time for them to migrate the additional 350 km and through the four Snake River dams so that timing of ocean entry (and presumably ocean conditions) would be similar. The comigration corridor extended from the confluence of the Columbia and Snake rivers to northwestern Vancouver Island, a distance of nearly 1,100 km.

Tag Specifications and Surgical Protocol. All work involving live fish met the standards laid out by the Canadian Council on Animal Care and was annually reviewed and approved by the Animal Care Committee of Vancouver Island University, Nanaimo, BC, Canada (applications 2006–08R, 2006–08R-2, and 2009–11R).

In each year of the study, we surgically implanted nearly 800 yearling Chinook salmon smolts with individually identifiable 69-kHz acoustic transmitters (VEMCO, Amirix System Inc.; Table 3). We attempted to size-match tagged fish within and between treatment groups in each year, although there was some variation in 2006 (Table 3). More details are provided in *SI Materials and Methods* and ref. 36.

Acoustic Array Elements and Location. The array design allowed us to track the smolts for 2,500 km from the release site in the Snake River through the hydrosystem, LRE, plume, and coastal ocean to Graves Harbor, Alaska, although our study focuses on the comigration area between Lake Wallula and Lippy Point. See Fig. 1 and *SI Materials and Methods* for array details.

Survival Estimation. For each year of the study, detection histories for each tagged individual were formed and estimates of survival and detection probability and their associated SEs were calculated for each population, using a model that was a special case of the Cormack-Jolly-Seber model for live-recaptured animals implemented with Program MARK (49). We then estimated survival across all 3 y of the study where possible (see *SI Materials and Methods* for model details).

The detection probability, p, of the Lippy Point (northwest Vancouver Island) subarray was not estimable using standard Cormack-Jolly-Seber methods because too few tagged smolts were detected in Alaska each year (n_{2006} = 2 Snake; n_{2008} = 1 Snake; n_{2009} = 0) to provide adequate information regarding the performance of the Lippy Point subarray; therefore, we assumed the p of the Lippy Point subarray was 0.90 for the V9 (VEMCO) tag used in 2006 and 0.67 in 2008 and 2009, when the less-

Table 3. Tagging summary for Snake and Yakima River spring Chinook salmon smolts

Population	Release date	n*	Mean length (FL; range), mm	Tag burden (% mass)†
2006				
Snake	May 1	190	146.9 (140–208)	9.2 (2.6–11.5)
	May 8	190	145.6 (140–192)	9.4 (3.7–11.3)
Yakima	May 30	199	154.5 (140–173)	7.3 (4.8–10.3)
	June 6	199	154.5 (140–168)	7.5 (5.2–10.8)
2008				
Snake	April 25	197	146.2 (130–159)	4.4 (2.9–6.9)
	May 2	198	146.3 (131–159)	4.5 (3.0-6.7)
Yakima	May 15	189	140.3 (129–158)	5.8 (3.9–7.3)
	May 21	189	140.4 (131–157)	5.8 (4.3–7.2)
2009				
Snake	May 4	196	142.3 (130–162)	5.0 (2.9–7.3)
	May 11	196	142.4 (130–164)	4.9 (3.0-6.8)
Yakima	May 18	199	141.3 (130–159)	5.7 (4.1–7.5)
	May 25	194	140.6 (130–159)	5.7 (4.2–6.9)

FL, fork length.

*All smolts were implanted with both acoustic and passive integrated transponder tags. In 2006, fish were tagged with V9-6L acoustic transmitters (9 × 21 mm, 3.1 g in air, 2 g in water). In 2008 and 2009, smolts were tagged with V7-2L acoustic transmitters (7 × 20 mm, 1.6 g in air, 0.75 g in water).

†Percentage tag burden was calculated as tag mass in air divided by fish mass in air.

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powerful V7 (VEMCO) tag was used. We evaluated whether relative survival of the two populations was sensitive to assumptions of p at Lippy Point. We found that under several detection scenarios, the relative survival comparison was not affected (Fig. S3; see *SI Materials and Methods* for additional model assumptions).

Strength of Evidence for Delayed Mortality. To evaluate the strength of evidence for delayed mortality of the Snake River spring Chinook salmon population relative to the Yakima River population, we used Akaike's Information Criteria to compare the performance of three competing survival models (Table 2; *SI Materials and Methods*).

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Supporting Information

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SI Text

Smolt Distribution on Ocean Subarrays. Our survival models accurately accounted for any off-shelf migration at Willapa Bay, WA, provided that the same proportion of both populations migrated around the subarray and that both populations subsequently returned to the shelf at Lippy Point, BC, Canada (i.e., smolts did not permanently emigrate from the shelf). To assess the extent to which off-shelf migration may have occurred and the possible differences in migration behavior that might have affected our comparison of relative survival, we examined the distribution of tagged fish across the Willapa Bay subarray. In all years, both populations were widely distributed across the Willapa Bay subarray (Fig. S2), supporting the idea that smolts migrated primarily on the shelf. In 2006, however, the Yakima River population was uniformly distributed but the Snake River population peaked on the offshore end of the subarray (1). Although the distributions of these populations were different in 2006, it is unclear whether one of them may have differentially migrated off-shelf, as individuals from both populations were detected on the farthest offshore receivers. The relatively large number of smolts from both populations detected on the Willapa Bay subarray in 2006 (Table S1) further supports the idea that smolts were mostly migrating on the shelf.

As very few fish were detected on the farthest-offshore receivers at Lippy Point in all years, our assumption that smolts remain on the shelf is supported, and thus, our relative survival comparison is likely not affected. If individuals from one population routinely migrated around the Willapa Bay subarray or permanently emigrated from the shelf, then our relative survival comparison would be biased; however, we do not have evidence that this was occurring.

Medium-Term Tag Loss. We have some concern that medium-term (>30 d) tag loss may be greater for the Yakima River population. Our studies of tagged smolts retained and held in freshwater tanks for up to several months at the release sites found that Yakima smolts had greater rates of transmitter expulsion (2). In 2006, 95% of V9-tagged Snake River smolts and 83% of Yakima River smolts retained their tags for nearly 3 mo. Retention of the smaller V7 transmitter was excellent for Snake River smolts (>96%) for the duration of the studies in 2008 and 2009 (5–6 mo). However, we were unable to quantify medium-term tag effects for Yakima River smolts in 2008 and 2009, as the captive studies were ended after approximately 1 mo because of disease outbreak or unknown mass mortality (tag retention to this point was 95–100%). Presumably, medium-term retention of the smaller V7 tag would be greater than the V9 tag, but given the 18% long-term tag loss of very small passive integrated transponder (PIT) tags reported by Knudsen et al. (3) for the Yakima River hatchery population, tag loss could be problematic for long-term tagging studies for this particular population. Nevertheless, acoustic tag retention at sea was likely high. For example, in 2006, by the time Snake River V9-acoustic-tagged smolts reached the Lippy Point subarray (median arrival time, 58 d), 98% of captive Snake River fish still retained their tags. By the time the V9-tagged Yakima population reached the Lippy Point subarray (median arrival time, 46 d), 91% of captive smolts still had tags intact. If we correct for tag loss observed in our holding study, our cumulative survival estimates from Lake Wallula to Lippy Point for Snake River smolts only change from 1.86% to 1.89% in 2006, and Yakima smolt survival increases only from 0.75% to 0.79%. Thus, although some acoustic tag loss likely occurred in free-swimming smolts, the effect of tag loss during the first 5–6 wk after release relative to natural mortality in the coastal ocean is likely negligible.

SI Materials and Methods

Populations Studied. Spring Chinook salmon originating from the Clearwater River subbasin are not part of the Snake River evolutionarily significant unit (ESU), but survival to adult return is routinely estimated for Dworshak spring Chinook salmon and is lower than listed populations in other Snake River subbasins, as well as the downstream Columbia River populations (4). Because of space limitations at Dworshak Hatchery, each year ~1,500 spring Chinook smolts were transferred to Kooskia National Fish Hatchery (NFH) (60 km upstream of Dworshak NFH) 1–3 mo before tagging. In addition to ample working space, springtime water temperatures at Kooskia NFH (12–13 °C) were warmer than water temperatures at Dworshak NFH (4–10 °C). The warmer temperatures facilitated the more rapid growth necessary to attain minimum body size requirements for tagging; however, it was still necessary to retain the fish for several weeks beyond the typical hatchery release date (~April 1) to ensure that a sufficient number of smolts exceeded the minimum size requirement. As a result, tagged smolts migrated an additional 60 km in the Clearwater River 3–6 wk later than conventionally released Dworshak spring Chinook smolts. Nevertheless, in all years, median date of passing Lower Granite Dam (the first dam the smolts encountered in the Snake River) lay within the 55th to 85th passage index date percentiles for yearling hatchery Snake River spring Chinook, according to data from the Fish Passage Center.

Tag Specification and Surgical Protocol. All acoustic tags transmitted a unique identification code and were programmed to provide operational life spans long enough to cover the observed duration of the migration to the Lippy Point subarray (up to 3 mo). In 2006, we surgically implanted V9-6L coded acoustic transmitters (9×21 mm, 3.1 g in air, 2 g in water), and in 2008–2009 we used smaller V7-2L transmitters (7×20 mm, 1.6 g in air, 0.75 g in water). A 0.1-g PIT tag was also placed in the body cavity (through the incision) of all acoustic-tagged smolts. We did this to ensure that tagged smolts were diverted back into the river at the dam bypass facilities and not collected for transport to below Bonneville Dam. Acoustic tag burdens were generally within the maximum recommended for salmon smolts (5, 6).

The larger, more powerful V9-6L transmitter used in 2006 had a greater detection radius than the smaller V7 tag used in 2008–2009. This provided higher detection probabilities by the telemetry array but imposed a greater tag burden on the animals; however, assessment of size at release of tagged animals relative to size at release of survivors reaching Willapa Bay showed no distortions in the distributions (7). In addition, models that included fork length as a covariate did not perform as well as models excluding fork length, suggesting that the tags did not substantially affect survival (2, 7).

At each hatchery, we tagged two release groups of ~200 fish. The same surgical protocol was used in all years for both treatment types; a detailed description of the protocol is provided in Rechisky and Welch (2). In brief, portable surgical units were assembled on site, and fish surgery was carried out by experienced, veterinarian-trained staff. Fish were anesthetized individually in 70 ppm tricaine methane sulphonate (Western Chemical) buffered with 140 ppm $NaHCO_3$. Fork length was measured to the nearest millimeter, and weight was measured to the nearest tenth of

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a gram. A maintenance dose of buffered anesthetic (50 ppm) 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. Each smolt was double tagged by placing a PIT and an acoustic tag through the incision into the peritoneal cavity. Depending on tag type, 1–2 absorbable sutures were used to close the incision. Immediately after surgery, fish were placed into a recovery bath and monitored. Fish generally regained equilibrium and reactivity within minutes. After release, we uploaded the PIT tag data into the Columbia River Basin PIT Tag Information System database, which is maintained by the Pacific States Marine Fisheries Commission. Acoustic tagging metadata was provided to the Pacific Ocean Shelf Tracking (POST) project, which is currently managed by the Ocean Tracking Network (OTN).

Acoustic Array Elements and Location. The marine elements of the acoustic telemetry array were composed of individual VEMCO receivers positioned above the seabed of the continental shelf to form a series of listening lines or acoustic subarrays extending from near-shore out to ~200-m depths. Individual receivers recorded the date and time that acoustic transmitters (tags) were detected, and these detections were used to estimate survival of each population to each subarray. During the study, marine components of the array extended from coastal Washington (Willapa Bay) through southern British Columbia (Lippy Point) and up to southeast Alaska (Graves Harbor; Fig. 1). Subarrays were also deployed in the lower Columbia River in McGowans Channel below Bonneville Dam (the final dam) and in several reservoirs or "lakes" created by the dams: Lake Celilo, downstream of John Day Dam; Lake Wallula, below the confluence of the Columbia and Snake rivers; and Lake Bryan, below Lower Granite Dam in the Snake River.

In 2008 and 2009, an additional subarray was deployed in the Columbia River estuary at Astoria, WA, allowing lower Columbia River and estuary (LRE) and plume survival to be separately measured. For this study, the LRE is defined as the tidal area ranging from Bonneville Dam to Astoria, and the plume is defined as the area from Astoria to the Willapa Bay subarray. Although the plume technically begins at the river mouth (not Astoria), the distance between the subarrays sited at Astoria and Willapa Bay was only 63 km and encompassed the plume. In 2009, an additional subarray was deployed in the coastal ocean 131 km south of the Columbia River mouth near Cascade Head, OR; no smolts from this study were detected on that array.

Survival Estimation. All acoustic detection data from the array were first screened for potential false-positive detections, which were rare: Excluded data typically formed less than 0.1% of the total recorded detections. All acoustic-tagged fish migrating in the river were included in our study, regardless of their specific route through the dams (e.g., spill, bypass, or turbine), except for a few Snake River smolts that were inadvertently collected and transported from lower Snake River dams (16 in 2006, 0 in 2008, and 3 in 2009). Court-ordered spill was occurring at the four lower Snake River dams and the four lower Columbia River dams, which reduced the chance that smolts migrated through the turbine and the bypass.

In each year of the study, we assessed the goodness of fit of our data with the bootstrap goodness-of-fit test within Program MARK (8). To do so, we fit the most general Cormack-Jolly-Seber (CJS) (9–11) model (survival, ϕ, and detection probability, p, were estimated for each treatment type at each subarray). If there was overdispersion resulting from a lack of fit of the data to the model, it was corrected by dividing the model deviance by the mean expected deviance (from 1,000 bootstrapped simulations) to yield an overdispersion factor, $\hat{c}$ (12). If $\hat{c}$ was greater than 1, the resulting SEs on the estimates were inflated (multiplied) by the estimated $\hat{c}$ value. In 2006, the $\hat{c}$ overdispersion factor was 1.9. In 2008, there was no overdispersion ($\hat{c} = 0.94$), and in 2009, $\hat{c}$ was 1.12. There was no overdispersion ($\hat{c} = 1$) for the model in which common survival parameters were estimated for each of the treatment types across 2008 and 2009 (survival was estimated in the hydrosystem, in the LRE and plume separately, and the coastal ocean). Finally, $\hat{c}$ was 1.7 for the model in which common survival parameters were estimated for each of the treatment types across all 3 y (survival was estimated for the hydrosystem, the LRE and plume combined, and the coastal ocean).

Survival was estimated in each migration segment for each treatment type for each year, and we made no additional assumptions about the cause of variability in $\hat{\varphi}$ (e.g., fish body size, travel time, etc.). Assessments of tag loss, tagging-induced mortality, tag operational life span, and survival differences between taggers (surgical skill) indicated that these factors did not have significant influence on the survival estimates during the time required for the freely migrating tagged smolts to pass Lippy Point (13). We allowed p to vary for each treatment type and subarray in freshwater, but p only varied by subarray in the ocean where sample size was low (i.e., we used the full data set to estimate a common p parameter for both populations at Willapa Bay). We also included in our models two additional groups (each N ≅ 200) of Snake River spring Chinook salmon smolts that were tagged with the same acoustic tag type and then transported (as part of a different comparison) to better quantify p of the Willapa Bay detection line (14). Confidence intervals for ϕ and p were estimated using the profile likelihood method. This model served as the base model from which we extracted survival and detection estimates.

For each population, we then estimated both cumulative survival in the comigration corridor between the Lake Wallula and Lippy Point subarrays as the product of the segment-specific survival estimates and the variances with the delta method.

We also estimated survival across all years. We used a reduced CJS model in which a common survival probability was estimated for each treatment type for all years between each detection subarray, and the detection probabilities were parameterized as for the year-separate models but were allowed to vary by year (i.e., a separate parameter was estimated for each treatment type in each year). Because the Astoria subarray was not deployed in 2006, it was necessary to run two separate models to obtain average survival estimates to all detection sites: one to estimate average survival across all years (2006, 2008, and 2009) in the river, the LRE and plume combined, and the coastal ocean, and another to estimate average survival across 2008 and 2009 in the LRE and in the plume as separate migration segments.

The detection probability of the Lippy Point subarray was fixed in all years. We did this for several reasons: (1) too few fish were detected on the Alaska subarray to estimate p at Lippy Point, (2) CJS analyses of p for other fully intact marine subarrays with similar receiver geometry, bounded by landmasses on either side, and with ample detections beyond the subarray in question (which renders them directly estimable) showed that marine detection rates are very consistent across multiple sites and multiple years (~0.90% for V9 transmitters and ~0.67% for V7 transmitters at three sites in 4 y) (15); (3) all marine receivers were deployed at approximately equal spacing; (4) the smolt distribution on the Lippy Point line was centered on the inner to middle continental shelf in all years, indicating that fish were confined to the shelf; and (5) if estimates at Lippy Point are biased, they should be equally biased for both treatment types, as identical acoustic tags were used in each year. Because the key scientific test involves whether Snake River smolts have lower post–Bonneville Dam survival than the Yakima River smolts, some inaccuracy in this final p assumption is acceptable; however, we required the assumption that the two tagged groups behaved similarly (i.e., that travel rate and potential offshore emigration beyond the shelf arrays were equal).

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Strength of Evidence for Delayed Mortality. We used Akaike's Information Criteria (AIC) to evaluate the strength of evidence for delayed mortality of the Snake River spring Chinook salmon population relative to the Yakima River population by comparing the performance of a model in which the effect of treatment (population) was removed in segments in which both groups migrated in common (i.e., downstream of the tributaries the groups were pooled, and only a single common survival parameter was estimated for each migration segment between Lake Wallula and Lippy Point), both to the base model described in *SI Materials and Methods, Survival Estimation* and to a model that more specifically represented delayed mortality downstream of Bonneville Dam. The base model included separate survival parameters for the Snake and Yakima River groups between all detection sites (from release to Lippy Point). The delayed mortality (DM) model included common survival parameters for the two populations in each of the common migration segments upstream of Bonneville Dam (from Lake Wallula to McGowans Channel); downstream of Bonneville Dam, survival parameters were estimated for each group in each migration segment to Lippy Point. Under the delayed mortality hypothesis, the differential effects of hydrosystem passage are limited to the estuary and coastal ocean. Detection probability was parameterized identically for all models. We conducted this analysis for each year of data, as well as for all years combined (with LRE and plume combined).

The AIC scores were adjusted for small sample size, which is denoted by AICc. When overdispersion occurred and $\hat{c}$ was applied to the model set, a quasi-AICc was computed (16). To evaluate the strength of evidence for the competing models, we assessed the difference in the AICc scores (ΔAICc) and AICc weights (or quasi-AICc where applicable).

Model Assumptions. For all subarrays, we recognized standard CJS model assumptions: (*i*) every tagged individual has equal survival probability and equal probability of detection following release, (*ii*) sampling periods are instantaneous, (*iii*) emigration is permanent, and (*iv*) tags are not lost.

For coastal ocean subarrays that were unbounded on the offshore end, we required three additional assumptions: (*v*) fish departing the Columbia River swam north, (*vi*) their migration was confined to the coastal zone spanned by the subarrays, and (*vii*) detection probability of the Lippy Point subarray was equivalent to that of other coastal subarrays with similar geometry (14). Assumptions (*v*) and (*vi*) are supported by evidence from ocean sampling programs that demonstrate that juvenile spring Chinook salmon remain almost entirely on the continental shelf and primarily migrate north on leaving the river (17–20). In addition, we deployed a subarray 131 km south of the Columbia River mouth at Cascade Head, OR (Fig. 1), in 2009 to validate assumption (*v*), but no smolts from this study were detected. See Fig. S3 for more information on assumption (*vii*).

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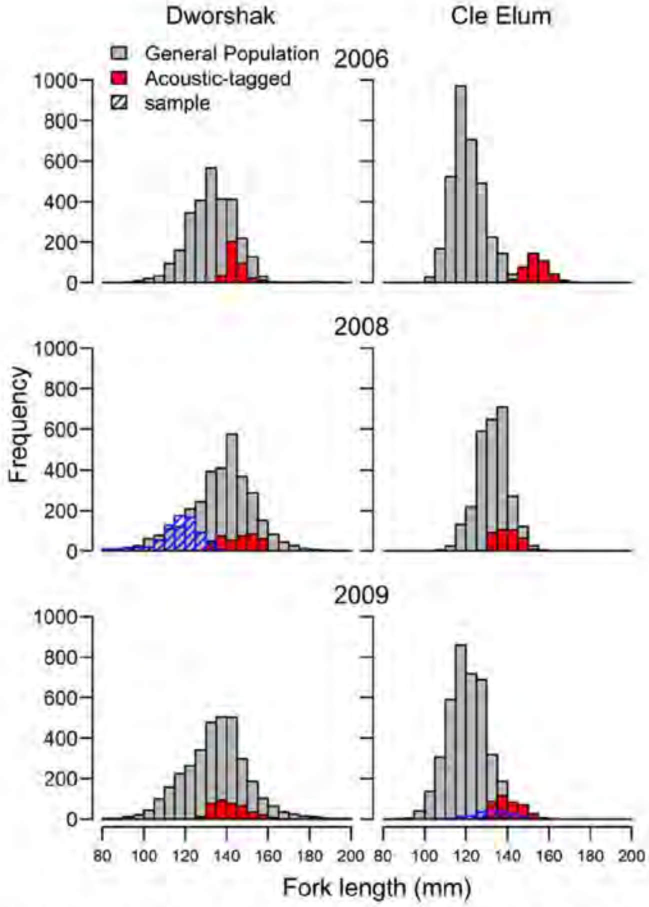

Fig. S1. Size–frequency distributions for Snake and Yakima River hatchery yearling Chinook smolts in 2006, 2008, and 2009. Red bars represent fork length at the time of tagging for acoustic tagged smolts. Gray bars represent the general population. The general population of Snake River hatchery smolts was sampled at Lower Granite Dam, according to data provided by the Pacific States Marine Fisheries Commission. The general population of Yakima (Cle Elum hatchery only) smolts, according to data provided by the Yakama Nation Fisheries, was sampled at the Chandler Juvenile Monitoring Facility (CJMF) in 2006 and 2008 and at Roza Dam in 2009. Blue bars in 2008 represent the size distribution of untagged Dworshak spring Chinook sampled at the hatchery just before release and several weeks before acoustic tagged fish were released. Note that these prerelease measurements were only available in 2008, according to data provided by US Fish and Wildlife Service. Blue bars in 2009 for the Yakima smolts represent Cle Elum smolts sampled at CJMF. Few smolts were sampled at CJMF that year, so we reported sizes for a larger sample of fish measured upstream at Roza Dam as the general population. Note, however, that the Roza Dam fish were smaller on average than those sampled at CJMF.

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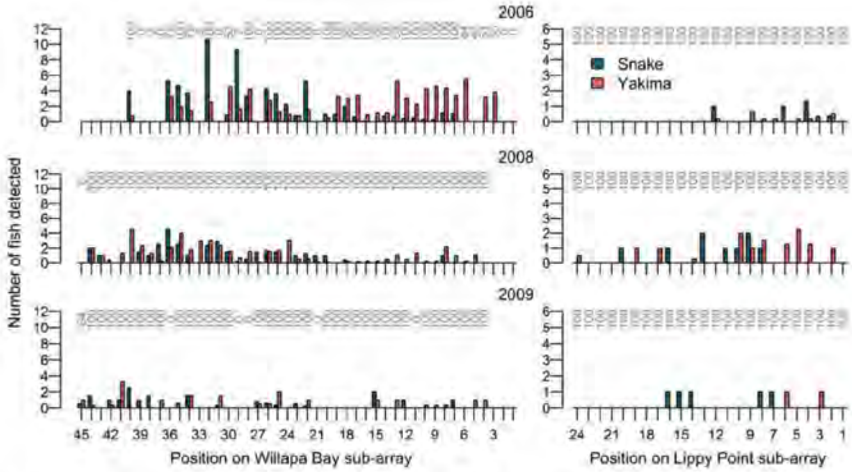

Fig. S2. Distribution of acoustic-tagged Yakima and Snake River spring Chinook salmon smolts on the Willapa Bay and Lippy Point subarrays. Position 1 on the x-axis represents the eastern-most acoustic receiver nearest shore, and the final position represents the shelf break (~200 m depth). If a fish was detected at more than one receiver, an equal proportion was allocated to all receivers detecting that fish; for example, if an identification code was detected on two receivers, each receiver was assigned a value of 0.5. A total of 40 receivers were deployed at Willapa Bay in 2006 (to 32 km offshore), and 45 were deployed in 2008 and 2009 (to 36 km offshore). In 2008, receiver 45 was not operational; therefore, the subarray was effectively 44 receivers in length. Positions 1, 2, and 3 of the Willapa Bay subarray were not redeployed in 2008 and 2009 because shallow depths resulted in acoustic nodes washing ashore within weeks of deployment in 2006. A total of 24 receivers were deployed at Lippy Point in all years (to 19 km offshore). The values above the bars indicate the proportion of time each receiver was operational during the migration period. Note that in 2008, the smolt detected on the most-offshore receiver was also detected on another receiver several kilometers inshore.

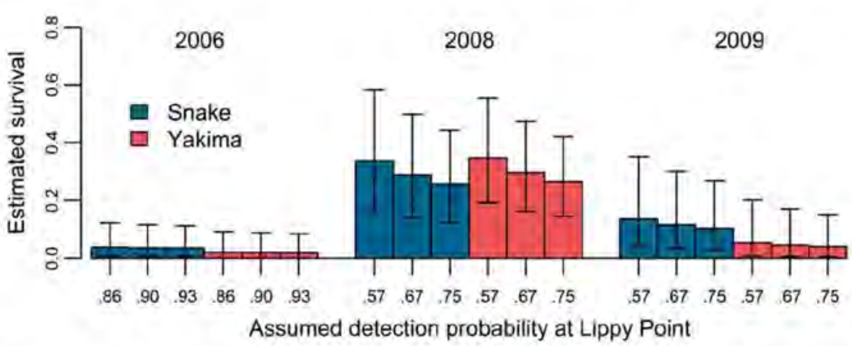

Fig. S3. Sensitivity of survival estimates to assumptions of detection probability at Lippy Point. The baseline assumption used in our analysis is that $P = 0.90$ in 2006 (V9 transmitter) and $P = 0.67$ in 2008 and 2009 (V7 transmitter). To examine how coastal ocean survival estimates (from Willapa Bay to Lippy Point) of acoustic tagged spring Chinook smolts might change with variation in detection probability (p) at Lippy Point, we reran our survival models using the upper and lower 95% confidence bounds on the baseline estimates. The baseline estimate and confidence intervals were estimated for the same tag types used in migrating juvenile salmon at other coastal subarrays with similar geometry in a previous study (1). Because all fish received identical tags within each year, we assumed that the detection efficiency of the Lippy Point subarray should be equal for the two groups. Plausible assumptions about the p of the Lippy Point subarray resulted in relatively small changes in estimated coastal ocean survival. Importantly, our conclusion that Snake River smolt survival was not reduced relative to Yakima River smolts should not be affected by the detection probability of the subarray.

1. Welch DW, et al. (2011) In situ measurement of coastal ocean movements and survival of juvenile Pacific salmon. *Proc Natl Acad Sci USA* 108(21):8708–8713.

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Table S1. Summary of detections of Snake and Yakima River hatchery spring Chinook salmon smolts detected on the acoustic array

			No. fish detected							
Year	Release group	No. fish released	Lake Wallula	Lake Celilo	McGowans Channel	Astoria	Willapa Bay	Lippy Point	Graves Harbor
2006	Snake 1	190	102	55	58	—	41	1	1
	Snake 2	190	114	46	48	—	42	3	1
	Yakima 1	199	127	74	49	—	18	2	0
	Yakima 2	199	144	79	75	—	61	0	0
2008	Snake 1	197	96	44	8	54	21	7	1
	Snake 2	198	95	32	9	41	13	2	0
	Yakima 1	189	123	29	8	63	24	7	0
	Yakima 2	189	147	53	10	68	25	6	0
2009	Snake 1	195	96	26	11	43	10	1	0
	Snake 2	194	106	30	12	39	8	4	0
	Yakima 1	199	171	46	15	58	10	1	0
	Yakima 2	194	150	13	7	55	8	1	0

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Table S2. **Estimated detection probability ($\hat{p}$) of acoustic subarrays**

Year	Population	Subarray*	$\hat{p}$	SE ($\hat{p}$)	95% CI
2006	Snake	LAB	0.97	0.01	0.93–0.99
		LAW	0.92	0.03	0.85–0.97
		LAC	0.60	0.06	0.48–0.71
		MCG	0.69	0.07	0.55–0.82
	Yakima	LAW	1.00	0.00	0.98–1
		LAC	0.79	0.05	0.68–0.87
		MCG	0.86	0.05	0.74–0.94
	Both	WIL	0.71†	0.15	0.48–0.93
	Both	LIP	0.90	fixed	NA
2008	Snake	LAB	0.96	0.01	0.92–0.98
		LAW	0.98	0.01	0.95–1.00
		LAC	0.52	0.05	0.42–0.61
		MCG	0.15	0.03	0.09–0.22
		AST	0.81	0.06	0.69–0.91
	Yakima	LAW	0.96	0.02	0.92–0.98
		LAC	0.33	0.04	0.26–0.41
		MCG	0.10	0.02	0.06–0.16
		AST	0.75	0.05	0.64–0.85
	Both	WIL	0.74‡	0.07	0.58–0.87
	Both	LIP	0.67	Fixed	NA
2009	Snake	LAB	0.95	0.02	0.92–0.98
		LAW	0.91	0.03	0.85–0.95
		LAC	0.32	0.05	0.24–0.42
		MCG	0.14	0.03	0.09–0.21
		AST	0.64	0.11	0.44–0.82
	Yakima	LAW	0.97	0.01	0.94–0.99
		LAC	0.22	0.04	0.16–0.30
		MCG	0.11	0.02	0.06–0.16
		AST	0.60	0.12	0.44–0.80
	Both	WIL	0.29	0.07	0.20–0.44
	Both	LIP	0.67	Fixed	NA

*Subarrays were deployed in the Snake River in Lake Bryan (LAB), below the confluence of the Columbia and Snake rivers in Lake Wallula (WAL), in Lake Celilo near John Day Dam (LAC), below Bonneville Dam in McGowans Channel (MCG), in the Columbia River estuary (Astoria, AST), north of the plume (Willapa Bay, WIL), and the coastal ocean (Lippy Point, LIP). A subarray was deployed south of the Columbia River mouth at Cascade Head, OR, but no fish from this study were detected. Data from both populations were used to estimate one detection parameter at WIL. Detection probability was fixed at LIP in all years. The AST subarray was not deployed in 2006.

†The $\hat{p}$ at WIL in 2006 was consistent with the 25% loss of the equipment at this site (largely to commercial fishing activities; i.e., if the assumed p for V9 tags was 0.90 (1), and gear loss was 25%, then the expected $\hat{p}$ is 0.68 (0.90*0.75), similar to our estimated value.

‡The $\hat{p}$ at WIL in 2008, when we had zero equipment loss during the fish migration season, was 0.74, consistent with the average $\hat{p}$ of V7 transmitters on bounded subarrays of 0.67 (1). In 2009, however, $\hat{p}$ at WIL declined to 0.29, possibly because of gear loss resulting from fishing (12% loss), changes in acoustic transmitter programming, and/or biological fouling of some receivers.

NA, not applicable.

1. Welch DW, et al. (2011) In situ measurement of coastal ocean movements and survival of juvenile Pacific salmon. *Proc Natl Acad Sci USA* 108(21):8708–8713.

BPA-2021-00513-F 0195

LETTER

Reply to Haeseker: Value of controlled scientific experiments to resolve critical uncertainties regarding Snake River salmon survival

In our report (1), we set out to explicitly control for the ecological differences Haeseker (2) cites so that we could assess the effect of a critical policy issue: whether Snake River dam passage results in poorer early marine survival of juvenile Snake River spring Chinook salmon. Thus, we selected smolts of common size and manipulated release times to ensure smolts from the two populations were as similar as possible, apart from the number of dams that they passed (1). We agree with Haeseker that ecological differences between the populations used in our study existed and may have influenced ocean survival; however, their net effect needed to be a 3.4-fold difference in survival to result in the nearly identical rates of apparent survival that we found.

We have since repeated the experiment on salmon collected and tagged at Snake and Columbia River dams and compared their postrelease survival (3). The findings were consistent with the results reported in our article in PNAS (1): Snake River spring Chinook salmon ≥130-mm fork length did not have lower survival relative to salmon originating elsewhere. (It is now technically possible to repeat these tests on smaller wild smolts if policy makers deem it sufficiently important).

Haeseker's (2) claim concerning the ocean distribution of salmon smolts is likely unfounded: long-term ocean surveys have consistently captured juvenile Columbia River spring Chinook almost exclusively on the continental shelf north of the Columbia River (4). Furthermore, the cross-shelf distribution plots we report (figure S2 in ref. 1) demonstrate that both of the populations used in our study were shelf-limited at Lippy Point. The survival models we use thus accounted for individuals temporarily carried south or off-shelf in the Columbia River plume. Finally, because our study estimates relative survival, precise estimation of detection probability is not critical unless enough of the Yakima population migrated offshore to reduce the number detected to equal that of the Snake River smolts.

As Hilborn noted in his commentary on our report (5), no amount of data are likely to resolve the gulf between ecologists arguing for a major delayed effect of Columbia River dams on ocean survival and those who do not. Many in the Columbia River Basin blame poor ocean survival on prior exposure to dams in freshwater; however, Chinook populations from undammed areas in British Columbia and Alaska have declined in recent years as well (1). Psychological studies repeatedly show that individuals and like-minded groups preferentially select those facts favoring their prior prejudices when presented with complex data capable of multiple interpretations (6), such as those in the correlation analyses cited by Haeseker (2). Without carefully designed scientific experiments that test specific variables, it may not be possible to break out of this dilemma. In other scientific fields, formal experimental tests of theories historically resulted in very rapid scientific progress. The stakes are high in the Columbia River region; the window for resolving the salmon conservation problem is likely closing fast, given the large predicted changes in future climate and poor ocean survival of salmon that will likely ensue.

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1 Rechisky EL, Welch DW, Porter AD, Jacobs-Scott MC, Winchell PM (2013) Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean. *Proc Natl Acad Sci USA* 110(17): 6883–6888.

2 Haeseker S (2013) Nonrepresentative fish and ocean migration assumptions confound inferences in Rechisky et al. *Proc Natl Acad Sci USA*, 10.1073/pnas.1309087110.

3 Porter AD, et al. (2012) Marine and freshwater measurement of delayed and differential-delayed mortality of Columbia & Snake River yearling Chinook smolts using a continental-scale acoustic-telemetry array, 2011. *Report to the Bonneville Power Administration by Kintama Research Services Ltd., Contract No. 46389, Project No. 2003-114-00*. Available at: http://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P127340.

4 Fisher J, et al. (2007) Comparisons of the coastal distributions and abundances of juvenile Pacific salmon from central California to the northern Gulf of Alaska. *American Fisheries Society Symposium 57: Ecology of Juvenile Salmon in the Northeast Pacific Ocean: Regional Comparisons*, eds Grimes C, Brodeur R, Haldorson L, McKinnell SM (American Fisheries Society, Bethesda), pp 31–80.

5 Hilborn R (2013) Ocean and dam influences on salmon survival. *Proc Natl Acad Sci USA* 110(17):6618–6619.

6 Trivers R (2011) *The Folly of Fools: The Logic of Deceit and Self-Deception in Human Life* (Basic Books, New York), p 395.

Author contributions: E.L.R., D.W.W., and A.D.P. wrote the paper.

The authors declare no conflict of interest.

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The following supplement accompanies the article

Delayed mortality effects in the early marine life history of Columbia River Basin yearling Chinook salmon

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Marine Ecology Progress Series 496: 159–180 (2014)

Supplement. Additional data

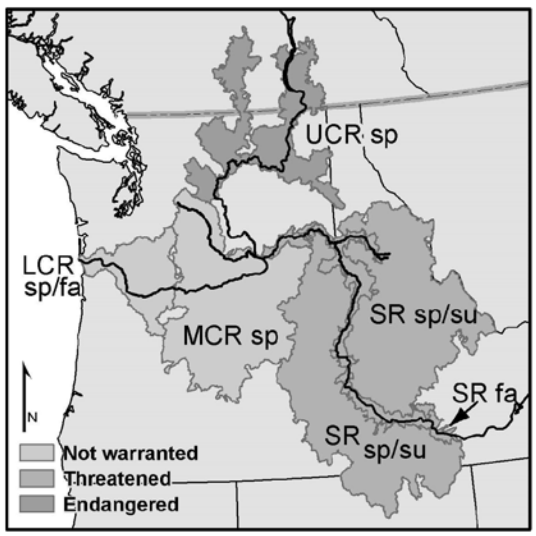

Fig. S1. *Oncorhynchus tshawytscha*. Historical range of Chinook salmon evolutionarily significant units (ESUs) within the Columbia River Basin and US Endangered Species Act (ESA) classification. Coarse-scale reporting groups used in this study generally correspond with ESUs, except the Snake River fall (SR fa) ESU, which is a component of the interior Columbia River reporting group. LCR sp/fa: lower Columbia River spring/fall, MCR sp: middle Columbia River spring, UCR sp: upper Columbia River spring, SR sp/su: Snake River spring/summer

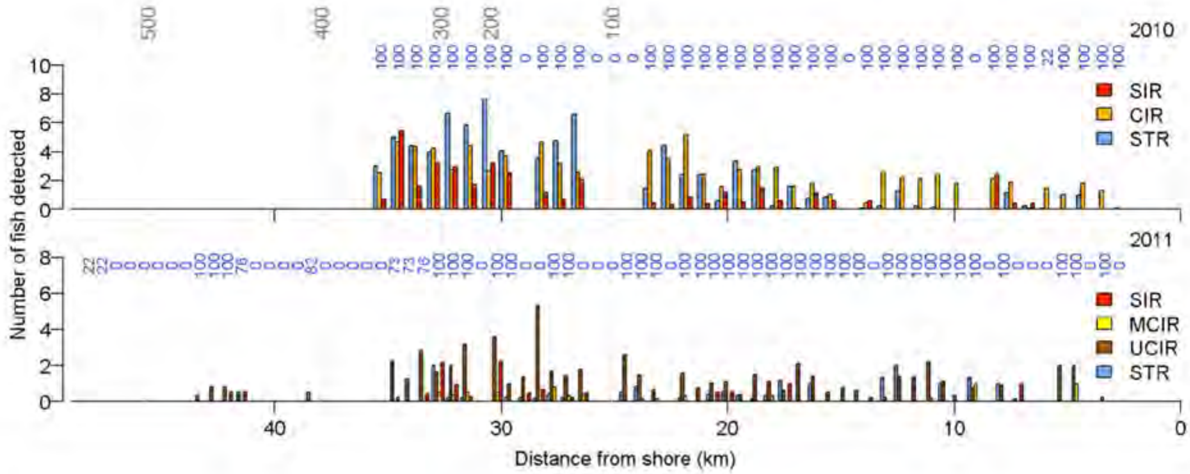

Fig. S2. *Oncorhynchus tshawytscha*. Cross-shelf distribution of acoustic-tagged yearling smolts on the Willapa Bay sub-array. If a fish was detected at >1 receiver, an equal proportion was allocated to all receivers detecting that fish, e.g. if an ID code was detected on 2 receivers, each receiver was assigned a value of 0.5 for that fish. The sub-array extended 35 km offshore in 2010, and 48 km offshore in 2011. Receivers were not deployed within 3 km of shore because shallow depths resulted in acoustic nodes washing ashore within weeks of deployment in previous years. The blue values above the bars indicate the proportion of time each receiver was operational during the migration period. In most cases where % operational was 0, the receiver was displaced by fishing activity. The grey values and vertical dashed lines indicate the bottom depth (m). Note that in 2011, 2 of 5 the smolts detected on offshore receivers (>35 km) were also detected on receivers <35 km from shore. SIR: Snake in-river, CIR: Columbia in-river, STR: Snake transported, MCIR: mid-Columbia in-river, UCIR: upper Columbia in-river

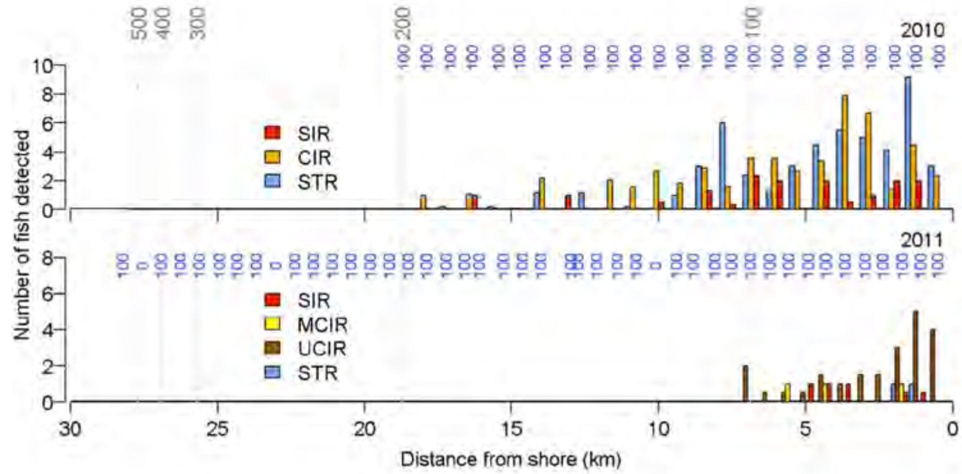

Fig. S3. *Oncorhynchus tshawytscha*. Cross-shelf distribution of acoustic-tagged yearling smolts on the Lippy Point sub-array. If a fish was detected at >1 receiver, an equal proportion was allocated to all receivers detecting that fish, e.g. if an ID code was detected on 2 receivers, each receiver was assigned a value of 0.5 for that fish. The sub-array extended 18.5 km offshore in 2010, and 28 km offshore in 2011. The blue values above the bars indicate the proportion of time each receiver was operational during the migration period. The grey values and vertical dashed lines indicate the bottom depth (m). SIR: Snake in-river, CIR: Columbia in-river, STR: Snake transported, MCIR: mid-Columbia in-river, UCIR: upper Columbia in-river

Table S1. *Oncorhynchus tshawytscha*. Estimated detection probability ($\hat{p}$) of acoustic sub-arrays. SIR: Snake in-river, CIR: Columbia in-river, STR: Snake transport, MCIR: mid-Columbia in-river, UCIR: upper Columbia in-river. LAB: Lake Bryan, WAL: Lake Wallula, LAC: Lake Celilo, MCG: McGowans Channel, CRI: Crims Island, AST: Astoria, SDI: Sand Island, WIL: Willapa Bay, LIP: Lippy Point, All: all treatment types combined, NA: not applicable. Data from all treatment types were used to estimate 1 detection parameter at WIL in 2010, and at all detection sites in 2011. Detection probability was fixed at LIP in both years ([a]assumed $\hat{p}$ based on Welch et al. 2011). LAB, WAL, LAC, MCG and CRI sub-arrays were not deployed in 2011

Year	Treatment type	Sub-array	$\hat{p}$	SE ($\hat{p}$)	95% CI
2010	SIR	LAB	1	0	0.98-1
		LAW	0.99	0.01	0.97-1
		LAC	0.33	0.04	0.25-0.41
		MCG	0.33	0.04	0.25-0.41
		CRI	0.23	0.04	0.16-0.31
		AST	0.86	0.04	0.78-0.92
		SDI	0.72	0.07	0.59-0.84
	CIR	LAC	0.42	0.02	0.38-0.47
		MCG	0.53	0.02	0.48-0.57
		CRI	0.25	0.02	0.22-0.29
		AST	0.76	0.02	0.72-0.81
		SDI	0.54	0.04	0.45-0.62
	STR	CRI	0.26	0.03	0.21-0.31
		AST	0.80	0.03	0.74-0.85
		SDI	0.43	0.03	0.37-0.49
	All	WIL	0.44	0.05	0.35-0.53
	All	LIP	0.67[a]	NA	NA
2011	All	AST	0.82	0.02	0.78-0.85
	All	SDI	0.78	0.03	0.73-0.84
	All	WIL	0.70	0.08	0.52-0.84
	All	LIP	0.67[a]	NA	NA

Table S2. *Oncorhynchus tshawytscha*. Summary of yearling Chinook salmon detections. SIR: Snake in-river, CIR: Columbia in-river, STR: Snake transport, MCIR: mid-Columbia in-river, UCIR: upper Columbia in-river

		No. of fish detected										
Treatment type	No. of fish released	Lake Bryan	Lake Wallula	Lake Celilo	McGowans Channel	Crims Island	Astoria	Sand Island	Willapa Bay	Cascade Head	Lippy Point	Graves Harbor
2010												
SIR	383	377	237	137	116	33	107	79	37	-	16	0
CIR	790	-	-	634	586	160	398	247	91	-	53	0
STR	406	-	-	-	-	100	243	131	81	-	51	3
2011												
SIR	80	-	-	-	-	-	51	51	11	1	4	-
MCIR	59	-	-	-	-	-	45	42	7	1	3	-
UCIR	386	-	-	-	-	-	257	240	60	4	21	-
STR	200	-	-	-	-	-	135	121	16	0	2	-

LITERATURE CITED

Welch DW, Melnychuk MC, Payne JC, Rechisky EL and others (2011) In situ measurement of coastal ocean movements and survival of juvenile Pacific salmon. Proc Natl Acad Sci USA 108:8708–8713

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Contribution to the Theme Section 'Tracking fitness in marine vertebrates'

FREE ACCESS

Testing for delayed mortality effects in the early marine life history of Columbia River Basin yearling Chinook salmon

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ABSTRACT: Juvenile Snake River Chinook salmon *Oncorhynchus tshawytscha* pass through 8 major hydroelectric dams during their >700 km migration to the sea, or are transported downriver to avoid these dams. Both of these anthropogenic processes may decrease fitness and lead to delayed mortality in the estuary and coastal ocean, and thus reduce the rate at which adults return to spawn. Using a large-scale telemetry array, we tested whether there was support for (1) hydrosystem-induced delayed mortality (hydro-DM) of yearlings migrating from the Snake River relative to yearlings migrating from the mid-Columbia River, and (2) transportation-induced delayed mortality (transport-DM) for transported Snake River yearlings relative to yearlings which migrated in-river. We also tested for differential early marine survival between yearlings migrating from the Snake and upper Columbia Rivers. In 2010, seaward migrating yearling Chinook were captured at dam bypasses and origin was based on capture location; in 2011, dam-caught fish were identified using genetic stock identification. Survival of all groups during the initial 750 km, >1 mo long migration through the estuary and coastal ocean to northwestern Vancouver Island ranged between 14 and 19% in 2010 and was lower in 2011 (1.5–8%). We found no support for hydro-DM, as survival of in-river migrating Snake and mid-Columbia River yearlings was indistinguishable. We found mixed results for our transportation study, with no support for transport-DM in 2010, and weak support in 2011. Our study provides further evidence that freshwater management strategies may not increase the rate of Chinook salmon returning to the Snake River if prior freshwater experience has no substantial influence on subsequent survival in the ocean.

KEY WORDS: *Oncorhynchus tshawytscha* · Latent mortality · Transportation · Snake River · Early marine survival · Acoustic telemetry

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INTRODUCTION

The Columbia River Basin (Fig. 1) once boasted some of the largest runs of Chinook salmon *Oncorhynchus tshawytscha* in the Pacific Northwest of North America. Chapman (1986) estimated that 2.7 million spring/summer Chinook salmon returned to the Basin annually in the late 19th century. The cumulative impacts of over-harvesting (Chapman 1986, Ward et al. 1997), hydroelectric dam development (Raymond 1979, 1988, Schaller et al. 1999), habitat degradation (Paulsen & Fisher 2001), hatchery production (National Research Council 1996, Levin et al. 2001) and unfavourable ocean climate (Mantua et al. 1997, Hare et al. 1999) reduced return rates to fewer than 100 000 fish by the end of the 20th century (Joint Columbia River Management Staff 2012). During the 1990s, Snake River (a tributary of the Columbia River) spring/summer Chinook were listed as threatened, and upper Columbia River spring Chinook were listed

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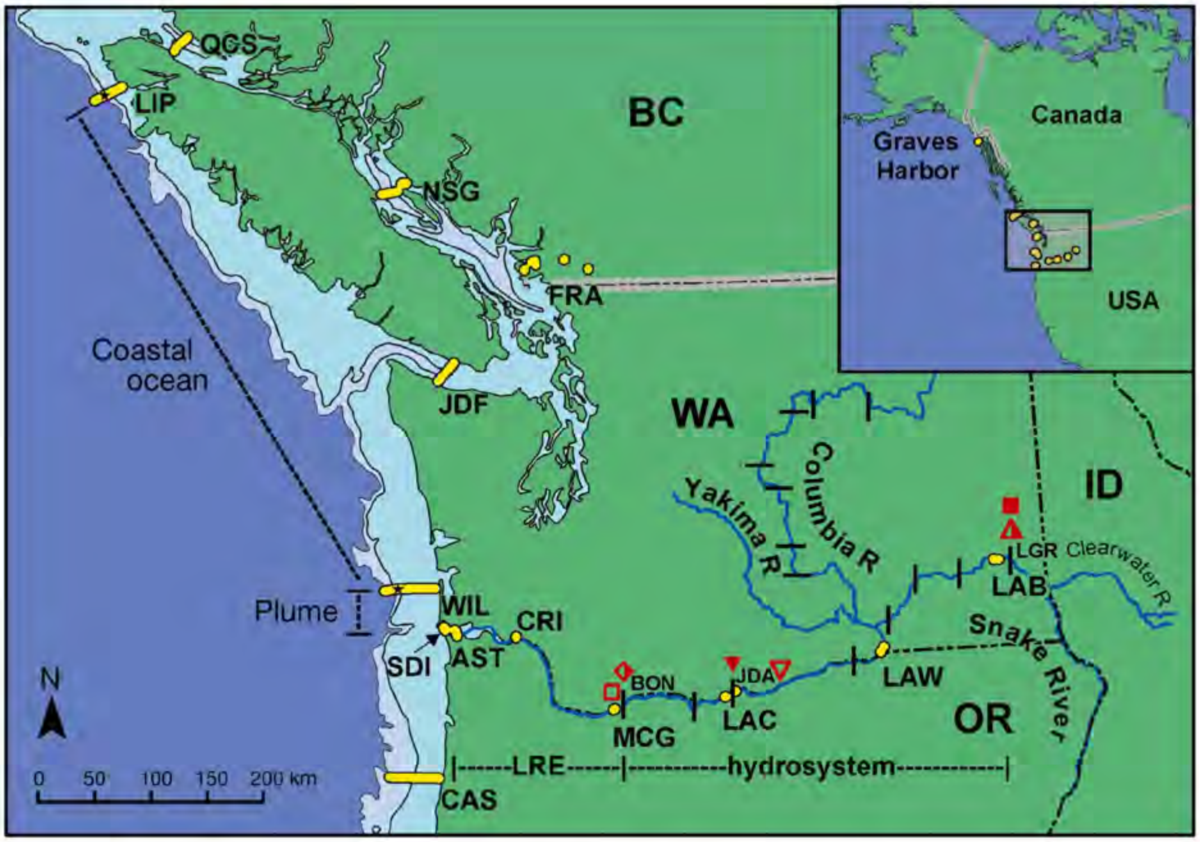

Fig. 1. Study area with acoustic tracking array (yellow dots and lines), capture and release locations (red symbols) and habitat designations (short-dashed lines, LRE: lower Columbia River and estuary). Snake and Columbia River dams are indicated with black vertical and horizontal lines. In 2010, Snake in-river (SIR) migrating salmon smolts were collected and released at Lower Granite Dam (LGR; half-filled red triangle), and Columbia in-river (CIR) smolts were collected at John Day Dam (JDA; inverted filled red triangle) and released 42 km upstream of JDA (inverted open red triangle). In 2011, all in-river smolts were collected and released at Bonneville Dam (BON; half-filled red diamond). In both years, Snake River transported (STR) smolts were collected at LGR (filled red square) and released at BON (open red square). In 2010, river and LRE sub-arrays were deployed at Lake Bryan (LAB), Lake Wallula (LAW), Lake Celilo (LAC), McGowans Channel (MCG), Crims Island (CRI), Astoria (AST) and Sand Island (SDI). Marine sub-arrays were deployed at Willapa Bay, WA (WIL), Lippy Point, BC (LIP), and Graves Harbor, AK, and extended across the continental shelf out to approximately the 200 isobath (indicated by the star). In 2011, LAB, LAW and LAC were removed since all smolts were released at BON. The CRI and Graves Harbor sub-arrays were also removed, and the WIL and LIP sub-arrays were extended offshore to the 500 m isobath. The Cascade Head, OR (CAS), sub-array was deployed in 2011 and extended out to the 500 m isobath. No smolts were detected on the Fraser River (FRA) sub-arrays or on the Pacific Ocean Shelf Tracking (POST) sub-arrays in Juan de Fuca Strait (JDF), Northern Strait of Georgia (NSG) and Queen Charlotte Strait (QCS). Isobaths show the continental shelf edge at 200 and 500 m depth

as endangered under the US Endangered Species Act (ESA); however, mid-Columbia River spring Chinook have not warranted ESA listing (Fig. S1 in the Supplement at www.int-res.com/articles/suppl/m496p159_suppl.pdf). A combination of unprecedented mitigation efforts within the Columbia River basin and improved ocean conditions have increased Chinook survival during the last decade (Williams et al. 2005), but the number of fish returning still remains at about 10% of the historical estimate (Joint Columbia River Management Staff 2012).

Columbia and Snake River dams altered the landscape from a free-flowing river to a series of slow-flowing reservoirs which resulted in fish habitat loss, proliferation of non-indigenous aquatic species and altered salmon migration routes and speeds (National Research Council 1996). Although dam bypasses are available to seaward migrating smolts, and water is spilled over the dams to promote fish passage, the cumulative effect of dams (dam passage and slower movement rate in reservoirs) is thought to lead to increased stress and decreased fitness for fish originating from the Snake River Basin (Budy et al. 2002). For various reasons, upper Columbia River dams have not been the subject of as much criticism (National Research Council 1996). Smolt-to-adult return rates (SARs) of the aggregate wild Snake River spring Chinook salmon run averaged only 1.1% over the last decade (Tuomikoski et al. 2012), well below the recovery target of 4% and minimum target of 2% (Northwest Power and Conservation Council 2009). In contrast, the SARs of wild spring Chinook salmon from 2 mid-Columbia River tributaries (John Day and Yakima Rivers) were 4.3 and 3.1%, respectively, over the same time period (Tuomikoski et al. 2012). Populations from the mid-Columbia migrate through only the lower Columbia River dams and are not exposed to Snake River dam passage. Thus, the lower productivity of the Snake River population was attributed to their exposure to first the 4 lower Snake River dams in addition to the 4 lower Columbia River dams which make up the Federal Columbia River Hydropower System (FCRPS or 'hydrosystem'; Fig. 1; Schaller et al. 1999, Deriso et al. 2001, Wilson 2003).

To avoid stressors associated with migration through the hydrosystem, some smolts are diverted from the Snake River dam bypasses into barges and transported 460 km downstream to below Bonneville Dam in the lower Columbia River (Fig. 1), the last (lowest) dam in the hydrosystem. Since survival of spring Chinook smolts after approximately 2 to 3 wk of migration in the hydrosystem is ~50% (Faulkner et al. 2011), and survival during the ~36 h trip in the barge is nearly 100% (McMichael et al. 2011), transported smolts initially survive at twice the rate of in-river migrants. However, transportation has not reliably doubled the rate of adults returning from the ocean, and in some years transported smolts returned at lower rates than in-river migrants, indicating that the transportation program may have reduced adult return rates of spring Chinook salmon (Ward et al. 1997, Williams et al. 2005). Since the mid-1990s, the SAR of transported wild spring Chinook smolts averaged only 1.2 times that of the in-river migrants (90% CI = 0.93–1.57), indicating only a small benefit from transportation on average (Tuomikoski et al. 2012).

The concept of delayed mortality was introduced because direct dam-related mortality, which has been relatively stable for decades, and barge-related mortality could not explain the magnitude of poor Snake River Chinook adult returns (Williams et al. 2005). Delayed mortality is thought to occur in either the Columbia River estuary or ocean, and can be hydrosystem-induced (hereafter hydro-DM) or transportation-induced (hereafter transport-DM). Budy et al. (2002) reviewed the potential effect of stressors that Snake River spring Chinook salmon may encounter during their downstream migration (e.g. injury, trauma, energy depletion, increased predation and disease susceptibility) and concluded that the accumulation of multiple stressors results in hydro-DM in the estuary and coastal ocean. Haeseker et al. (2012) provided further evidence for hydro-DM by demonstrating that freshwater and ocean survival is correlated, and concluded that increased spill and decreased transit time in the hydrosystem improved survival in both environments.

Anderson et al. (2011) reviewed the numerous potential causes of transport-DM, including physiological or behavioural stress associated with dam bypass facilities (Budy et al. 2002), co-transportation with steelhead salmon *Oncorhynchus mykiss* (Congleton et al. 2000), increased disease transmission (Van Gaest et al. 2011), smaller body size and earlier ocean entry of transported smolts (Muir et al. 2006) and impaired adult homing abilities (Keefer et al. 2008). Although there is no consensus on how delayed mortality of transported spring Chinook salmon occurs, timing of transport appears to be important (Muir et al. 2006, Smith et al. 2013). As a result, managers have delayed the start of the transportation program by several weeks in recent years (Tuomikoski et al. 2012).

As spring/summer Chinook salmon typically spend 2 yr at sea, and conservation efforts and technological fixes in the Columbia River Basin have not increased population growth rates to sustainable levels, the marine phase has been given increasing attention. Modelling exercises have demonstrated that even if hydrosystem survival was 100%, population growth rates would continue to decline unless reductions in first-year mortality, particularly early ocean and estuarine mortality, occurred (Kareiva et al. 2000). Several studies have shown that survival of spring Chinook is high in the Columbia River estuary (Schreck et al. 2006, Clemens et al. 2009, McMichael et al. 2010, Harnish et al. 2012, Rechisky et al. 2012, 2013), leaving little room for improvement. Given the significant correlation between ocean conditions that juvenile spring Chinook salmon encounter following ocean entry and the number of adults subsequently returning to the Columbia River (Burke et al. 2013, NOAA Fisheries Service 2013) and that depressed Chinook salmon populations are not unique to the Columbia River Basin (Chinook salmon in the highly altered Sacramento River suffered a recent collapse, Lindley et al. 2009, as did several populations originating from pristine Alaskan rivers, ADF&G Chinook Salmon Research Team 2013), increasing scrutiny of marine survival is warranted.

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Although delayed mortality is assumed to manifest soon after ocean entry, previous evaluation of hydro- or transport-DM has been based on studies where fish were tagged as juveniles and then captured or detected as returning adults (e.g. Muir et al. 2006, Schaller & Petrosky 2007, Haeseker et al. 2012). These studies confound delayed mortality in the early marine environment with events influencing survival that occur later in the marine life history. The only way to unambiguously determine the magnitude of early marine mortality and any potential relationship to prior freshwater experience is to estimate the survival of tagged juveniles directly in the estuary and early marine phase (e.g. Rechisky et al. 2013).

Using a continental-scale acoustic telemetry array (Fig. 1), we tracked the movements and estimated survival to northern Vancouver Island (a distance of 750 km beyond the final dam) of both in-river migrating and transported yearling Chinook salmon smolts obtained from dam bypass facilities in the Columbia and Snake Rivers in 2010 and 2011. To evaluate hydro-DM, we compared the survival estimates of in-river migrating Snake River yearling Chinook (SIR) to in-river migrating mid-Columbia River yearling Chinook (MCIR). In 2010, the sample of smolts captured in the Columbia River (CIR) was comprised of an unknown proportion of Snake, mid- and upper Columbia smolts which precluded us from specifically testing the hydro-DM hypothesis in that year. In 2011, we used genetic stock analyses to determine smolt origin, and thus we could directly test the hydro-DM hypothesis. We also had the unique opportunity in 2011 to compare survival of endangered upper Columbia yearling Chinook salmon (UCIR), which may migrate through as many as 9 dams before reaching the lower river and estuary, to SIR salmon in the estuary and coastal ocean. For completeness, we report survival results from the Columbia/Snake comparison in 2010 as supporting information.

To evaluate transport-DM, we compared survival estimates of the SIR treatment type to Snake River yearling Chinook transported (STR) via barge to below Bonneville Dam. The origin of SIR and STR smolts was known in both years.

In this study, we report findings from the final 2 yr of a 6 yr study. We (E.L.R., D.W.W., A.D.P.) began testing hydro- and transport-DM in 2006 using Spring Chinook smolts obtained directly from a Snake River Basin hatchery (Dworshak). Each treatment (in-river and transport) had 2 release groups, and release-timing was manipulated so that ocean-entry timing was similar for the treatment groups as well as for tagged smolts obtained from a mid-Columbia River hatchery. We found no evidence of hydro- (Rechisky et al. 2009, 2013) or transport-DM (Rechisky et al. 2012) from 2006 to 2009. In 2010 and 2011, we collected Chinook smolts (which were primarily hatchery origin) from dam bypass facilities and released them over a broader interval. Results from the current study are thus more reflective of the general population of hatchery smolts migrating through the Columbia River Basin. If survival differences arise in the estuary and coastal ocean for the various in-river treatment types as a result of the degree of dam passage, as postulated, we should expect survival to reflect the degree of ESA listing, i.e. $S_{MCIR} > S_{SIR} > S_{UCIR}$. If transportation further reduces survival of yearling Chinook originating from the Snake River, then we should expect transported fish to have lower survival than their in-river counterparts, i.e. $S_{SIR} > S_{STR}$.

MATERIALS AND METHODS

Species run and rearing type

Chinook salmon in the interior Columbia River Basin (upstream of Bonneville Dam) exhibit 2 life history strategies that belong to separate major genetic lineages (e.g. Narum et al. 2010). Although this is an oversimplification, these lineages are commonly differentiated by a suite of traits including spawning location, adult upstream run timing and marine distribution. Chinook that return to their natal rivers in the spring and early summer ('spring' or 'spring/summer' Chinook) generally spawn in headwater tributaries in late summer and fall, 4 to 6 mo after river entry. Their offspring, which then spend more than 1 yr in fresh water before migrating seaward to coastal waters in the spring, are also referred to as 'stream-type'. Spring Chinook smolts then migrate northward along the continental shelf after ocean entry and then eventually are distributed through the oceanic subarctic Pacific Ocean. Chinook that enter fresh water in the summer and fall ('fall' Chinook) spawn in mainstem locations shortly after entry, and their offspring are considered 'ocean-type' because they migrate to the ocean the following summer as subyearlings (Healey 1991). In the marine environment, fall Chinook are typically found closer to shore and seem to remain as continental shelf residents for their entire marine phase.

In this study we collected and tagged migrating, yearling (>1 yr old) Chinook salmon smolts in the spring at Columbia River Basin dams; thus, salmon

Table 1. *Oncorhynchus tshawytscha*. Attributes of tagged, yearling Chinook smolts. All smolts were implanted with both acoustic and passive integrated transponder (PIT) tags. FL: fork length; LGR: Lower Granite Dam; JDA: John Day Dam; BON: Bonneville Dam; SIR: Snake in-river; CIR: Columbia in-river; STR: Snake transport; MCIR: mid-Columbia in-river; UCIR: upper Columbia in-river; PBT: parentage based tagging; GSI: genetic stock identification. % hatchery origin was determined by the absence of an adipose fin supplemented by genetic stock analysis for SIR and STR in 2011 (see 'Materials and methods'). Tag burden was calculated as tag mass in air divided by fish mass in air

Collection site	Treatment type	Stock ID	Method used to determine stock	n	% hatchery origin	Mean FL (range) (mm)	Mean % tag burden (range)
2010							
LGR	SIR	Snake River	Collection site	383	97	141.6 (130–167)[b]	5.5 (3.2–8.0)
JDA	CIR	Columbia River[a]	Collection site	790	62	161.3 (130–215)[c]	3.7 (1.7–8.0)
LGR	STR	Snake River	Collection site	406	94	141.8 (130–171)[b]	5.4 (2.4–7.8)
2011							
BON	SIR	Snake River	PBT + GSI	80	98	147.6 (132–168)[d]	5.4 (3.3–0.4)
BON	MCIR	Mid-Columbia River	GSI	59	81	144.0 (131–168)[c]	5.7 (3.2–7.7)
BON	UCIR	Upper Columbia River	GSI	386	92	143.6 (130–170)[e]	5.5 (2.7–7.8)
LGR	STR	Snake River	PBT + site	200	99	142.3 (130–165)[e]	5.8 (3.5–7.9)

[a]An unknown proportion of these smolts were Snake River origin (See 'Materials and methods: Smolt collection sites, release sites and populations studied')
[b–e]Superscripts group treatments with statistically similar fork length (Wilcoxon rank sum test, $p > 0.05$)

smolts tagged in our study were primarily the spring/summer run type which were differentiated from fall run type by their seaward migration timing and larger body size. It is possible, however, that some fall Chinook were included in our 2010 sample, as some of the summer/fall Chinook hatchery programs in the Columbia River (at least above the Snake confluence) release fall Chinook smolts as yearlings. Additionally, a small proportion of fall Chinook smolts have been known to spend an additional winter in freshwater and then migrate seaward as yearlings at approximately the same time as spring Chinook, albeit at a larger body size (Connor et al. 2005). In 2011, we were able to exclude this fall Chinook ecotype from our analysis following stock identification (see Results; 7% were fall Chinook). For simplicity, we refer to all smolts in our study as yearling Chinook.

Smolt collection sites, release sites and populations studied

In 2010, we collected migrating yearling Chinook smolts ≥130 mm fork length (FL) from the juvenile fish bypass facilities at Lower Granite Dam on the lower Snake River and at John Day Dam on the lower Columbia River (Fig. 1). Smolts collected at Lower Granite Dam were randomly allocated into Snake in-river (SIR) and Snake transported (STR) treatment groups. The SIR groups were released into the tailrace below Lower Granite Dam over 8 d, with ~50 smolts released per day (range 37–52) between 17 and 24 May (383 fish in total; Table 1, Fig. 2). Transported smolts were concurrently tagged and then loaded into barges at the dam in groups of ~50 fish each day (range 22–51) and transported for ~36 h to a release site below Bonneville Dam in the lower Columbia River (river km 222–225), the last (lowest)

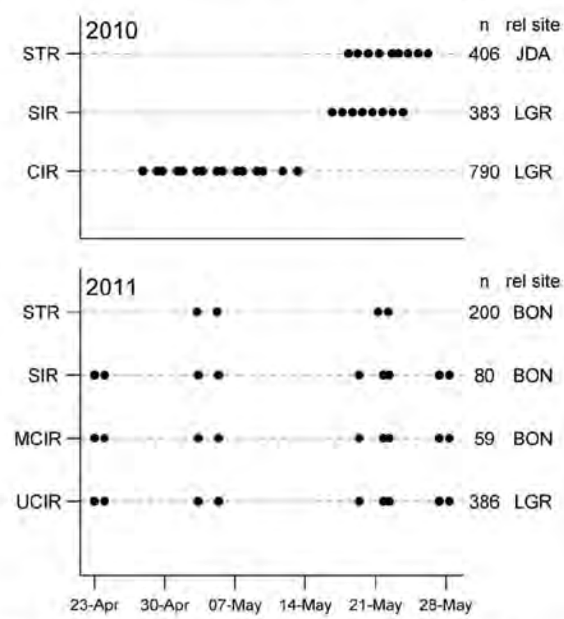

Fig. 2. *Oncorhynchus tshawytscha*. Release dates for acoustic tagged Columbia River Basin yearling Chinook. STR: Snake transported; SIR: Snake in-river; CIR: Columbia in-river; MCIR: mid-Columbia in-river; UCIR: upper Columbia in-river; rel site: release site (abbreviations defined in Fig. 1)

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dam in the hydrosystem. The STR fish were released between 19 and 27 May (9 release groups; 406 fish in total). Columbia in-river (CIR) smolts were collected and tagged at John Day Dam and then released 42 km above the dam in daily groups of ~50 smolts (range 48–52 except 1 release group that combined 2 d of tagged smolts, for a total of 98). The CIR fish were released between 28 April and 13 May (15 release groups; 790 fish in total; Table 1, Fig. 2).

Smolts in the CIR group collected at John Day Dam in 2010 originated from the mid-Columbia, upper Columbia and Snake Rivers; however, the proportion of these stocks in our experiment was unknown because we did not identify stock of origin for each individual. Based on the computed estimates of the number of Chinook smolts arriving at John Day Dam in 2010, most of the 2010 yearling Chinook sample were likely of spring run upper Columbia River origin with smaller numbers of spring run mid-Columbia and spring run Snake River origin (Ferguson 2010). This is consistent with genetic analysis of smolts that we collected and tagged at Bonneville Dam in 2011 (67% upper Columbia spring, 10% mid-Columbia spring, 14% Snake spring, 9% interior-Columbia fall; see 'Results: Stock identification'). Because we could not individually identify fish originating from the mid-Columbia River region in our 2010 sample, we could not explicitly test the hydro-DM hypothesis (survival of SIR relative to MCIR) in that year. We do, however, present a differential survival analysis of the general CIR group collected at John Day Dam relative to the SIR group collected at Lower Granite Dam in 2010, as estuarine and early marine survival of a pure-SIR group is hypothesized to be lower due to Snake River dam passage than for a mixed group containing mostly mid- and upper Columbia River origin smolts.

In 2011, STR smolts were again collected from the juvenile fish bypass facility at Lower Granite Dam on the Snake River. One hundred smolts were tagged, transported, and then released from the barge in 2 intervals, one in early May and another in mid-May (200 fish in total; Table 1, Fig. 2). All in-river migrating groups (SIR, MCIR, UCIR) were collected from the juvenile fish bypass facility at Bonneville Dam. Approximately 100 to 200 fish were tagged and released at each of 4 intervals between 23 April and 28 May (580 fish in total, 525 used in the analysis; Table 1, Fig. 2). There were fewer release intervals of STR fish because the transport season was shorter than the overall migration (Fig. 2). A caudal fin clip was collected from each tagged fish and genetic stock analyses were performed to determine the run type (e.g. spring or fall run), ecotype (e.g. yearling spring or hold over yearling fall), stock of origin (i.e. Snake River, upper Columbia River or mid-Columbia River) and hatchery of origin for Snake River smolts (see 'Results: Stock identification' and Table 1 for final sample size for each stock.). Thus, in 2011, we were able to test hydro-DM for the SIR group relative to the in-river migrating mid-Columbia yearling Chinook (MCIR) group, and to evaluate differential survival for the SIR group relative to endangered upper Columbia in-river populations (UCIR).

The majority of smolts captured were hatchery reared as indicated by the absence of an adipose fin (Table 1). Adipose fin removal is implemented at most hatcheries (e.g. in 2010–2011, ~90% of smolts released in the Snake and Columbia Rivers above Bonneville Dam, and ~92% of smolts released in the Snake River were either adipose fin-clipped or passive integrated transponder [PIT]-tagged; www.FPC.org). In 2010, we assumed that fish with their adipose fin intact were progeny of naturally spawning adults, i.e. 'wild'. In 2011, we supplemented this diagnostic with results from the parentage-based tagging genetic analysis which was applicable to SIR and STR groups only (see 'Stock identification' below).

During the final 2 d of tagging at Bonneville Dam (in 2011), some tagged smolts were inadvertently exposed to gas-supersaturated river water at the tagging facility, presumably due to high spill levels at up-river dams. This resulted in the death of 20 smolts due to gas bubble trauma (Bouck 1980, Mesa et al. 2000), reducing the total sample size released at Bonneville Dam from 600 to 580.

Stock identification

A combination of 2 genetic assignment methods was used to determine the most probable stock of origin for each smolt for which we obtained a caudal fin clip in 2011: (1) genetic stock identification (GSI) and (2) parentage-based tagging (PBT, e.g. Steele et al. 2011). The GSI method employed 188 single nucleotide polymorphism (SNP) loci that were used to genotype individuals from reference populations in the Columbia River Basin. These reference populations were classified into coarse-scale reporting groups and then used to individually assign all tagged smolts to their likely reporting-group-of-origin (see Hess et al. 2012 for details regarding baseline and GSI accuracy). The following 5 coarse-scale reporting groups were used to represent the entire Columbia River Basin: lower Columbia River spring and fall-run, middle Columbia River spring-

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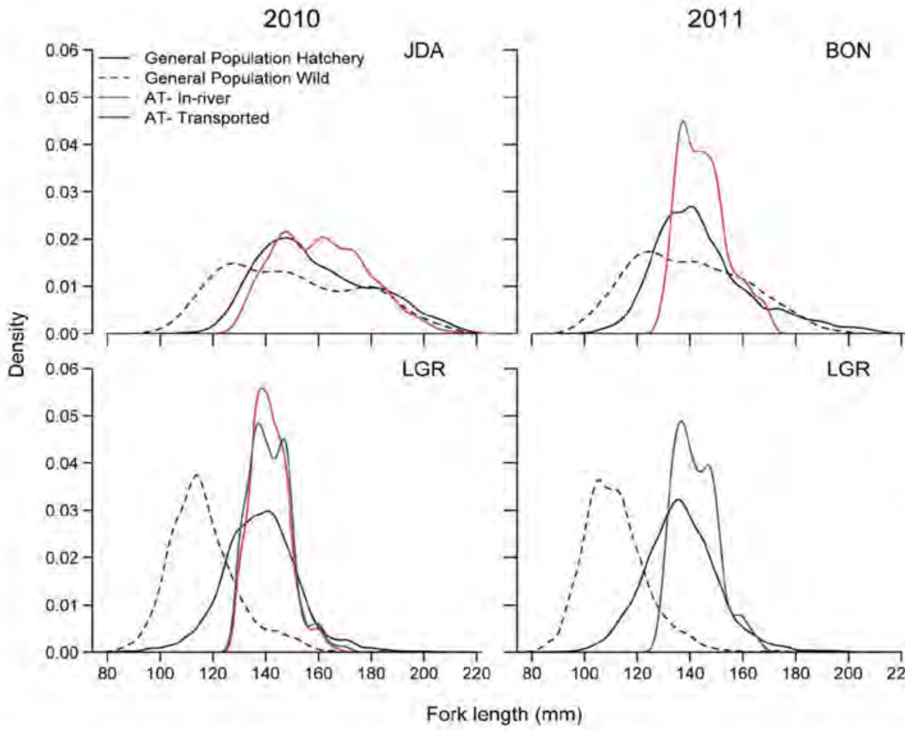

Fig. 3. *Oncorhynchus tshawytscha*. Fork length of yearling smolts (kernel density estimates). The solid black lines represent the general population of hatchery smolts, and the dotted black lines represent the general population of wild smolts migrating through Lower Granite (LGR), John Day (JDA), and Bonneville (BON) Dams (data provided by the Pacific States Marine Fisheries Commission). Red lines represent in-river groups of acoustic tagged (AT) smolts and blue lines represent AT smolts transported from LGR

run, upper Columbia River spring-run, Snake River spring/summer-run and interior Columbia River summer/fall-run. These reporting groups generally correspond to the evolutionarily significant units (ESUs) used by the ESA to designate conservation status (Fig. S1 in the Supplement). ONCOR v1.0 (www.montana.edu/kalinowski/Software/ONCOR.htm) was used to assign individual smolts according to highest probability ('best estimate') baseline reporting groups. These 5 reporting groups were found to yield high assignment accuracy (averaging greater than 85% correct assignment) according to the leave-1-out test performed in ONCOR v1.0.

The PBT analysis employed a pedigree approach by genotyping 95 SNPs in nearly all (94%) potential spring/summer Chinook salmon parents spawned at Snake River hatcheries in 2009 in order to assign smolt progeny back to their parents, and thus to their specific hatcheries. Assignments with the PBT approach are nearly 100% accurate since offspring are matched directly to parents (Steele et al. 2013). We performed all parental assignments using the program SNPPIT (Anderson 2010) and used a false discovery rate threshold of 1% as a basis for accepting confident assignments. Most Snake River hatchery smolts collected at the Lower Granite and Bonneville Dams could be matched with their parents using PBT. If PBT results were not available (i.e. for natural-origin smolts, or for smolts whose parents were not genotyped), smolts tagged at Lower Granite Dam were assigned to the Snake River spring/summer stock based on collection site (although we confirmed using GSI that no fall Chinook were present in the Lower Granite Dam sample). For smolts that were collected at Bonneville Dam, stock of origin was determined with PBT as a priority due to its high level of accuracy, or determined by GSI as the next best alternative.

Smolt size distribution and migration timing

In both years, smolts ≥130 mm FL were tagged in order to avoid large tag burdens. This size criterion prevented us from tagging the smallest individuals from the hatchery populations, and the majority of the wild smolts passing Lower Granite Dam (Fig. 3). Both hatchery and wild smolts were larger at John Day and Bonneville Dams. In 2010, the upper 74% of the size range of the general hatchery population and the upper 15% of the size range of the wild population sampled at Lower Granite Dam met our size criterion. At John Day Dam the upper 96% of the hatchery and the upper 74% of the wild population met our size criterion. In 2011, the upper 71% of the general hatchery and the upper 8% of the general wild population at Lower Granite Dam met our size criterion. At Bonneville Dam, the upper 81% of the hatchery and the upper 63% of the wild population met our size criterion.

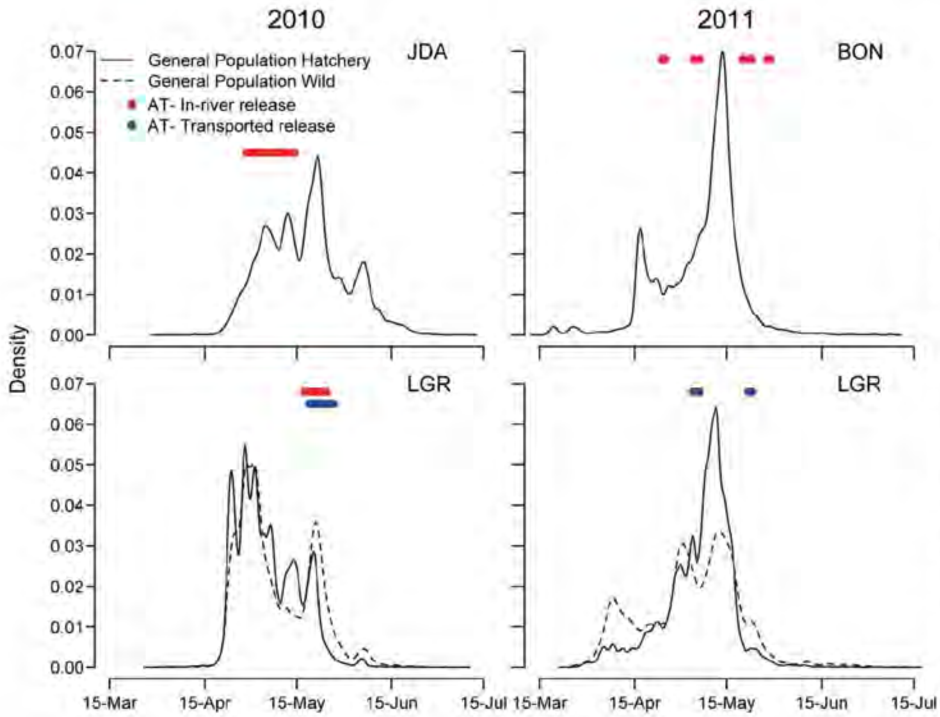

Fig. 4. *Oncorhynchus tshawytscha*. Run-timing of yearling smolts (kernel density estimates). The solid black lines represent the general population of hatchery smolts, and the dotted black lines represent the general population of wild smolts migrating through Lower Granite (LGR), John Day (JDA), and Bonneville (BON) Dams (passage index data accessed from www.FPC.org, June 2013). Red dots represent in-river groups of acoustic tagged (AT) smolts and blue dots represent AT smolts transported from LGR. AT fish were captured 3 d before release in 2010 and 4 d before release in 2011

We attempted to size-match the various treatment types in both years (Table 1). In 2010, the STR FL distribution was not significantly different from the SIR group (all were tagged at Lower Granite Dam); however, the CIR group (tagged at John Day Dam) had significantly more large individuals than the SIR group (Wilcoxon rank sum test, $p < 0.05$). In 2011, the size ranges were similar for the 4 treatment types, but the FL distribution of the SIR group was significantly different (i.e. there were more larger individuals in the SIR group) than the STR MCIR and UCIR groups (Wilcoxon rank sum test, $p < 0.05$).

In 2010, at John Day Dam, we collected and tagged CIR smolts during the first half of the smolt seaward migration, and at Lower Granite Dam, we collected and tagged smolts (SIR and STR) during the latter part of the smolt seaward migration (Fig. 4). In 2011, we were able to tag smolts concurrently at both Bonneville (SIR, UCIR, MCIR groups) and Lower Granite (STR group) Dams, and we released smolts across the majority of the seaward run time.

Because we did not tag smolts concurrently at the 2 dams in 2010, SIR smolts were released later than the CIR smolts; however, SIR and STR smolts, which were collected at Lower Granite Dam, were released/transported on approximately the same days (Fig. 2). In 2011, SIR, MCIR and UCIR groups were released concurrently, and STR groups were released on the same days as the early May and mid-May in-river groups.

Tag specifications and surgical protocol

All work involving live fish met the standards laid out by the Canadian Council on Animal Care and was annually reviewed and approved by the Animal Care Committee of Vancouver Island University, Nanaimo, BC, Canada (application no. 2009-11R). We surgically implanted yearling Chinook salmon smolts with V7-2L (69 kHz, 7 mm × 20 mm, 1.6 g in air, 0.75 g in water) acoustic transmitters (VEMCO, Amirix System). All acoustic tags transmitted a unique ID code and were programmed to provide operational lifespans long enough to cover the observed duration of the migration to the Lippy Point sub-array. In 2010, the rated lifespan of the tags was either 52 or 95 d; these were evenly allocated between treatment groups as an assessment of the effects of tag programming on detection probability (not reported here). In 2011, the rated lifespan of all tags was 51 d.

A 12 mm (0.1 g) PIT tag was also placed in the body cavity (through the incision) of all acoustic tagged smolts to ensure that tagged smolts were diverted back into the river at the juvenile fish bypass facilities and not transported for release below Bonneville Dam, as well as to detect any tagged smolts returning as adults. Acoustic tag burdens (Table 1) were generally lower than the maximum recommended for Chinook salmon smolts (Brown et al. 2006, 2010) and were similar to the tag burden ranges in our previ-

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ously conducted tag effects studies which demonstrated little to no effect of V7 transmitters on survival and retention in Columbia River Basin yearling Chinook smolts ≥130 mm FL (Rechisky & Welch 2010). Further, as part of the present study, we conducted a tag effect study at Bonneville Dam in 2011; after 35 d, survival of the acoustic tagged group held back at the dam was 97% and tag retention was 99% (Porter et al. 2012).

The same surgical protocol was used in both years for all treatment types; a detailed description is provided in Rechisky & Welch (2010). In brief, portable surgical units were assembled on site, and fish surgery was carried out by experienced, veterinarian-trained staff. Fish were anaesthetized individually in 70 ppm MS-222 buffered with 140 ppm $NaHCO_3$. FL was measured to the nearest mm, and weight was measured to the nearest 0.1 g. A maintenance dose of buffered anesthetic (50 ppm) 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. Each smolt was double tagged by placing a PIT and acoustic tag through the incision into the peritoneal cavity, and 1 or 2 absorbable sutures were used to close the incision. Immediately following surgery, fish were placed into a recovery bath and monitored. Fish generally regained equilibrium and reactivity within minutes. After release, we uploaded the PIT tag metadata into the Columbia River Basin PIT Tag Information System (PTAGIS) database maintained by the Pacific States Marine Fisheries Commission (PSMFC, Portland, OR, USA). Both the acoustic tagging metadata and the tracking data from the array were provided to the Pacific Ocean Shelf Tracking (POST) project, which is now managed by the Ocean Tracking Network (OTN, Halifax, NS, Canada).

Acoustic array elements and location

In 2010, we tracked acoustic tagged smolts from the SIR release site in the Snake River (Lower Granite Dam) through the hydrosystem, lower Columbia River and estuary, plume and coastal ocean to southeast Alaska, a total of 2300 km (Fig. 1). In 2011, we tracked smolts from the common release site below Bonneville Dam through the lower Columbia River and estuary, plume and coastal ocean to north-western Vancouver Island, a total of 750 km.

The acoustic telemetry array was composed of individual VEMCO receivers positioned above the seabed of the continental shelf or above the riverbed to form a series of listening lines or acoustic sub-arrays (referred to as 'sub-arrays'). Individual receivers recorded the date and time that acoustic transmitters (tags) were detected, and these detections were used to estimate the survival of each treatment group to each sub-array.

Sub-arrays upstream of Bonneville Dam were deployed in several reservoirs created by the Federal Columbia River Power System: in Lake Bryan below Lower Granite Dam in the Snake River, in Lake Wallula below the confluence of the Columbia and Snake Rivers, and in Lake Celilo downstream of John Day Dam in the lower Columbia River. These sub-arrays were removed in 2011 because all fish were released downstream near Bonneville Dam.

In 2010, sub-arrays downstream of Bonneville Dam were deployed in the lower Columbia River in McGowans Channel below Bonneville Dam (the last dam), in the estuary near Crims Island, near Astoria, WA, and near the river mouth at Sand Island. This area is collectively referred to as the lower river and estuary. In 2011, the McGowans Channel and Crims Island sub-arrays were removed.

During the 2010 study, marine components of the array were deployed in coastal ocean waters off southern Washington (near Willapa Bay), northwestern Vancouver Island (Lippy Point, BC) and southeast Alaska (Graves Harbor). These sub-arrays extended from near-shore out to ~200 m depths. In 2011, the Graves Harbor sub-array was removed, a sub-array was deployed in coastal Oregon waters near Cascade Head to detect any southward migrating smolts, and all coastal sub-arrays were extended farther offshore out to ~500 m depths. For this study, the hydrosystem is defined as the area between Lake Bryan and McGowans Channel, the lower river and estuary is defined as the tidal area ranging from McGowans Channel to Sand Island, the plume is defined as the area from Sand Island to Willapa Bay, and the coastal ocean is defined as the area between Willapa Bay and Lippy Point. A more detailed description of array elements, location and performance can be found in Porter et al. (2012).

Base model selection and survival estimation

Estimates of smolt survival (φ) and detection probability on each sub-array (p) were calculated for each treatment group (SIR, CIR and STR in 2010 and SIR, MCIR, UCIR and STR in 2011) using a modified Cormack-Jolly-Seber (CJS) model (Cormack 1964, Jolly 1965, Seber 1965) for live-recaptured animals in Pro-

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gram MARK (White & Burnham 1999). The CJS model uses maximum likelihood estimation to derive estimates of φ and p parameters and the sampling variance of those parameters. We further modified these models to test whether there was support for hydro- and transport-DM, or differential survival of the treatment groups.

For each year, the analysis followed a series of steps. First, we screened the detection data and formed detection histories for each tagged individual. Second, we assessed goodness of fit (GOF) of the data to the model. Third, we investigated the effect of treatment-type on p in order to determine the structure of the model that provided the best estimates of φ for each treatment type (our base model). Finally, we compared the base model to models used for hypothesis testing. We provide details of each of these steps below.

All acoustic detection data from the array were screened for potential false positive detections, which were rare; excluded data typically formed <0.2% of the total recorded detections (see Porter et al. 2012 for screening criteria). All tagged smolts were included in the analyses, regardless of their specific route through the dams (e.g. spill, bypass or turbine). Court-ordered spill levels were met or exceeded at the 4 lower Snake River dams and the 4 lower Columbia River dams during our study, which reduced the chance that smolts migrated through the turbines and bypasses. Detection histories for each tagged individual were then formed from the screened data.

We assessed the GOF of our data to the CJS model prior to parameter estimation. To do so, we fit the most general CJS model (φ[type × segment] p[type × site], φ and p estimated for each treatment type in each reach and on each sub-array) and assessed GOF with the median $\hat{c}$ test within Program MARK to yield an overdispersion factor, $\hat{c}$ (Cox & Snell 1989). In both years, there was no overdispersion due to lack of fit of the data to the model, i.e. $\hat{c} = 1$ in 2010 and 0.94 in 2011; therefore, no correction to the estimated standard errors was necessary.

Although all fish were implanted with the same model of acoustic tag, we wanted to ensure that assuming a common detection efficiency for each sub-array would not bias the relative survival estimates. Therefore, we compared the performance of models where p parameters were estimated in 3 different ways. We hypothesized that p may be similar for the treatment types at each sub-array (p [site]), that p may vary for each treatment type at each sub-array (p [type × site]), or that p may vary for the different treatment types at each sub-array in freshwater (FW), but be similar across treatment types in the ocean (specifically the Willapa Bay sub-array [WIL], p [type × site × FW + site × WIL]). The number of φ parameters in each model did not vary since one of our goals was to produce estimates of survival for each treatment type between each sub-array (φ [type×seg]) in each year.

For all models, we fixed the p of the Lippy Point sub-array to 0.67. We used a fixed value because we wished to estimate survival to Lippy Point, but within the CJS model, survival and detection are confounded at the final detection site. (Although there was a sub-array in southeast Alaska in 2010, too few fish were detected on this sub-array [n = 3 STR, n = 0 SIR, n = 0 CIR] to provide adequate information regarding the performance of the Lippy Point sub-array; the Alaskan sub-array was not deployed in 2011). By fixing p, we could estimate φ conditional on this assumed value. Using this fixed value was a reasonable approach for several reasons: (1) CJS analyses of p for other fully intact marine sub-arrays with similar receiver geometry, bounded by landmasses on either side, and with ample detections beyond the sub-array in question (which renders them directly estimable) showed that marine detection rates are very consistent across multiple sites and multiple years (~0.67 for V7 transmitters at 3 sites in 4 years, Welch et al. 2011); (2) marine receivers were deployed at approximately equal spacing to the Welch et al. (2011) study; (3) the smolt distribution on the Lippy Point sub-array was centered on the inner to middle continental shelf (Rechisky et al. 2012, 2013), indicating that fish were confined to the shelf; and (4) if estimates at Lippy Point are biased they should be equally biased for both treatment types, as identical acoustic tags were used in each year. Ideally, we would have fixed p at Lippy Point to equal the estimated p at Willapa Bay; however, receiver loss at Willapa Bay due to commercial fishing reduced detection efficiency, whereas the Lippy Point sub-array did not suffer losses due to fishing. Because the key scientific tests are (1) whether SIR smolts have lower post-Bonneville Dam survival than the CIR smolts and (2) whether STR smolts have lower post-Bonneville Dam survival than the SIR smolts, some uncertainty in the value of this final sub-array's detection probability is acceptable; however, we do require the assumption that the 2 tagged groups behaved similarly (i.e. that travel rate and potential offshore emigration, beyond the shelf arrays, were equal).

We used Akaike's Information Criteria corrected for low sample size (AIC_c) to evaluate the strength of evidence for the 3 competing base models formulated in each year. The model with the lowest AIC_c and highest probability of fitting the data as indicated by the AIC_c weight ($wAIC_c$) was chosen as the best base model (Burnham & Anderson 2002, Wagenmakers & Farrell 2004). The segment survival estimates and standard errors reported (see Tables 2 & 3) were obtained from this model. Parameter confidence intervals were estimated using the profile likelihood method within Program MARK. We did not investigate other potential causes of variability in φ (e.g. we did not include fish body size, travel time or release-timing covariates in our models). Prior assessments of other sources of variability such as tag loss, tagging induced mortality, tag operational lifespan and survival differences between taggers (surgical skill), as well as fish body size, indicated that these factors did not have significant influence on the survival estimates during the time required for the freely migrating tagged smolts to pass Lippy Point, BC (Porter et al. 2012).

For each treatment type, we then estimated cumulative survival in the co-migration corridor between Bonneville Dam and northwestern Vancouver Island as the product of the segment-specific survival estimates. Survival of the SIR group in the hydrosystem (to Lake Celilo below John Day Dam) in 2010 was calculated similarly as the product of segment-specific survival estimated from Lower Granite Dam to Lake Celilo. All variances on cumulative estimates were estimated with the delta method.

Strength of evidence for delayed mortality

To assess evidence of transport-DM, hydro-DM and/or differential survival of tagged groups of yearling Chinook salmon, we compared models which represented differences in survival of 2 treatment groups with reduced models which were formulated to represent the alternative hypothesis that there was no difference in survival of those groups. In all comparisons, the base models described above served as the delayed mortality or differential survival models since they were parameterized to produce estimates of φ for all 3 treatment types (STR, SIR and CIR) in each migration segment, and henceforth are referred to as base/DM models. In the reduced models, data from treatment types which were being compared were pooled and only 1 common φ parameter was estimated for each migration segment. To evaluate the strength of evidence for the competing models, we assessed the difference in the AIC_c scores (ΔAIC_c) and the $wAIC_c$ to determine which model had the highest probability of fitting the data (Burnham & Anderson 2002, Wagenmakers & Farrell 2004). For instance, if a reduced model had a lower AIC_c score and higher $wAIC_c$, i.e. if the data fit the reduced model best, then there was little or no support for delayed mortality in Snake River smolts. If the base/DM model had more support than the reduced model, it was necessary to then examine the φ parameter estimates (from the base/DM model) to determine which treatment group had better survival. Delayed mortality hypotheses would have empirical support if the group hypothesized to have greater stress indeed had poorer survival.

The 2010 base/DM model served as the transport-DM model in the transport-DM hypothesis test and also served as the differential survival model in the test of differential survival for in-river groups. To assess evidence of transport-DM in 2010, we compared the base/DM model to a reduced model (transport H1) which represented the alternative hypothesis that no transport-DM occurred for the STR treatment type relative to the SIR treatment type in the lower river and estuary, and the coastal ocean, i.e. survival was similar for the 2 groups. Thus, in the transport H1 model, data used to estimate SIR and STR base/DM model parameters SIR5-9 and STR1-5 were combined to estimate transport H1 model parameters S1–5 (Fig. 5a).

To test whether differential survival occurred for SIR and CIR groups in 2010, we compared the 2010 base/DM model to a model that represented the alternative hypothesis that survival of SIR and CIR treatment types was similar (model: hydro H1). In the hydro H1 model the effect of treatment (population) was removed in common migration segments where SIR and CIR smolts were tracked. The common tracking area began at Lake Celilo in 2010; thus beginning at this site, data for the groups were pooled and only 1 common survival parameter was estimated between each sub-array from Lake Celilo to Lippy Point (Fig. 5a: data used to estimate base/DM model parameters SIR4-9 and CIR2-7 were combined into hydro H1 model parameters IR1–6). We also formulated a model that more specifically represented differential survival downstream of Bonneville Dam (model: DM2). Similar to the base/DM model, the DM2 model estimated survival parameters between each detection site from Lake Bryan to Lake Celilo for the Snake River population, and separate survival parameters for each population in the lower river and estuary and coastal ocean; however, a common survival parameter was estimated for both populations between Lake Celilo and McGowans Channel (Fig. 5a: data used to estimate base/DM model parameter SIR4 and CIR2 were combined to estimate DM2 model parameter R1). We do not explicitly refer to this test as hydro-DM since the source populations contributing to the tagged CIR smolts were unknown in 2010.

The 2011 base/DM model served as the transport-DM model in the transport-DM hypothesis test and also served as the hydro-DM model in the hydro-DM hypothesis test. For the transport-DM test, the reduced model (transport H1) represented the alternative hypothesis that no transport-DM occurred for the SIR treatment type relative to the STR treatment type in the lower river and estuary, and the coastal ocean. Thus, data used to estimate base/DM model parameters SIR1–4 and STR1–4 were combined to estimate transport H1 model parameters S1–4 (Fig. 5b).

We then compared the 2011 base/DM model to a reduced model (hydro $H1_{MCIR}$) which represented the alternative hypothesis that no hydro-DM occurred for the SIR treatment type relative to the MCIR treatment type. Thus, data used to estimate base/DM model parameters SIR1–4 and MCIR1–4 were combined to estimate hydro $H1_{MCIR}$ model parameters IR1–4. We repeated this process to assess whether the data supported differential survival of SIR and UCIR treatment types as well (see Fig. 5b: data used to estimate base/DM model parameters SIR1–4 and UCIR1–4 were combined to estimate hydro $H1_{UCIR}$ model parameters IR1–4). We do not explicitly call this a test of hydro-DM since the UCIR and SIR smolts migrate through a similar number of dams prior to reaching the ocean; however, the results are of significant interest

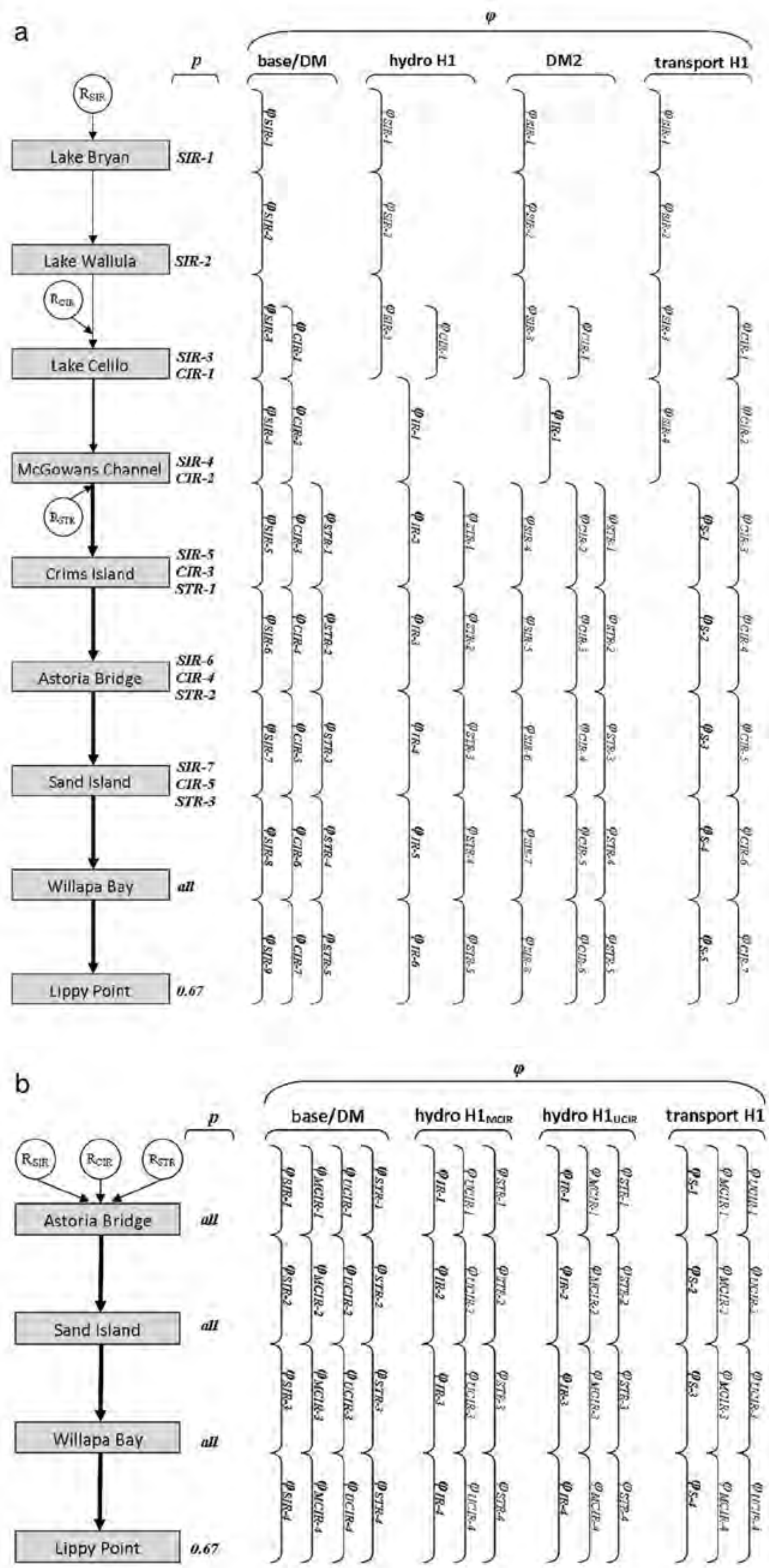

Fig. 5. *Oncorhynchus tshawytscha.* Schematic of study design and models used to estimate survival (φ) and detection probability (*p*), and to assess the strength of evidence for delayed-mortality in yearling smolts from the Snake and Columbia Rivers in (a) 2010 and (b) 2011. Thick arrows indicate seaward migration of all release groups (R). Parameters not in bold are identical to base/DM model parameters and are included to show the full model parameterization of alternative models. Abbreviations defined in Fig. 1

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because they provide the first data on the early marine survival of upper Columbia River yearling Chinook.

Model assumptions

Standard CJS model assumptions applied for all sub-arrays: (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. For coastal ocean sub-arrays that were unbounded on the offshore end, we required 3 additional assumptions: (5) fish departing the Columbia River swim north, (6) their migration is confined to the coastal zone spanned by the sub-arrays and (7) detection probability of the Lippy Point sub-array is equivalent to that of other coastal sub-arrays with similar geometry (Welch et al. 2011; see 'Materials and methods: Base model selection and survival estimation'). Assumptions (5) and (6) are supported by evidence from our prior studies (Rechisky et al. 2012, 2013), as well as ocean sampling programs that demonstrate that juvenile spring Chinook salmon remain almost entirely on the continental shelf as they migrate north (Miller et al. 1983, Fisher & Pearcy 1995, Bi et al. 2007, Trudel et al. 2009, Peterson et al. 2010). As well, the Cascade Head sub-array (Fig. 1), which was deployed in 2011 to further assess assumption (5), detected only 6 tagged smolts, 1 of which was later detected first on the Willapa Bay and then the Lippy Point sub-arrays (see Discussion). Assumption (7) can only be validated by the addition of another sub-array; however, we previously demonstrated that changes in the p of Lippy Point will not affect the relative survival of the various treatment types (Rechisky et al. 2012, 2013).

RESULTS

Stock identification

Of the 580 smolts released at Bonneville Dam in 2011, 55 fish were identified by GSI as fall-run yearling Chinook smolts (interior Columbia River summer/fall-run reporting group) and were excluded from the study. Although we hoped to tag primarily Snake and mid-Columbia River smolts at Bonneville Dam, many fish (386 of the remaining 525) were identified post-release by GSI as upper Columbia River spring Chinook. Only 59 smolts were identified as mid-Columbia spring Chinook, and 80 smolts were identified as Snake River spring/summer Chinook. Of the 200 smolts released at Lower Granite Dam, 170 were identified as spring or summer-run Snake River Chinook, using PBT, and the remaining 30 Chinook were assumed to be spring-run fish originating from the Snake River based on the fact that they were captured in the Snake River Basin and that no fall Chinook were identified using GSI. Most of these smolts (24 of 30) were identified by GSI as Snake River spring/summer Chinook, but we chose to use collection site as the stock determinant in the absence of PBT results to avoid introducing low level mis-assignment contributed by GSI.

Most hatchery smolts originating from the Snake River Basin were matched with their parents using PBT, and were thus identified to their specific hatchery (86% of the 197 Snake River hatchery fish at Lower Granite Dam, and 73% of the 78 Snake River hatchery fish at Bonneville Dam). Of these fish, approximately 40% of SIR and STR smolts originated from the Rapid River Hatchery (Fig. 6). South Fork

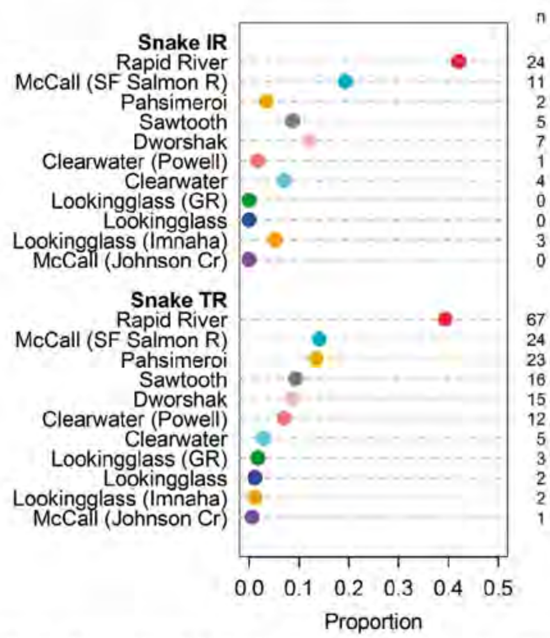

Fig. 6. *Oncorhynchus tshawytscha*. Hatchery allocation of acoustic-tagged Snake River spring/summer Chinook in 2011 determined by parentage-based tagging (PBT). Transported (TR) smolts were collected at Lower Granite Dam (170 of 200 smolts were identified with PBT). In-river (IR) smolts were collected at Bonneville Dam (57 of 80 smolts were identified with PBT). Hatcheries listed more than once indicate that the tributary or satellite facility in which the fish are reared (details given in parentheses) is different from the hatchery's location. SF: South Fork; GR: Grand Ronde. Other abbreviations as in Fig. 1

Salmon River smolts from McCall Hatchery made up an additional 21% of the SIR group and 14% of the STR group, and the remaining smolts originated from 9 other Snake River spring/summer Chinook populations. Sample sizes were too small to estimate survival for individual hatchery groups or for naturally spawning smolts (only 14 tagged smolts had an intact adipose fin and 9 of these were identified as hatchery fish using PBT).

Base model selection results and survival estimates

In 2010, there was more support for a base model where detection probability *p* varied for the treatment types at each sub-array in freshwater, but was similar across treatment types at Willapa Bay (*p* [type × site × FW + site × WIL]; $\Delta AIC_c \geq 2.5$ for competing models and $wAIC_c = 77\%$). In 2011, there was more support for a base model where *p* was similar for all treatment types at each sub-array up to and including Willapa Bay (*p* [site], $\Delta AIC_c \geq 9.9$ for competing models and $wAIC_c = 99\%$). Estimates of *p* are reported in Table S1 in the supplement.

Estimated survival in the lower river and estuary (from base/DM models) was high for all treatment groups in both years and ranged between 0.81 and 1.0 (Tables 2 & 3; see Table S2 in the supplement for the number of fish detected on each sub-array). Survival in the plume ranged between 0.46–0.79 in 2010 and only 0.14–0.30 in 2011. Coastal ocean survival beyond the plume ranged between 0.28–0.43 in 2010 and 0.14–0.39 in 2011.

Cumulative post-Bonneville Dam survival to northwestern Vancouver Island (Lippy Point) was similar for all 3 treatment types in 2010 (0.14–0.19; Fig. 7). In 2011, SIR, MCIR and UCIR treatment types had remarkably similar survival to Lippy Point (0.07–0.08), but the STR group was considerably lower, only 0.015.

Strength of evidence for transportation-induced delayed mortality

Model selection results indicated that in 2010 the base/DM model had slightly more support (lower AIC_c and higher $wAIC_c$) than the transport H1 model (Table 4). Thus, there were some differences in survival of STR and SIR smolts; however, the estimates indicate that survival in the plume was lower for STR smolts relative to SIR smolts, but survival in the coastal ocean beyond the plume was higher for STR smolts (Fig. 8). Lower river and estuary survival varied as well. As cumulative post-Bonneville survival to Lippy Point was slightly greater for STR smolts (Fig. 7), there was no support for transport-DM in 2010.

Model selection results for the 2011 data showed that the transport H1 model had slightly more support than the base/DM model (Table 4). Transported smolts experienced similar survival as the SIR smolts in the lower river and estuary but relatively lower survival in both the plume and coastal ocean (Fig. 8). Although the transport H1 model had the highest probability of fitting the data and did not support the transport-DM hypothesis, survival estimate confi-

Table 2. *Oncorhynchus tshawytscha*. Estimated survival, φ (± SE), of acoustic tagged, yearling Chinook salmon, 2010. Snake in-river (SIR) smolts were collected and released at Lower Granite Dam (LGR). Columbia in-river (CIR) smolts were collected at John Day Dam (JDA) and released 42 km upstream of JDA. Snake River transported (STR) smolts were collected at Lower Granite Dam and released 7 to 12 km below Bonneville Dam (BON, located upstream of McGowans Channel, MCG; see Fig. 1). REL: release site; LRE: lower Columbia River and estuary; NA: not applicable. Definitions of abbreviations for detection sites delineating migration segments are found in Fig. 1

Habitat	Migration segment (distance, km)	Treatment type SIR	CIR	STR
Hydrosystem	REL-LAC (355/42)	0.46 ± 0.04[a]	0.95 ± 0.03	NA
	LAC-MCG (116)	0.77 ± 0.07	0.77 ± 0.03	NA
LRE	MCG-CRI (137)	0.96 ± 0.06	1 ± 0	0.85 ± 0.04
	CRI-AST (64)	0.97 ± 0.05	0.90 ± 0.03	0.88 ± 0.05
	AST-SDI (15)	0.88 ± 0.07	0.89 ± 0.07	1 ± 0
Plume	SDI-WIL (48)	0.79 ± 0.13	0.46 ± 0.06	0.58 ± 0.07
Ocean	WIL-LIP (485)	0.28 ± 0.07	0.37 ± 0.06	0.43 ± 0.07

[a]Estimated as the product of all segments between release and LAC (see 'Materials and methods')

Table 3. *Oncorhynchus tshawytscha*. Estimated survival, φ (± SE), of acoustic tagged, yearling spring Chinook salmon, 2011. Snake in-river (SIR) smolts and mid- and upper Columbia in-river (MCIR, UCIR) smolts were collected and released at Bonneville Dam, and thus it was not possible to estimate hydrosystem survival. Snake River transported (STR) smolts were collected at Lower Granite Dam and released 7 to 12 km below Bonneville Dam. REL: release site; LRE: lower Columbia River and estuary. Definitions of abbreviations for detection sites delineating migration segments are found in Fig. 1

Habitat	Migration segm. (distance, km)	Treatment type SIR	MCIR	UCIR	STR
LRE	REL-AST (201)	0.83 ± 0.05	0.91 ± 0.04	0.81 ± 0.02	0.83 ± 0.03
LRE	AST-SDI (15)	1 ± 0	1 ± 0.08	0.98 ± 0.04	0.92 ± 0.06
Plume	SDI-WIL (48)	0.23 ± 0.07	0.22 ± 0.07	0.30 ± 0.04	0.14 ± 0.04
Ocean	WIL-LIP (485)	0.39 ± 0.18	0.39 ± 0.21	0.34 ± 0.07	0.14 ± 0.09

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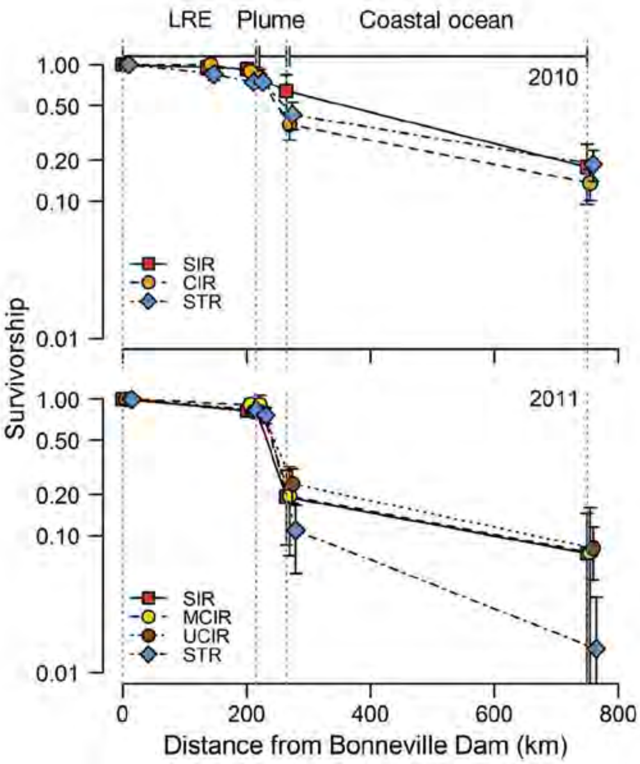

Fig. 7. *Oncorhynchus tshawytscha*. Post-Bonneville Dam survival of yearling smolts to north-western Vancouver Island. Kilometer 0 represents the location of the McGowans Channel sub-array and the release site for Snake transported (STR) smolts (which are both ~10 km below Bonneville Dam), and the Bonneville Dam juvenile monitoring facility where IR smolts were released in 2011. LRE: lower river and estuary; SIR: Snake in-river; CIR: Columbia in-river; MCIR: mid-Columbia in-river; UCIR: upper Columbia in-river. Data points were adjusted to prevent overlap of 95% confidence intervals (bars). Note that survivorship is plotted on a log scale to show differences in survival at low levels

dence intervals, particularly at Lippy Point, were very wide in this year. Taken together, the cumulative post-Bonneville survival to Lippy Point was considerably lower for STR smolts, providing some evidence that transport-DM may have occurred (Fig. 7; but see 'Discussion').

Strength of evidence for hydrosystem-induced delayed mortality

Model selection results indicated that the DM2 model had more support in 2010 and that there was very little support for the hydro H1 model (Table 5). Thus, differential survival occurred for SIR and CIR smolts; however, the survival estimates indicated that this result was driven by the abrupt decline of the CIR treatment group (not the SIR group) in the plume shortly after ocean entry (Fig. 9, Table 2).

In 2011, model selection results indicated that the hydro $H1_{MCIR}$ model assessing hydro-DM of SIR relative to MCIR had more support (Table 5). Thus, there was no support for hydro-DM in 2011. The hydro $H1_{UCIR}$ model assessing comparative survival of the SIR treatment type relative to UCIR treatment type also had more support. Thus, survival of all 3 in-river treatment types was similar in all of the migration segments (Fig. 9).

DISCUSSION

Hydrosystem-induced delayed mortality would have important implications for salmon management, as human-induced changes to freshwater

Table 4. *Oncorhynchus tshawytscha*. Model selection results investigating transportation-induced delayed mortality (transport-DM) for transported Snake River yearling Chinook salmon relative to in-river migrating Snake River Chinook salmon. Base/DM models: survival was estimated for each treatment type in each migration segment; transport H1 model: common survival parameters were estimated for both treatments in the lower Columbia River estuary and ocean (LREO); φ: survival probability; *p*: detection probability; type: treatment type; seg: migration segment; river: river upstream of Bonneville Dam; AIC_c: Akaike's Information Criteria with low sample size; ΔAIC_c: $AIC_c - AIC_{c\,min}$; $wAIC_c$: Akaike weight; *L*: model likelihood; K: number of parameters

Model Description	Model[a]	AIC_c	ΔAIC_c	$wAIC_c$	*L*	K	Deviance	Outcome
2010								
Base/DM	φ (type×seg) *p*	9685.0	0	0.74	1	37	257.1	No transport-DM; φ is
Transport H1	φ (type×seg×river + seg×LREO) *p*	9687.1	2.1	0.26	0.35	32	269.4	variable (see Table 2)
2011								
Transport H1	φ (seg) *p*	2523.4	0	0.72	1	15	31.6	Weak support for
Base/DM	φ (type×seg) *p*	2525.3	1.92	0.28	0.38	19	25.4	transport-DM

[a]In all models, *p* was estimated identically within each year (see 'Materials and methods: Base model selection and survival estimation')

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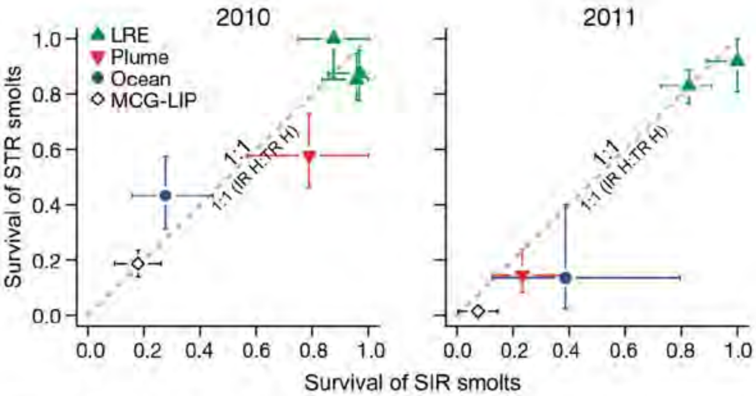

Fig. 8. *Oncorhynchus tshawytscha*. Comparative survival of in-river migrating Snake River yearling Chinook (SIR) with transported yearling Chinook (STR) in common migration segments. Lower river and estuary (LRE) survival was divided into 3 migration segments in 2010, and 2 segments in 2011. MCG-LIP is the cummulative survival estimate from McGousans Channel to Lippy Point. The dashed 1:1 line represents equal survival. Points falling below the line represent lower survival of STR smolts. The dashed line also represents the mean ratio of smolt-to-adult return rates (SAR) of in-river migrating Snake River hatchery yearling Chinook (IR H) to the SAR of transported Snake River hatchery yearling Chinook (TR H), reported as 'D' in Comparative Survival Study reports (Tuomikoski et al. 2012). Only 3 to 5% of acoustic tagged Snake River fish were wild; thus we did not plot the IR W:TR W ratio for comparison

habitat may affect fitness during the estuarine and marine phases of the life history. Although a significant amount of post-Bonneville Dam mortality occurred by the time Chinook smolts reached northwest Vancouver Island, and there was little to no support for delayed mortality of Snake River Chinook due to migration through the Snake River dams.

If delayed mortality due to hydrosystem-induced stress is expressed in the estuary or within the first month of life in the coastal ocean, we would expect to see reduced post-hydrosystem survival of the Snake in-river migration group relative to the mid-Columbia in-river migration group. Despite tracking smolts as far as northern Vancouver Island, 750 km beyond the last dam and for approximately 1 mo after ocean entry, we did not observe lower survival of SIR smolts. Consistent with several studies (Schreck et al. 2006, Clemens et al. 2009, McMichael et al. 2010, Harnish et al. 2012, Rechisky et al. 2012, 2013), survival in the lower river and estuary was high, and although subsequent marine survival was low, smolts originating from the Snake River apparently did not suffer deleterious effects (i.e. extra mortality) from additional dam passage. Thus, our results do not support the hypothesis that hydrosystem-induced stress leads to reduced fitness and reduced survival of Snake River spring Chinook salmon pop-

Table 5. *Oncorhynchus tshawytscha*. Model selection results investigating differential mortality for in-river migrating Snake River yearling Chinook salmon (SIR) relative to in-river migrating yearling Chinook from the Columbia River (CIR) in 2010, and hydrosystem-induced delayed mortality (hydro-DM) for SIR salmon relative to mid-Columbia River (MCIR) and upper Columbia River (UCIR) yearling Chinook salmon in 2011. DM2 model: survival parameters were estimated for each treatment type in all common migration segments; base/DM models: survival parameters were estimated for each treatment type in the lower Columbia River, estuary and coastal ocean (LREO); hydro H1 model: common survival parameters were estimated for both treatments in the LREO; φ: survival probability; *p*: detection probability; type: treatment type; seg: migration segment; rel-LAC: release to Lake Celilo; LAC-MCG: Lake Celilo to McGowans Channel; river: river upstream of Bonneville Dam. Definitions of abbreviations for model selection are found in Table 4

Model Description	Model[a]	AIC_c	ΔAIC_c	$wAIC_c$	*L*	K	Deviance	Outcome
2010–SIR/CIR								
DM2	φ (type×seg×rel-LAC + seg×LAC-MCG + type×seg×LREO) *p*	9683.0	0	0.68	1	36	257.1	$\varphi_{SIR}>\varphi_{CIR}$ in the plume
Base/DM	φ (type×seg) *p*	9685.0	2.0	0.25	0.36	37	257.1	
Hydro H1	φ (type×seg×river + seg×LREO) *p*	9687.5	4.5	0.07	0.11	32	269.7	
2011–SIR/MCIR								
Hydro H1	φ (seg) *p*	2518.9	0	0.96	1	15	27.1	No hydro-DM
Base/DM	φ (type×seg) *p*	2525.3	6.4	0.04	0.04	19	25.4	
2011–SIR/UCIR								
Hydro H1	φ (seg) *p*	2518.2	0	0.97	1	15	26.4	No hydro-DM
Base/DM	φ (type×seg) *p*	2525.3	7.1	0.03	0.03	19	25.4	

[a]In all models, *p* was estimated identically within each year (see 'Materials and methods: Base model selection and survival estimation')

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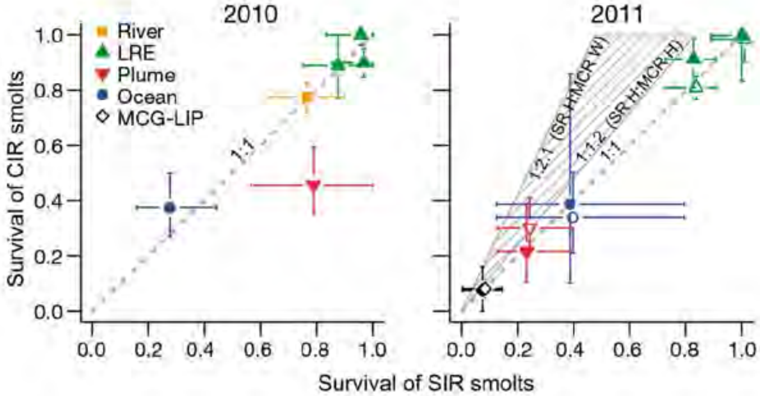

Fig. 9. *Oncorhynchus tshawytscha*. Comparative survival of in-river migrating Snake River yearling Chinook (SIR) with Columbia River yearling Chinook (CIR) in common migration segments. Lower river and estuary (LRE) survival was divided into 3 migration segments in 2010, and 2 segments in 2011. 'River' is the migration segment between LAC and MCG (see Fig. 1 for abbreviation definitions). CIR smolts were identified as mid- (closed symbols) and upper (open symbols) Columbia River origin in 2011. The dashed 1:1 line represents equal survival. Points above the line indicate lower survival of SIR smolts. The shaded area is bounded by lines representing the ratio of the mean smolt-to-adult return rate (SAR) of Snake River hatchery yearling Chinook (SR H) to (1) mid-Columbia River wild yearling Chinook (MCR W), and (2) mid-Columbia River hatchery yearling Chinook (MCR H). (Only 1 to 2% of acoustic tagged Snake River smolts were wild, while 18% of mid-Columbia smolts were wild in 2011.) SR H and MCR H SAR estimates were derived from Comparative Survival Study reports (Tuomikoski et al. 2012), NOAA reports (Faulkner et al. 2012) and Rechisky et al. (2013) and exclude juvenile and adult hydrosystem mortality, i.e. SARs are from Bonneville Dam to return to Bonneville Dam. MCR W SAR only excludes adult hydrosystem mortality; therefore the SR H:MCR W ratio is underestimated. If all delayed mortality of acoustic tagged SIR smolts relative to mid-Columbia IR smolts (in 2011) occurred in the LRE and early marine period, then the expected survival outcomes would lie within this shaded region. 2011 points are jittered to show error bars

ulations in the estuary or early marine period. These results are consistent with our 2006–2009 study, where we found no support for hydrosystem-induced delayed mortality when comparing survival of smolts of similar size and ocean-entry timing from single-source populations of Snake and mid-Columbia River hatchery origin spring Chinook salmon (Rechisky et al. 2009, 2013).

In addition to testing the hydro-DM hypothesis, we were also able to compare survival of in-river migrating Snake River yearling Chinook to (1) yearling Chinook collected at John Day Dam whose origin was unknown in 2010 and (2) endangered upper Columbia River yearling Chinook in 2011. Survival of the SIR group was comparable to the CIR group in 2010 and the UCIR group in 2011, demonstrating that estuarine and early marine survival was similar for all tagged yearling Chinook irrespective of origin. The comparison between upper Columbia and Snake River-origin Chinook smolts reflects the relative survival of smolts exposed to the 4 federal dams in the Snake River with that of smolts exposed to 3 to 5 public utility district dams in the upper Columbia River. Both groups also migrate through the 4 lower Columbia River dams before reaching the estuary. Because the apparent survival estimates were equivalent between these treatment groups, our study does not indicate that migration through hydro dams in one system is better (or worse) than the other.

We also did not observe strong support for transportation-induced delayed mortality of STR smolts relative to SIR smolts. The lack of an overall effect of transport-DM was not surprising, however, because our sample of smolts from the bypass facilities was comprised primarily of hatchery smolts, and most hatchery populations from the Snake River do not experience decreased transport SARs to the degree that is observed in wild smolts (Tuomikoski et al. 2012). Our results do show that survival of the SIR and STR groups in the lower river and estuary was comparable in both years, and that survival in the plume and coastal ocean fluctuated despite similar body size and release dates. In 2010, STR smolts had lower survival in the plume and higher survival in the coastal ocean relative to SIR smolts, and model selection results and cumulative survival to Lippy Point indicated that transport-DM did not occur. In 2011, survival of the STR group in the plume was somewhat reduced, and survival in the coastal ocean was further reduced relative to the SIR group, but despite reduced survival in these 2 individual migration segments, model selection results did not provide support for transport-DM. Reductions in survival of the STR group in the individual segments in 2011 resulted in a large cumulative survival difference to Lippy Point; however, the error around the 2011 parameter estimates to Lippy Point was large due to reduced sample size at this distant location, particularly for the SIR group (Fig. 7), and thus transport-DM may have occurred. Ideally, the sample size of the SIR group would have been larger in 2011 (only 80 of 580 smolts released below Bonneville Dam were from the Snake River), but because we did not know the genetic origin at

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the time of tagging, we could not control the sample size of the in-river treatment groups.

In our previous study comparing estuarine and early marine survival of spring Chinook smolts from a Snake River hatchery, we found no evidence for transportation-induced delayed mortality (Rechisky et al. 2012). The expected effect (that transported smolts would show reduced survival post-release relative to non-transported smolts) did not occur in the month following ocean entry. In both the present study and our earlier study (Rechisky et al. 2012), fluctuations in plume survival were substantially larger than those occurring in freshwater or in the coastal ocean beyond the plume. Brosnan et al. (2014, this volume) demonstrated that plume survival was primarily related to smolt residence time in the plume, but they also showed that the greater variability in plume survival of groups of transported smolts was likely related to the shorter time period (~1 d) that transported smolts entered the plume relative to smolts migrating in-river. Those authors speculated that the compressed entry period may make the survival of transported smolts more variable because there was less opportunity to average out stochastic events affecting survival, such as whether smolts encountered aggregations of predators while migrating through the plume.

It is worth noting that 6.6 and 2.9% of the PIT tags we implanted in 2010 and 2011, respectively, were recovered in bird colonies. Most were found at East Sand Island near the mouth of the Columbia River (81% in 2010 and 100% in 2011). This PIT tag recovery rate is consistent with minimum Chinook predation rates estimated for Caspian terns *Hydroprogne caspia* (formerly *Sterna caspia*) and double-crested cormorants *Phalacrocorax auritus* on East Sand Island (Evans et al. 2012). Given that the tag deposition rate on the island is unknown, that survival upstream of Sand Island was high, and that East Sand Island is in close proximity to the ocean, it is possible that avian predation was responsible for a moderate proportion of the mortality in the plume migration segment.

Several factors should be considered when interpreting our data. First, we assumed that exposure to either dams or transport operations was the primary difference between the treatment groups and the controls. Therefore, Columbia and Snake River populations, which are genetically distinct, could vary in how they respond to the conditions experienced during migration (e.g. temperature, predators, dam bypass). Additionally, there were some differences between our treatment groups in release timing and subsequent ocean entry timing, tagging location and smolt size.

In 2010, we were able to control for tagging location and body size of the SIR and STR groups because they were tagged concurrently at Lower Granite Dam; however, CIR smolts were tagged downstream at John Day Dam and were significantly longer than both the SIR and STR groups at the time of tagging (20 mm on average; Table 1). Additionally, the timing of the CIR releases was chosen to meet the objectives of a separate study, and as a consequence, the CIR smolts reached the ocean about 1 wk before the STR group and 2 wk before the SIR smolts. Estimates of plume survival for the 3 groups were positively correlated with median arrival date at Willapa Bay ($R^2 = 0.998$). Given that the survival of the larger CIR smolts was worse in the plume than their smaller SIR counterparts, timing of ocean entry may have been more important for survival than increased body size.

The result that increased body size conferred little to no survival benefit is consistent with our previous findings where we incorporated FL in our Chinook survival models and found either little support for an effect, or variable and contradictory effects (Rechisky & Welch 2010, Porter et al. 2012). It is possible that size-selective mortality occurs in smolts smaller than 130 mm FL (Claiborne et al. 2011); however, ocean entry timing may be a more important factor influencing marine survival (e.g. Muir et al. 2006, Scheuerell et al. 2009)

In 2011, we tagged the SIR, MCIR and UCIR groups concurrently at Bonneville Dam, and therefore ocean-entry timing for in-river groups was similar; however, out of necessity, the STR fish were tagged at Lower Granite Dam. This was the first year (since 2006) that the SIR and STR fish were collected at different locations; this was also the first year that we saw some support for transport-DM. Although the SIR smolts were significantly larger than the other treatment groups, the difference was only ≤5 mm on average. As well, ocean-entry dates coincided (median arrival date at Astoria Bridge with 25th to 75th percentile range: SIR = 25 May 2011 [11–30 May]; STR = 24 May 2011 [10–26 May]). Therefore, we are more concerned that tagging location may have contributed to the differential survival of STR and SIR groups in the plume and coastal ocean in 2011. Although the juvenile bypasses at these sites do not appear to have differential effects on smolt survival (Buchanan et al. 2011), there was a higher occurrence of pre- and post-tagging mortality at Lower Granite Dam in 2011. Of the 275 fish we collected, 1% died prior to sedation, 1% died during sedation, and 3% died after tagging and before release. In contrast, at Bonneville Dam only 1 smolt out of 1049 collected (0.1%) died after tagging and before release (excluding fish that died from gas bubble trauma prior to release in late May). As stock composition was similar for the SIR and STR groups, and we have never found a measurable tagger effect on survival in our previous studies (Porter et al. 2012), the survival difference may be confounded by capture location.

Lastly, although we collected and tagged yearling Chinook salmon smolts migrating out of the Columbia River Basin over much of the migration season during the 2010–2011 study period (Fig. 4), we did not fully represent the size range of the general population (Fig. 3). The 7 mm transmitter allowed us to tag a substantial part of the size distribution of hatchery and wild smolts at John Day Dam and Bonneville Dam, but wild smolts at Lower Granite Dam were smaller than the minimum size threshold (130 mm FL) we imposed in order to prevent tag burdens from becoming excessive.

One assumption of our work is that equal proportions of each group of smolts swim north after ocean entry and remain on the continental shelf until they are out of our study area. Trudel et al. (2009) compiled more than a decade of juvenile Chinook salmon catch data from multiple at-sea sampling programs ranging from northern California to the Aleutian Islands of Alaska, and established that nearly all (>98%) mid- and upper Columbia River and Snake River yearling Chinook migrate north and Fisher et al. (2014) found that they do so rapidly. Our telemetry data support this finding. In 2011, we deployed a sub-array at Cascade Head, OR, 130 km south of the Columbia River mouth to test the assumption that Columbia River Spring Chinook smolts migrate north. Six smolts were detected on the southern sub-array compared to 93 which were detected on the northern (Willapa Bay) sub-array. One of the 6 tagged smolts was detected at Cascade Head for 1 wk (30 May to 6 June) and was subsequently detected at Willapa Bay (18 June) and then farther north at Lippy Point (3 July; see visualization at http://vimeo.com/47340003). In our previous study (Rechisky et al. 2012), 2 smolts were detected on the Cascade Head sub-array in 2009, while 136 smolts were detected on the Willapa Bay sub-array. Thus, a very small proportion of smolts may initially migrate south (3.4% of fish detected in the ocean in our studies), and we have some evidence that although southward migration may initially occur, smolts do have the capacity to reverse direction and ultimately head north. The 7 smolts that were never detected again either continued to migrate south, or were eaten by a predator before they reached the Willapa Bay sub-array to the north, or migrated around or through the Willapa Bay sub-array undetected. Given the low survival estimates in the plume and coastal ocean, it seems plausible that the 7 initially southern migrating smolts not subsequently detected to the north may have been consumed by predators before reaching the northern arrays.

Second, some smolts may have migrated around the Willapa Bay sub-array, as several smolts were detected on the outer edge of the sub-array (Fig. S2 in the Supplement). Ocean conditions are highly dynamic along the Washington coast near the mouth of the Columbia River (Hickey et al. 2005). This may explain why smolts are widely distributed across the shelf at Willapa Bay. However, because smolts appeared to be confined to the shelf farther north at Lippy Point (Fig. S3 in the Supplement), our survival models should account for any undetected or off-shelf migrant smolts at Willapa Bay and thus the survival estimates would not be affected.

If these limitations differentially affect survival, the net effect would have to be large enough to mask an up to 2-fold difference in apparent survival to Lippy Point for SIR smolts relative to the MCIR smolts (Fig. 9), assuming that all delayed mortality caused by prior hydrosystem experience is expressed by the end of the first month at sea. As we found no support for hydro-DM within the co-migration corridor, we conclude that the observed survival difference seen in the adult return rates likely develops in the ocean farther north or that delayed mortality is greatly delayed.

Numerous studies are beginning to shed light on the ocean distribution and migration behaviour of Chinook salmon in the North Pacific Ocean (e.g. Fisher et al. 2007, Trudel et al. 2009, Peterson et al. 2010, Weitkamp 2010, Tucker et al. 2011, Larson et al. 2013), and some specific ocean distribution information is now available for the genetically distinct population groupings identified in this study. Mid-Columbia, upper Columbia and Snake River yearling Chinook migrate quickly into coastal waters of British Columbia and Southeast Alaska during summer, but are rare in the fall, indicating that they migrate through those areas before leaving the shelf (Trudel et al. 2009, Tucker et al. 2011). Since we did not detect acoustic tagged smolts from the mid and upper Columbia River populations on our sub-array in southeast Alaska in 2010 (the Alaska sub-array was not deployed in 2011), and we did not detect Yakima River hatchery smolts (also from the mid-Columbia River) on that sub-array in our previous study (Rechisky et al. 2013), it is possible that mid-Columbia populations may leave the shelf at a different time or location and have different subsequent ocean distributions which may result in consistently different adult return rates. Larson et al. (2013) reported that immature Chinook salmon from the coastal US (WA, OR, CA) are found on the eastern Bering Sea shelf during summer and fall. Although fine-scale stock resolution was not reported, it is plausible that specific populations of Columbia River Basin Chinook may enter the Bering Sea, and that there may be a common ocean process influencing fitness in that region.

Our results demonstrate that mortality processes affecting Snake River Chinook salmon fitness may occur later in the marine life history, which supports the idea that the critical period may not be only limited to high predation rates soon after ocean entry (Beamish & Mahnken 2001). It remains unclear whether smaller, wild Snake River smolts have survival comparable to the smolts reported here, although there is evidence that hatchery and wild smolts respond similarly to ocean conditions (Daly et al. 2012) and have similar ocean distributions (Tucker et al. 2011). Recent advances in transmitter miniaturization mean that it is now feasible to repeat these experimental tests using wild smolts, which would address perhaps the greatest remaining uncertainty concerning the potential role of dam-induced and transport-induced mortality on fitness.

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Estuarine and early-marine survival of transported and in-river migrant Snake River spring Chinook salmon smolts

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Many juvenile Snake River Chinook salmon are transported downriver to avoid hydroelectric dams in the Columbia River basin. As mortality to the final dam is ~50%, transported fish should return as adults at roughly double the rate of nontransported fish; however, the benefit of transportation has not been realized consistently. "Delayed" mortality caused by transportation-induced stress is one hypothesis to explain reduced returns of transported fish. Differential timing of ocean entry is another. We used a large-scale acoustic telemetry array to test whether survival of transported juvenile spring Chinook is reduced relative to in-river migrant control groups after synchronizing ocean entry timing. During the initial 750 km, 1 month long migration after release, we found no evidence of decreased estuarine or ocean survival of transported groups; therefore, decreased survival to adulthood for transported Chinook is likely caused by factors other than delayed effects of transportation, such as earlier ocean entry.

Spring Chinook salmon, *Oncorhynchus tshawytscha*, declined dramatically in the Columbia River, USA, over the last century, initially due to over-harvesting[1,2] and, in later years, due to the impacts of hydroelectric dams[3–5]. Concurrent with the completion of the last four major dams within the Federal Columbia River Hydropower System (FCRPS or "hydrosystem"; Fig. 1) in the lower Snake River (a tributary of the Columbia River) in 1975, an unfavourable change in ocean climate also contributed to reduced survival of many salmon stocks in southern parts of their range, including spring Chinook salmon in Washington, Oregon, and California[6,7]. In 1992, following a precipitous decline in adult returns from the ocean, Snake River spring Chinook salmon were listed as threatened under the U.S. Endangered Species Act.

Since that time, billions of dollars have been spent on programs to reverse population decline and improve smolt (seaward migrating juvenile salmon) survival through dams and turbines, in tributary habitats and in the Columbia River estuary[8]. Direct mortality at the dams has been successfully reduced[9–11], and survival of Snake River spring Chinook smolts that migrate through the eight-dam, 460 km hydrosystem (a series of four dams in the lower Snake River, and four in the lower Columbia River) is now typically >50%[12], higher than Chinook populations that migrate a similar distance in the adjacent undammed Fraser River[13].

As another measure to mitigate juvenile salmon losses at the Snake River dams, transportation experiments were initiated in 1965, with migrating salmon smolts collected at dams and transported via truck to a location downstream of Bonneville Dam (the final dam that smolts must pass during their seaward migration). Initial adult return rates of transported spring Chinook smolts relative to smolts that migrated in the river were promising, and the amount of straying observed in returning adults was low, and so transportation was continued as a management strategy intended to rebuild salmon populations[14–18]. This program is still running today[17,19], although juvenile salmon are now transported in large, purpose-built barges[14,18].

Survival in the transportation barge during the ~36 hour trip from Lower Granite Dam (LGR) to below Bonneville Dam is currently near 100%[20], while survival of in-river migrants is approximately 50%[12]. For this reason, if there is no difference in survival in subsequent life stages, survival to adult return of transported fish should be approximately double that of in-river migrants[21,22]. Transported smolts do not, however, return at double the rate of the in-river migrant smolts that pass through the eight dams, and in some years transported smolts returned at lower rates than in-river migrants, indicating that the transportation program may have reduced adult return rates of spring Chinook[1,19].

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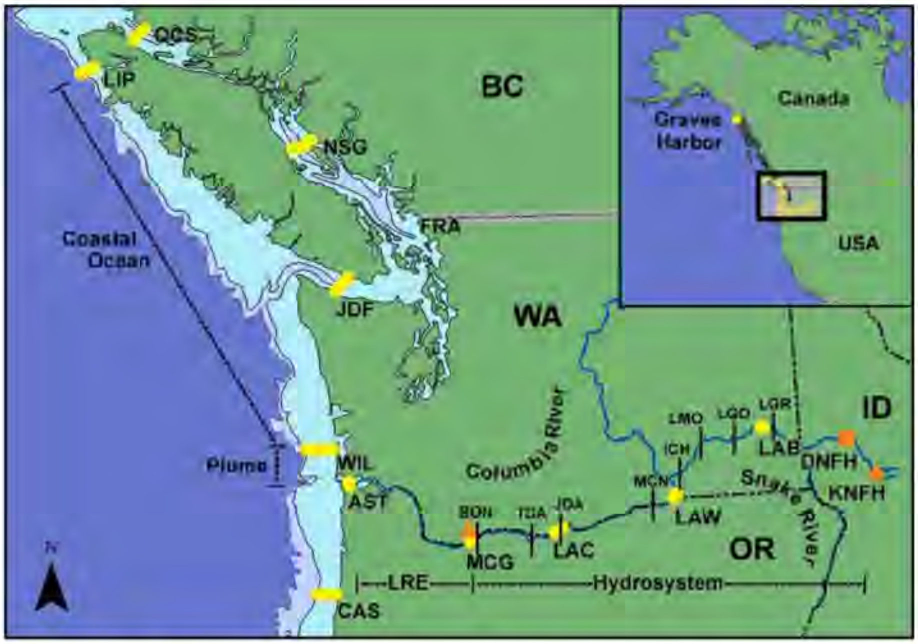

Figure 1 | Study area with acoustic tracking array (yellow dots and lines) and habitat designations (LRE=lower Columbia River and estuary). Spring Chinook smolts obtained at Dworshak National Fish Hatchery (DNFH; orange square) were either released at Kooskia NFH (KNFH) as in-river migrants, or transported and released into McGowans Channel (MCG), located just below Bonneville Dam (release sites are represented by orange triangles). Sub-arrays were deployed in Lake Bryan (LAB), Lake Wallula (LAW), Lake Celilo (LAC), MCG, Astoria (AST), Willapa Bay, WA (WIL), Lippy Point, BC (LIP), and Cascade Head, OR (CAS) and Graves Harbor, AK. No smolts were detected on POST sub-arrays in Juan de Fuca Strait (JDF), Northern Strait of Georgia (NSG), Queen Charlotte Strait (QCS), or on Fraser River (FRA) sub-arrays. The AST sub-array was not installed in 2006 and CAS was only deployed in 2009. Snake and Columbia River dams are indicated with vertical lines (LGR=Lower Granite, LGO=Little Goose, LMO=Lower Monumental, ICH=Ice Harbor, TDA=The Dalles, MCN=McNary, JDA=John Day, BON=Bonneville). Isobaths show the continental shelf edge at 200 m depth (offshore limit of the array during the study) and the 500 m depth interval.

Two metrics are typically used to evaluate the effectiveness of the transportation program: the "transport to in-river migrant ratio" (abbreviated in various ways, including "T/I" or "T:M"; we use T/I henceforth), and the "post-hydrosystem survival ratio" ("D"). Both ratios are currently estimated using fish that are tagged as juveniles with passive integrated transponder (PIT) tags, which are detected at selected dams when tagged fish return as adults. The T/I ratio is based on the proportion of tagged fish leaving LGR as juveniles that eventually return to be detected as adults at LGR after their ocean migration (smolt-to-adult return rate, or SAR). Thus, T/I is the ratio of the (LGR-to-LGR) SAR of transported fish ("T") to that of in-river migrants ("I"). When T/I >1, transportation provided a net benefit by producing higher return rates than leaving smolts to migrate downstream through the eight-dam hydrosystem. D is usually estimated as the component of the T/I ratio that represents relative estimated post-hydrosystem survival of transported and in-river migrant fish; however, D can be conceptualized as the ratio of return rates for transported and in-river fish, using Bonneville Dam (BON) as the starting point for smolts instead of LGR (BON-to-LGR SAR). When D<1, transported fish suffered more mortality after passing Bonneville Dam than their in-river counterparts. Thus, T/I includes survival downstream through the hydrosystem, during ocean migration, and during adult upstream migration through the hydrosystem, whereas D excludes mortality incurred by in-river smolts while migrating downstream. In principle, D is influenced by mortality that is caused by the transportation process but not expressed until after fish are released from the barge (i.e., "delayed" differential mortality), as well as by direct sources of mortality in the estuary and ocean that are not associated with delayed effects of transportation but have differential effect on transported and in-river migrant fish (see below).

Since the mid-1990s, transported spring Chinook smolts have had marginally better return rates than in-river migrants. The geometric mean $\widehat{T/I}$ for PIT-tagged wild Snake River spring Chinook was 1.19 (90% CI=0.89-1.58) for release years 1994 through 2009, indicating only a small benefit from transportation on average, while the geometric mean of $\hat{D}$ for these years was 0.61 (90% CI=0.49–0.75)[23], indicating that post-Bonneville Dam (or post-hydrosystem) survival of transported smolts was significantly lower than the in-river migrant smolts. Estimates of *T/I* and *D* were slightly higher for Dworshak National Fish Hatchery (NFH) spring Chinook (the population used in this study), but followed the same pattern. From 1997 to 2009, the geometric mean $\widehat{T/I}$ was 1.36 (90% CI=1.00–1.85), and the geometric mean of $\hat{D}$ was 0.75 (90% CI=0.60–0.94)[23], indicating that transported hatchery smolts also generally returned at a higher rate; however, when compared from Bonneville Dam to adult return, overall mortality was higher for transported smolts.

Vast resources have been allocated to investigate potential causes of differential post-hydrosystem mortality of transported and in-river migrating Chinook salmon smolts. Recent studies suggest that transportation-induced stress may lead to delayed mortality of transported smolts. These stressors include: i) physiological or behavioural stress associated with collection at juvenile fish bypass facilities through which transported fish must pass prior to entering the barge[22]; ii) stress associated with co-transportation with steelhead salmon, *O. mykiss*[24]; or iii) increased disease transmission in the transportation barge[25]. Transported smolts may also have reduced survival compared to in-river migrants as a result of direct rather than delayed effects of transportation. Muir et al.[26] hypothesized that smaller body size of transported smolts when released from the barges compared to smolts that migrated and fed for several weeks

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in the river may have lead to reduce survival. Confounded with this, earlier ocean entry of transported smolts may expose them to less favourable ocean conditions[26]. Upon adult return, impaired adult homing abilities for those that had been transported as smolts can lead to more straying into other river tributaries (leading to lower SAR) than for smolts that imprinted during in-river seaward migration[27].

Other studies failed to find a mechanism which may cause differential delayed mortality, variously reporting that transporting spring Chinook salmon smolts with increasing densities of juvenile steelhead did not result in lower smolt to adult return rates[28]; that transported smolts may be less susceptible to pathogens[29]; that susceptibility to pathogen transmission in the barge may be specifically related to the hatchery of origin[30]; and that transportation had little or no effects on auditory and olfactory systems of smolts[31].

Anderson et al.[32] provide a recent review of differential mortality studies in the Snake River Basin. Although there is no consensus on how differential mortality of transported spring Chinook salmon occurs, timing of transport is hypothesized to affect D[26] and the T/I ratio[33], with values for both being lowest early in the season. As a result, managers have delayed the start of the transportation program by several weeks in recent years[23].

If the early marine period is important for survival[34], then we would expect differential survival due to transportation to be manifested soon after ocean entry. It is therefore preferable to measure survival directly in the estuary and during the earliest period of the marine phase. This approach also allows us to avoid the potentially confounding effects of events occurring later in the marine life history. Additionally, by controlling for ocean-entry timing we are able to separate this direct effect on survival from the delayed effects of transportation.

The development of acoustic tags small enough to surgically implant into salmon smolts, and continental-scale telemetry arrays with which to track them, provides a technique for directly estimating freshwater and early marine survival after smolts migrate beyond the hydrosystem[13,35–37] and into the ocean[36,38–40]. Conceptually similar to the PIT tag system (a short range radio-frequency identification (RFID)-based system that can work at dams)[41], acoustic telemetry arrays can aid in determining when differential mortality occurs beyond the dams. Acoustic tags have three major advantages over PIT tags: 1) tag detections are not physically restricted to dams; 2) it is unnecessary to wait 2–3 years for the adult return of a cohort before making comparisons of the survival of transported and in-river groups; and 3) much smaller sample sizes can be used to achieve similar statistical precision because of the greater detection probability of acoustic tags. Although PIT tag studies have been essential for estimating SARs of transported and in-river migrating spring Chinook salmon, the marine survival of juvenile, immature, and maturing salmon over a 2–3 year period is confounded because SARs are estimated only upon adult return. The use of acoustic tags allows survival to be directly estimated during seaward migration in the lower river, estuary, and early marine life phase where transport-related effects on survival are most likely to be expressed.

Using a large-scale acoustic telemetry array, we tracked the movements of size-matched groups of acoustic tagged, one-year-old Chinook salmon smolts reared at Dworshak NFH (see Methods). Smolts were released directly into the river (IR) or transported (TR) by truck from the hatchery to the barges at LGR and then by barge 650 km to a release point approximately 10 km downstream of Bonneville Dam in 2006 ($n_{IR}=380$, $n_{TR}=203$), 2008 ($n_{IR}=395$, $n_{TR}=199$), and 2009 ($n_{IR}=389$, $n_{TR}=392$; Table 1). We then used the telemetry data to estimate and compare post-hydrosystem survival. In conventional transport operations, smolts are collected from dams in the Snake River and immediately barged downstream; therefore, transported smolts typically enter the ocean about three weeks earlier than their counterparts migrating in-river. For our experiment, we held transported groups at the hatchery until the in-river migrant groups were projected to arrive below Bonneville Dam, and timed their transport so release from the barge would roughly match the arrival of the in-river migrants at the release point below Bonneville Dam (McGowans Channel). This coordinated the migration timing of smolts from both treatment groups so that they experienced similar ocean conditions, and reduced the confounding of potential transportation effects such as stress[24], reduced growth opportunity[26], or increased disease transmission[25], with temporal variation in ocean survival[42,43]. We then calculated post-hydrosystem transport to in-river survival ratios in the three sequential post-hydrosystem habitats through which smolts co-migrate (lower Columbia River estuary, plume, and coastal ocean). We hypothesized that transported smolt survival is the same as in-river migrant survival in the co-migration pathway downstream of Bonneville Dam after controlling for body size and time of ocean entry; the alternative hypothesis is that survival of transported smolts is lower than in-river migrant survival. The results presented here report the first direct test of the hypothesized effect of transportation on subsequent survival of transported spring Chinook salmon smolts relative to in-river migrating smolts in the estuary and coastal ocean.

Table 1 | Summary of Dworshak NFH spring Chinook salmon smolts that were implanted with an acoustic tag and a passive integrated transponder (PIT) tag. All fish were transferred and tagged at Kooskia NFH. In 2006, fish were tagged with V9-6L acoustic transmitters. In 2008 and 2009, smolts were tagged with V7-2L acoustic transmitters. In-river (IR) migrating groups were released at Kooskia NFH; transported (TR) fish were released below Bonneville Dam. FL= fork length, g=grams

Year	Release Group	Release Date	# Tagged	Mean length at tagging (mm FL; range)	Mean mass at tagging (g; range)	Tag burden (% mass)
2006	IR 1	1-May	190	146.9 (140–208)	35.2 (26.9–117.5)	9.2 (2.6–11.5)
	IR 2	8-May	190	145.6 (140–192)	34.0 (27.4–83.7)	9.4 (3.7–11.3)
	TR 1	6-Jun	102	154.5 (141–168)	42.5 (30.8–55.3)	7.4 (5.6–10.1)
	TR 2	14-Jun	101	154.6 (140–168)	41.9 (28.5–55.5)	7.5 (5.6–10.9)
2008	IR 1	25-Apr	197	146.2 (130–159)	37.5 (23.3–55.5)	4.4 (2.9–6.9)
	IR 2	2-May	198	146.3 (131–159)	37.3 (23.9–52.7)	4.5 (3.0–6.7)
	TR 1	17-May	100	149.4 (135–159)	39.9 (26.5–52.3)	4.1 (3.1–6.0)
	TR 2	23-May	99	148.3 (131–158)	39.3 (26.2–51.8)	4.2 (3.1–6.1)
2009	IR 1	4-May	195	142.3 (130–162)	33.1 (21.9–54.7)	5.0 (2.9–7.3)
	IR 2	11-May	194	142.4 (130–164)	33.6 (23.7–54.1)	4.9 (3.0–6.8)
	TR 1	27-May	191	142.5 (130–164)	34.2 (22.3–59.1)	5.0 (2.5–7.7)
	TR 2	3-Jun	201	142.7 (130–164)	32.4 (22.4–54.8)	4.9 (2.7–7.2)

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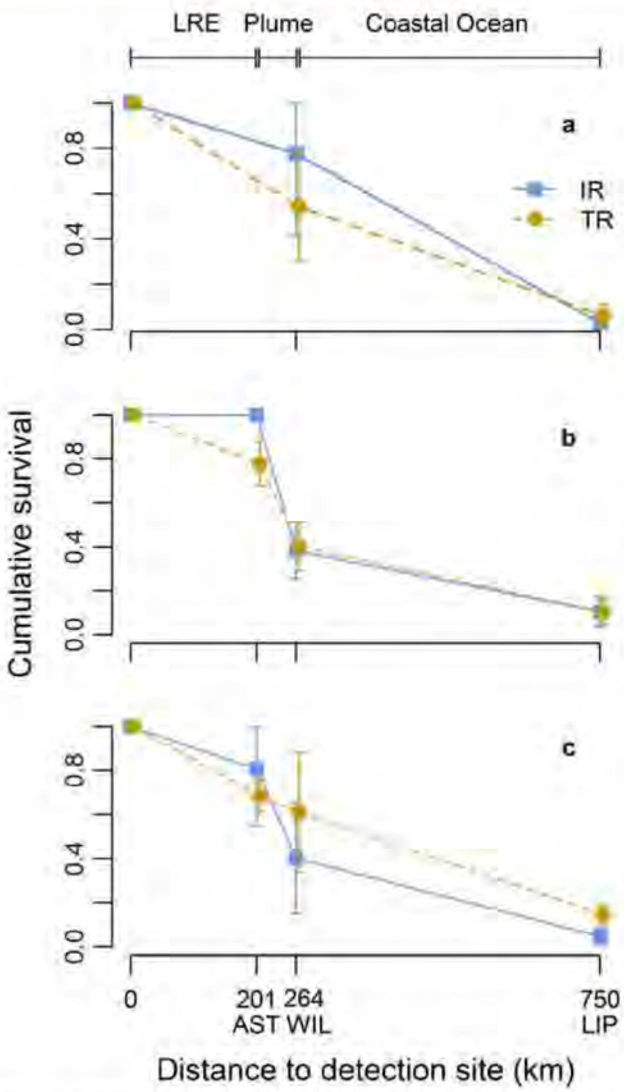

Figure 2 | Post-hydrosystem cumulative survival of z-test results (IR) and transported (TR) Dworshak hatchery spring Chinook salmon smolts to Astoria (AST), Willapa Bay, (WIL), and Lippy Point, (LIP; error bars show 95% confidence intervals) in 2006 (a), 2008 (b), and 2009 (c). Kilometre 0 is the location of the McGowans Channel sub-array downstream of Bonneville Dam where IR smolts were detected, and where TR smolts were released from the barge. The Astoria sub-array was not installed in 2006. Data points were adjusted to prevent overlap of confidence intervals.

Results

Estimated survival from Bonneville Dam to the northwestern end of Vancouver Island ranged between 0.03–0.14 for both treatment types during our three year study (Fig. 2; Table 2), with highest survival in the lower Columbia River and estuary (LRE) in 2008 and 2009 (0.69–1.0), and in the LRE and plume combined in 2006 (0.54–0.78; Fig. 3, Table 3). In all years, survival was lowest in the coastal ocean between Willapa Bay, WA, and Lippy Point, BC (0.04–0.29; Fig. 3; Table 3). Estimated survival in the plume was intermediate despite the short migration distance (0.40–0.51), except in 2009, when transported smolts had the highest survival through that migration segment (0.87). Estimated detection probabilities of the acoustic receiver sub-arrays are presented in Supplementary Table S1.

Our finding that most mortality occurs in the coastal ocean hinges on our assumption that the detection probability of the Lippy Point sub-array, p_{LIP}, was similar to other Pacific Ocean Shelf Tracking (POST) marine sub-arrays that could be directly assessed (too few smolts reached the final sub-array in Alaska, 1000 km distant, to allow direct estimation of p_{LIP}; see Methods and Supplementary Table S2). If our assumption is incorrect, then survival estimates in the coastal ocean (Willapa Bay to Lippy Point) will be under or overestimated. We looked more closely at the sensitivity of survival estimates in the coastal ocean relative to p_{LIP} (Supplementary Fig. S1), and found that coastal ocean survival remains low for both TR and IR groups over a range of assumed values, and our conclusions do not change. In any event, because both TR and IR smolts were implanted with the same tag type, the relative survival of the two groups should be invariant because p_{LIP} should be the same for both groups.

Transported smolts did not survive as well as the IR migrants after release in the LRE and plume combined in 2006, and in the LRE in 2008 and 2009 (Table 3; Fig. 3), and the resulting ratios (TR/IR) for individual years were significantly <1 in 2006 ($R=0.70$, $SE=0.12$, $z=-2.55$, $p=0.02$) and 2008 ($R=0.78$, $SE=0.05$, $z=-4.3$, $p<0.01$; Table 2), indicating that TR smolts had lower relative survival. The estimated survival ratios in the LRE for 2008 and 2009 combined ($R=0.86$, $SE=0.10$, $z=-1.31$, $p=0.10$), and LRE and plume combined in all years ($R=0.86$, $SE=0.11$, $z=-1.16$, $p=0.12$) were also <1, but this effect was not significant (Table 2).

Once in the plume and coastal ocean, transported smolts survived either better than or the same as the IR groups. In the plume (2008, 2009, and 2008 and 2009 combined) all ratios were >1. In the coastal ocean, survival ratios were >2 in 2006, 2009, and all years combined, indicating that TR smolts had twice the survival of IR smolts from Willapa Bay to Lippy Point. In 2008, the survival ratio in the coastal ocean was 0.87 ($SE=0.35$), although this ratio was not significantly less than 1 ($z=-0.35$, $p=0.36$).

Despite depressed survival of TR smolts in the LRE, the overall TR/IR post-hydrosystem survival ratio across all three habitats from McGowans Channel to Lippy Point was >2 in 2006 and >3 in 2009, i.e., 2–3 times greater survival for TR smolts. In 2008 the ratio was 0.85, but again this was not significantly less than 1 ($z=-0.40$, $p=0.35$). The total ratio averaged across all three years was 1.84 ($SE=0.65$), indicating that TR smolts generally had higher post-hydrosystem survival compared to IR smolts. If differential mortality caused by transportation occurred in TR smolts soon after release and the differential persisted for one month, the MCG-LIP ratios would have been less than 1.0. Therefore, our results demonstrate that when IR and TR smolts of approximately the same size enter the ocean concurrently, survival of TR smolts is comparable or better than IR smolts, which is inconsistent with hypotheses that decreased post-hydrosystem survival to adult return of transported fish is due to stress caused by transportation.

Discussion

Transported spring Chinook smolts typically survive to return as adults at rates only slightly better than in-river migrants, despite avoiding the approximately 50% mortality experienced during the 460 km migration down the eight-dam FCRPS[23]. If differential delayed mortality caused by stressful transportation is expressed after release within the first month of life in the coastal ocean, we would expect to see reduced post-hydrosystem survival for transported smolts compared to smolts that migrated in-river. Despite tracking size-matched groups with similar ocean entry timing as far as northern Vancouver Island, 750 km beyond the last dam and for approximately one month after ocean entry, we did not observe lower survival for TR smolts. Thus, our results do not support the hypothesis that transportation-induced stress leads to higher mortality of smolts in the early marine period. It is likely that it is the accelerated timing of ocean entry which occurs during conventional transport practice that leads to differences in post-hydrosystem SARs

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Table 2 | Post-hydrosystem survival estimates (S), survival ratios ($R=S_{TR}/S_{IR}$), and z-test results for in-river (IR) and transported (TR) Dworshak spring Chinook salmon smolts. In-river fish were released at Kooskia NFH; transported fish were released below Bonneville Dam. LRE = lower Columbia River and Estuary. See Figure 1 for migration segment abbreviations. We could not estimate estuary and plume survival independently in 2006 because the Astoria sub-array was not deployed that year. Bold p-values indicate z statistics significantly less than 1

Habitat	Migration Segment	Years used in survival estimation	S_{TR}	SE (S_{TR})	S_{IR}	SE (S_{IR})	R	SE (R)	Z-stat	p-value
LRE & plume	MCG-WIL	2006	0.54	0.12	0.78	0.19	0.70	0.12	−2.11	**0.02**
Coastal ocean	WIL-LIP	2006	0.11	0.05	0.04	0.03	2.96	2.35	1.37	0.91
Total post-hydrosystem	MCG-LIP	2006	0.06	0.02	0.03	0.02	2.07	1.64	0.92	0.82
LRE	MCG-AST	2008	0.77	0.05	1.00	0.00	0.77	0.05	−3.93	**<0.01**
Plume	AST-WIL	2008	0.51	0.07	0.40	0.07	1.27	0.24	1.27	0.90
Coastal ocean	WIL-LIP	2008	0.25	0.07	0.29	0.09	0.87	0.35	−0.35	0.36
Total post-hydrosystem	MCG-LIP	2008	0.10	0.03	0.12	0.04	0.85	0.36	−0.40	0.35
LRE	MCG-AST	2009	0.69	0.04	0.82	0.15	0.84	0.16	−0.92	0.18
Plume	AST-WIL	2009	0.87	0.21	0.48	0.17	1.81	0.53	2.01	0.98
Coastal ocean	WIL-LIP	2009	0.24	0.07	0.12	0.06	2.06	1.09	1.36	0.91
Total post-hydrosystem	MCG-LIP	2009	0.14	0.02	0.05	0.02	3.12	1.56	2.28	0.99
LRE	MCG-AST	2008 & 2009	0.75	0.03	0.88	0.10	0.86	0.10	−1.31	0.10
Plume	AST-WIL	2008 & 2009	0.60	0.07	0.41	0.06	1.48	0.21	2.83	1.00
LRE & plume	MCG-WIL	All years	0.52	0.05	0.61	0.08	0.86	0.11	−1.16	0.12
Coastal ocean	WIL-LIP	All years	0.21	0.04	0.10	0.03	2.15	0.75	2.20	0.99
Total post-hydrosystem	MCG-LIP	All years	0.11	0.02	0.06	0.02	1.84	0.65	1.73	0.96

typically observed between transported and in-river migrating spring Chinook smolts. As Muir et al.[26] hypothesized, altered timing of ocean entry for transported smolts, which arrive 2–4 weeks earlier than in-river migrants, may place them into less favourable ocean conditions.

To further test this hypothesis, we transported a single group of acoustic tagged smolts (n=196) on April 17, 2009, approximately five weeks earlier than the other two groups transported that year. Smolts were transported several days after tagging, to allow recovery, (but were not delayed at the hatchery) in order to simulate conventional transportation practice early in the migration season. These early transport (T_0) smolts had noticeably different migration behaviours compared to the TR groups held for several weeks and then transported[44]. Overall survival from release to Lippy Point was 0.08 (SE=0.02) for the early transport group, and 0.14 (SE=0.02) for the later released TR groups. Thus, survival of transported smolts that were released earlier, and therefore entered the ocean earlier, was only 58% of the delayed-entry transport groups. As estuarine survival was nearly identical (T_0=0.70, SE=0.05; TR=0.69, SE=0.04), this survival difference occurred in the plume and coastal ocean.

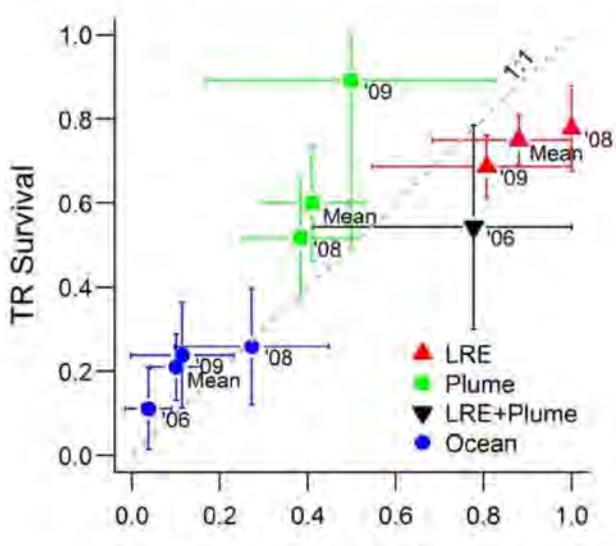

Figure 3 | Comparative survival of in-river (IR) and transported (TR) Dworshak hatchery spring Chinook smolts (error bars are 95% confidence intervals). The dashed 1 : 1 line represents equal survival of both treatment types; data points falling below the line indicate lower survival of TR fish. The Astoria sub-array was not deployed in 2006; therefore, we could not separate Lower Columbia River and estuary (LRE) survival from Plume survival in 2006.

Our results lend support to the altered ocean entry timing hypothesis. Although transportation apparently caused negligible harm to these smolts, altered ocean arrival timing will continue to be a consequence of conventional transport practice unless transportation is only initiated when ocean conditions are more favourable for survival.

Several factors may have influenced our finding that transported fish did not experience reduced mortality relative to in-river migrants in the first month of ocean life. First, all smolts in the study were grown to a larger size (≥140 mm FL in 2006, ≥130 mm FL in 2008 and 2009) to accommodate the acoustic transmitters and, as a result, size at release was larger (but see Supplementary Fig. S2) and timing of release of both IR and TR groups was later than for typical Dworshak spring Chinook. There is some evidence that larger smolt size may lead to increased SARs for hatchery Chinook salmon[45]. Juvenile migration timing may also play a significant role in determining subsequent SARs. Wild Snake River spring Chinook migrating seaward early in the season (until mid-May) had high and relatively stable SARs, which then decreased substantially for smolts that migrated later in the season[42]. Adult return rates of transported smolts declined later in the season as well; however, relative to in-river migrants, transported smolt SAR was higher (i.e., T/I ratios increased)[26,33]. Thus, it is possible that larger body size or later migration timing may have ameliorated stress caused by transportation.

Second, there were some differences in ocean entry timing and mean body size at tagging for TR and IR smolts (in 2006 only). In all years, we attempted to release TR fish below Bonneville Dam at approximately the time IR fish passed Bonneville Dam so that smolts could co-migrate and experience common estuarine and ocean conditions, minimizing the potential confounding of variable ocean survival conditions with transportation. We also attempted to size

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Table 3 | Estimated survival ($\hat{\phi}$) of transported and in-river migrant Dworshak spring Chinook smolts by habitat. Confidence intervals (95%) were estimated using the profile likelihood method. All fish were transferred and tagged at Kooskia NFH. In-river (IR) migrating groups were released at Kooskia NFH; transported (TR) fish were released below Bonneville Dam. See Figure 1 for habitat designations. Counts of fish detected on each sub-array are reported in Supplementary Table S2. LRE = lower Columbia River and estuary. (a) Smolts were transported via barge around the hydrosystem, therefore survival was set to 1. (b) We could not estimate estuary and plume survival independently in 2006 because the Astoria sub-array was not deployed that year

	Transported			In-river		
	$\hat{\phi}$	SE ($\hat{\phi}$)	95% CI	$\hat{\phi}$	SE ($\hat{\phi}$)	95% CI
Hydrosystem (646 km)						
2006	1 (a)			0.40	0.04	0.32–0.49
2008	1 (a)			0.30	0.03	0.24–0.35
2009	1 (a)			0.41	0.04	0.33–0.49
LRE + Plume (264 km) (b)						
2006	0.54	0.12	0.37–0.86	0.78	0.19	0.52–1.0
LRE (201 km)						
2008	0.77	0.05	0.68–0.88	1.0	0	0.85–1.0
2009	0.69	0.04	0.61–0.78	0.82	0.15	0.59–1.0
Plume (63 km)						
2008	0.51	0.07	0.38–0.67	0.40	0.07	0.28–0.55
2009	0.87	0.21	0.58–1	0.48	0.17	0.24–0.91
Ocean (485 km)						
2006	0.11	0.05	0.04–0.23	0.04	0.03	0.01–0.12
2008	0.25	0.07	0.14–0.40	0.29	0.09	0.14–0.50
2009	0.24	0.07	0.15–0.39	0.12	0.06	0.03–0.30

match the IR and TR treatment groups. Nevertheless, IR smolts arrived at Bonneville Dam two to three weeks earlier than the TR groups in 2006, owing to high river flows, and TR smolts were 8–9 mm larger on average at tagging then the IR smolts. As plume conditions can change rapidly[46] (potentially within two to three weeks), the increased survival of TR smolts in the coastal ocean in that year may be confounded with mismatched timing of ocean entry[42]; TR smolts may have encountered different, or more favourable, ocean conditions when they reached the ocean several weeks after the IR smolts. Transported smolts may have also had a slight size advantage over the IR smolts in 2006, but we found that within the size range of smolts that we tagged, survival was not a function of body size[47,48]. In 2008 and 2009, the time of ocean entry and mean body size was similar for both groups.

Third, there is some uncertainty as to whether smolts may have migrated around the coastal ocean sub-arrays, as individuals were detected on the farthest offshore receiver nodes at Willapa Bay, and several tagged fish that returned to the Columbia River as adults (which were detected by PIT tag detectors at the dams) were not detected as smolts on the ocean sub-arrays. In all years, however, the majority of the fish that were detected from both treatment types migrated between 20–30 km offshore and within the boundaries of the Willapa Bay sub-array (Supplementary Fig. S3). At the Lippy Point sub-array further along the migration pathway, detections of acoustic-tagged smolts were almost completely confined to the inner half of the continental shelf in all years, although some returning adults were not detected as smolts on this sub-array. The movement of some individuals off the shelf, or non-detection of individuals that migrated over the sub-arrays on the shelf, would bias survival estimates low. As the Dworshak spring Chinook population generally has a very low SAR, very few of our acoustic tagged adults or jacks were detected upon return (juvenile migration year 2006 = 0, $2008_{IR} = 2$, $2008_{TR} = 3$, $2009_{IR} = 1$, $2009_{TR} = 5$) which precluded us from quantifying this potential bias; however, unless a different proportion of smolts from each treatment type was detected, the relative survival comparison between TR and IR smolts remains unaffected.

Lastly, there is a possibility that yearling Chinook smolts may migrate south upon ocean entry. McMichael et al.[49], found that acoustic tagged and tracked yearling Chinook smolts were detected within the Columbia River plume up to ~15 km to the west and south of the river mouth when surface ocean currents were more southerly in 2010. To address this concern, we deployed a sub-array south of the Columbia River mouth near Cascade Head, OR, in 2009; none of the smolts tagged in this study were detected on this sub-array (131 km distant), except for two smolts (1%) from the 2009 early transport (T_0) group, demonstrating that few yearling Chinook smolts migrate south upon ocean entry.

Estimated survival of IR migrants in the LRE was high in all years, ranging between 0.82–1.0, consistent with other telemetry studies[37,49,50]. Transported smolt survival was slightly depressed relative to the IR group immediately following release into the LRE, but subsequent survival in the plume and coastal ocean was comparable or better. With all habitats (i.e., segments of the migration pathway) combined, the three year mean post-hydrosystem survival estimate to Lippy Point was substantially higher for TR smolts.

Reduced survival of TR smolts following release into the LRE prompted us to look more closely at post-release mortality, i.e., mortality that occurs in the first migration segment following release, as this could be confounded with transportation-induced delayed mortality. TR smolts were transferred directly from the hatchery to the barge and then to the lower river downstream of Bonneville Dam; therefore, we hypothesized that transported smolts experienced initially elevated and similar levels of mortality after release into the LRE compared to IR smolts because they had never encountered predators[51]. In-river smolts, which would also be similarly naïve after release from the hatchery, would have experienced this additional elevated mortality in the Clearwater River, not in the LRE, thus explaining the reduced survival of the TR smolts relative to the IR smolts between Bonneville Dam and Willapa Bay in 2006, and between Bonneville Dam and Astoria in 2008 an 2009. To statistically compare post-release mortality for IR and TR smolts, we used a Monte Carlo procedure to assess the mortality rate in the first migration segment following release (Supplementary Fig. S4). In all three years, there was no statistical difference in post-release mortality rate per km of travel for TR smolts from below Bonneville Dam to their first detection site compared to IR smolts from the hatchery in the Clearwater River to their first detection site below LGR (Lake Bryan). Thus, both treatment types suffered similar loss rates following release. We interpret this period of initially high post-release mortality as likely due to culling of less fit or less wary smolts by predators.

Our directly estimated early marine survival probabilities are consistent with interannual predictions of juvenile salmon survival based on coastal ocean indicators[52], supporting the hypothesis that transported smolts may experience increased mortality upon early entry into the coastal ocean, particularly in years when early marine survival rates are lower than hydrosystem survival. Post-hydrosystem survival rates to adult return of PIT tagged only, transported Dworshak spring Chinook smolts[23] was substantially lower than in-river migrant PIT tagged smolts for outmigration years 2006 ($\hat{D}$= 0.60, CI=0.43–0.83) and 2009 ($\hat{D}$=0.61, CI=0.37–0.95), but less so in 2008 ($\hat{D}$=0.84, CI=0.63–1.12), when ocean conditions were particularly favourable for juvenile salmon survival[52]. Our estimates of coastal marine survival from Willapa Bay to Lippy Point for acoustic tagged smolts were relatively low in 2006 and 2009 and highest in 2008 (for both treatment types), and in 2008 only, survival estimates of IR smolts in the hydrosystem and coastal ocean were comparable (0.30 from release to Bonneville Dam, ~650 km; 0.29 from Willapa Bay to Lippy Point, ~530 km). In contrast, coastal ocean survival was only 1/3rd–1/10th hydrosystem survival in 2006 and 2009. Thus, the increased D estimate for PIT tagged smolts in 2008 could simply be the result of transferring transported smolts between two habitats with similar survival rates. In 2006 and 2009, transported PIT tagged Dworshak smolts may have spent several additional weeks exposed to higher ocean mortality rates than the in-river migrants experienced in the hydrosystem, potentially providing a simple explanation for why $\hat{D}$ ratios were <1 in 2006 and 2009. This is an important finding, in that efforts to reduce stress and disease transfer during barging are likely to fail if the true cause of reduced adult returns is increased exposure to poor ocean conditions.

A better understanding of the mechanisms causing differential mortality should lead to improved management decisions. The results of our study suggest that differential ocean entry timing is the most likely cause of D ratios less than 1, not transportation-induced stress. Strategies such as delaying the start of transportation, or using ocean indicators, direct early marine survival estimates, and climate-based predictive models[53] to potentially make real-time decisions as to when to start or end transportation may therefore be effective measures that could increase SARs for some Chinook populations.

Methods

Smolt acquisition and acoustic tagging. We used spring Chinook salmon smolts reared at the Dworshak NFH, on the Clearwater River (a tributary of the Snake River) as the source population; however, for logistical purposes we transferred smolts to a nearby hatchery (Kooskia NFH) for tagging (See Supplementary Methods). All work involving live fish was annually reviewed and pre-approved as meeting or exceeding the standards laid out by the Canadian Council on Animal Care. Annual reviews of submitted protocols and approvals were made by the Animal Care Committee of Vancouver Island University, Nanaimo, BC, Canada (application # 2006-08R, 2006-08R-2, 2009-11R).

In 2006, we used individually identifiable VEMCO V9-6L coded acoustic transmitters (9×21 mm, 3.1 g in air, 2 g in water) and in 2008-09 we used smaller V7-2L transmitters (7 mm×20 mm, 1.6 g in air, 0.75 g in water). The same surgical protocol was used in all years for both treatment types. A brief description is given in the Supplementary Methods with more details provided in Rechisky and Welch[47].

In each year, approximately 600–800 smolts were surgically implanted with acoustic transmitters (Table 1). We attempted to size-match tagged fish within and between treatment groups in each year while randomly assigning fish to treatment groups. In 2008 and 2009, mean FL, mass, and tag burden (tag mass as a percent of body mass) were similar both between release groups and across treatment types; however, in 2006 the TR groups were 8–9 mm larger than IR groups on average and thus tag burden was less for the transported groups (Table 1). These tag burdens generally lie within maximum recommended tag burdens for salmon smolts[54,55] and assessment of size at release of tagged animals relative to size at release of survivors reaching Willapa Bay showed no distortions in the distributions[48]. Further, models that included fork length as a covariate did not perform as well as models excluding fork length, suggesting that the tags did not substantially affect survival[47,48]. In 2006 and 2008, we released twice as many IR as TR smolts to compensate for mortality in the Clearwater River and during hydrosystem migration and to obtain roughly balanced sample sizes upon arrival below Bonneville Dam; however, in 2009 additional tags were available to increase the number of transported smolts. The IR groups were released from Kooskia NFH into Clear Creek which flows successively into the Clearwater, Snake, and Columbia rivers (Fig. 1). Distance to Bonneville Dam was 637 km. Transported fish were held for up to several weeks at Kooskia NFH until in-river migrant groups were estimated to be nearing Bonneville Dam, and were then transferred by truck to a barge at Lower Granite Dam. Barge transport time to below Bonneville Dam (a distance of 470 km) was approximately 36 hours. Smolts were released from the barge ~7–12 km downstream of Bonneville Dam in the evening between 19:10–22:50. Distance to the Columbia River mouth at Cascade Head , OR was 222–227 km, depending on the release site. Observers on the barges reported no mortalities of acoustic tagged fish in any year of the study and we assumed survival during transport was 100%. Release dates, fish size, and tag burdens are reported in Table 1; sex was not determined.

Acoustic array elements and location. The marine elements of acoustic telemetry array were composed of individual VEMCO receivers positioned above the seabed of the continental shelf to form a series of listening lines or acoustic receiver sub-arrays (referred to as "sub-arrays") extending from near-shore out to ~200 m depths. The receivers recorded the date and time that acoustic transmitters (tags) were detected, and these detections were used to estimate survival to each sub-array. During the study, the array extended from coastal Washington through southern British Columbia and up to southeast Alaska (Fig. 1). Sub-arrays were also deployed within the Snake and Columbia rivers (see Welch et al.[56], Porter et al.[57], Porter et al.[44] for site-specific details on sub-array performance). This design allowed us to track the smolts for 2,500 km from the release site in the Snake River through the hydrosystem, lower Columbia River and estuary (LRE), plume, and coastal ocean to Graves Harbor, Alaska. We report hydrosystem survival of IR smolts to the sub-array located in the lower Columbia River at McGowans Channel (MCG) at river kilometre (rkm) 224 (10 km below Bonneville Dam). For both treatment types, we report survival in the LRE and plume from MCG to Willapa Bay, WA (WIL; 264 km beyond Bonneville Dam) and in the coastal ocean from WIL to Lippy Point, BC (LIP; 749 km beyond Bonneville Dam). In 2008 and 2009, an additional sub-array was deployed in the Columbia River estuary at Astoria, WA (AST; 201 km below Bonneville Dam), allowing LRE and plume survival to be separately measured. For this study, the LRE is defined as the tidal area ranging from Bonneville Dam to Astoria, and the plume is defined as the area from Astoria to the Willapa Bay sub-array. Although the plume technically begins at the river mouth (not Astoria), the distance between the sub-arrays sited at Astoria and Willapa Bay was only 63 km and encompassed the plume. In 2009, an additional sub-array was deployed in the coastal ocean south of the Columbia River mouth at Cascade Head, OR; no smolts from our treatment groups were detected on this array.

Data analysis. All acoustic detection data from the array were first screened for potential false positive detections, which were rare; excluded data typically formed <0.1% of the total recorded detections. In-river fish were defined as any acoustic tagged fish migrating in the river, regardless of their specific route through the dams (e.g. spill, bypass or turbine). We excluded from the analysis a few IR smolts inadvertently collected and transported from lower Snake River dams (2006: 16; 2008: 0; 2009: 3).

Survival estimation. For each year of the study, capture (detection) histories for each tagged individual were formed and estimates of survival and detection probability and their associated standard errors were calculated using a suite of models that were special cases of the Cormack-Jolly-Seber (CJS) model for live-recaptured animals implemented with Program MARK[58]. Confidence intervals were estimated using the profile likelihood method. We estimated goodness of fit (see Supplementary Methods) and then estimated apparent survival (ϕ) for each treatment type between each sub-array. We allowed detection probability (p) to vary for each treatment type and sub-array in freshwater, but only by sub-array in the ocean (i.e., a common p parameter was estimated for TR and IR groups for coastal ocean sub-arrays using the full data set). We then estimated cumulative post-hydrosystem survival to Lippy Point as the product of the segment-specific survival estimates for each treatment type, and estimated the variance with the Delta Method.

As a final step, we estimated survival for each treatment type across all three years of the study. We used a reduced CJS model where a common survival probability was estimated for each treatment type for all years, and the detection probabilities were parameterized as for the year-separate models but were allowed to vary by year, i.e., a separate parameter was estimated for each treatment type in each year. We refer to the estimate of the common parameter as the 'average' survival across years. Because the Astoria sub-array was not deployed in 2006, it was necessary to run two separate models to obtain average survival estimates to all detection sites: one to estimate average survival for all years (2006, 2008, 2009) in the LRE and plume combined, and

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another to estimate average survival for 2008 and 2009 combined in the LRE and in the plume as separate migration segments. We used the former model to estimate average survival across all three years in the coastal ocean. We then used these average survival estimates, as well as the survival estimates produced for individual years, to statistically compare post-hydrosystem survival of the TR and IR smolts as described below.

For all sub-arrays, we recognized CJS model assumptions: every tagged individual has equal survival probability and equal probability of detection following release, sampling periods are instantaneous, emigration is permanent, and tags are not lost. Assessments of tag loss, tagging induced mortality, tag operational lifespan, and survival differences between taggers (surgical skill) indicated that these factors did not have significant influence on the survival estimates during the time required for the freely migrating tagged smolts to pass Lippy Point[44].

For coastal ocean sub-arrays that were unbounded offshore, we required three additional assumptions: i) fish departing the Columbia River swam north; ii) their migration was confined to the coastal zone spanned by the sub-arrays; and iii) detection probability of the Lippy Point sub-array was 0.90 for the V9 tag used in 2006 and was 0.67 in 2008 and 2009 when the less powerful V7 tag was used. Assumptions (i) and (ii) are supported by evidence from ocean sampling programs that demonstrate that juvenile spring Chinook salmon remain almost entirely on the continental shelf and primarily migrate north upon leaving the river[59–61]. As well, we deployed a sub-array 131 km south of the Columbia River mouth at Cascade Head, OR (Fig. 1) in 2009 to validate assumption (i); only two acoustic tagged smolts, both from the early transported (T_0) group, were detected on this southern sub-array.

The detection probability of the Lippy Point (NW Vancouver Island) sub-array was not estimable using standard CJS methods because too few tagged smolts were detected in Alaska each year to provide adequate information ($N_{2006} = 2$ IR; $N_{2008} = 1$ IR; $N_{2009} = 1$ TR). In order to estimate survival to Lippy Point, we assumed the specific values listed in assumption (iii) given the performance of similar sub-arrays for which it was possible to use CJS to estimate detection probability. The basis for this assumption and the implications of its violation are discussed in the Supplementary Methods. We conclude that as long as the real detection probability is similar for the TR smolts and the IR controls, our key scientific test of whether TR smolts have lower post-hydrosystem survival than IR controls is not affected.

Post-hydrosystem survival ratios. To compare post-hydrosystem survival of TR and IR smolts, we calculated survival ratios of TR smolts that were released near the McGowans Channel sub-array, to the post-hydrosystem survival of IR smolts from McGowans Channel onwards. This approach excluded upstream mortality for IR smolts and allowed a survival comparison within common migration segments for the two groups. To assess the evidence for lower TR survival, we tested whether the survival ratios were significantly less than 1 (i.e., whether TR smolts had lower survival than IR smolts) on the anti-log scale or less than 0 on the log scale. On the log scale, the z-statistic can be formed as:

$$\hat{z} = \frac{ln(\hat{R}_i) - 0}{\widehat{SE}(ln(\hat{R}_i))} = \frac{ln(\hat{R}_i)}{\widehat{SE}(\hat{R}_i)/\hat{R}_i} \quad (1)$$

Where $\hat{R}_i$ is the estimated survival ratio (TR smolts to IR smolts) for the common migration segments below Bonneville Dam, and $\widehat{SE}(\hat{R}_i)$ is the standard error of the ratio as determined by the Delta Method. We tested the z-statistic at the 5% significance level.

We used the z-test to compare the survival of TR smolts to IR smolts in each of the common migration segments: i) LRE and plume ($S^{TR}_{MCG-WIL}/S^{IR}_{MCG-WIL}$) in 2006 and for all years combined; ii) coastal ocean ($S^{TR}_{WIL-LIP}/S^{IR}_{WIL-LIP}$) for individual years and for all years combined; iii) LRE alone ($S^{TR}_{MCG-AST}/S^{IR}_{MCG-AST}$) for 2008 and 2009 and for 2008 and 2009 combined; and iv) plume ($S^{TR}_{AST-WIL}/S^{IR}_{AST-WIL}$) for 2008 and 2009 and for 2008 and 2009 combined, when the Astoria sub-array was in place (see Fig. 1 for sub-array abbreviations). We also calculated a post-hydrosystem survival ratio which included all migration segments (v) LRE, plume, and coastal ocean, ($S^{TR}_{MCG-LIP}/S^{IR}_{MCG-LIP}$), for all individual years and for all years combined.

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Author contributions

DWW conceived the experiments. ELR, MJS, PMW, and JLM conducted the fieldwork. ELR, ADP and DWW analyzed the data. ELR wrote the manuscript. All authors reviewed and edited the manuscript.

Additional information

Supplementary information accompanies this paper at http://www.nature.com/scientificreports

Competing financial interests: DWW is president of Kintama Research Services, an environmental consultancy that designed and operates the main elements of the current POST array described in this paper. All other authors declare no competing financial interests.

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Supplementary Information

Estuarine and early-marine survival of transported and in-river migrant Snake River spring Chinook salmon smolts

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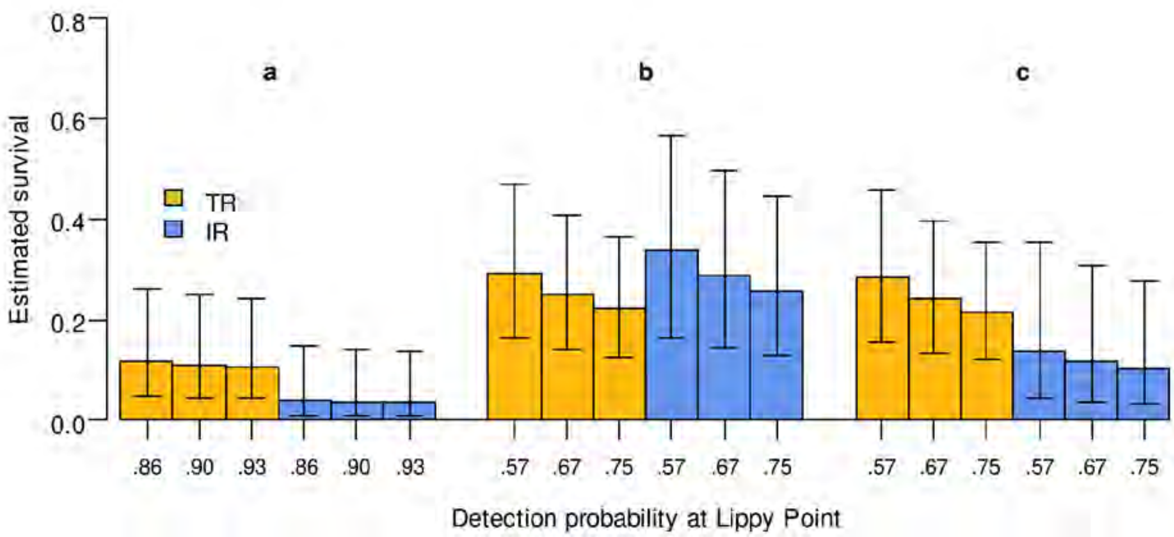

Supplementary Figure S1. Sensitivity of survival estimates to assumptions of detection probability at Lippy Point. To examine how coastal ocean survival estimates (from Willapa Bay, WA, to Lippy Point, BC) of transported (TR) and in-river (IR) migrating Snake River spring Chinook smolts might change with variation in detection probability (p) at Lippy Point, we re-ran our survival models using the upper and lower 95% confidence bounds of the assumed p value for Lippy Point in 2006 (a), 2008 (b), 2009 (c). This assumed value was estimated for the same tags in migrating juvenile salmon at similar coastal-sub-arrays in a previous study[1]. Assumptions about the p of the Lippy Point sub-array resulted in small changes in estimated coastal ocean survival of TR and IR smolts. Because all fish received identical tags within in each year, we have assumed that the detection efficiency of the Lippy Point array should be equal for the two groups. Importantly, the S_{TR}/S_{IR} ratio remains stable such that our conclusion that TR smolt survival was not reduced relative to IR smolts would not be affected by the value of p at Lippy Point.

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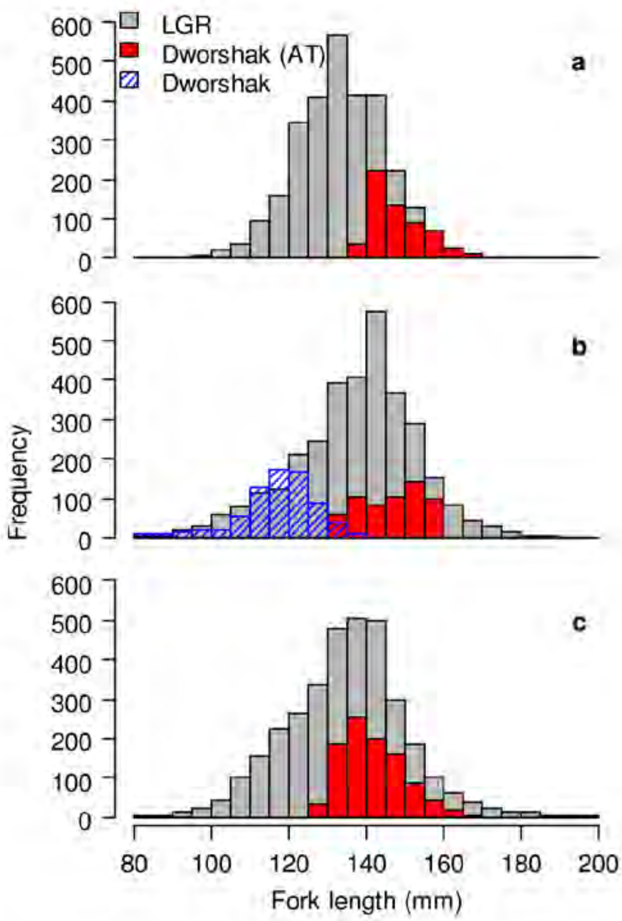
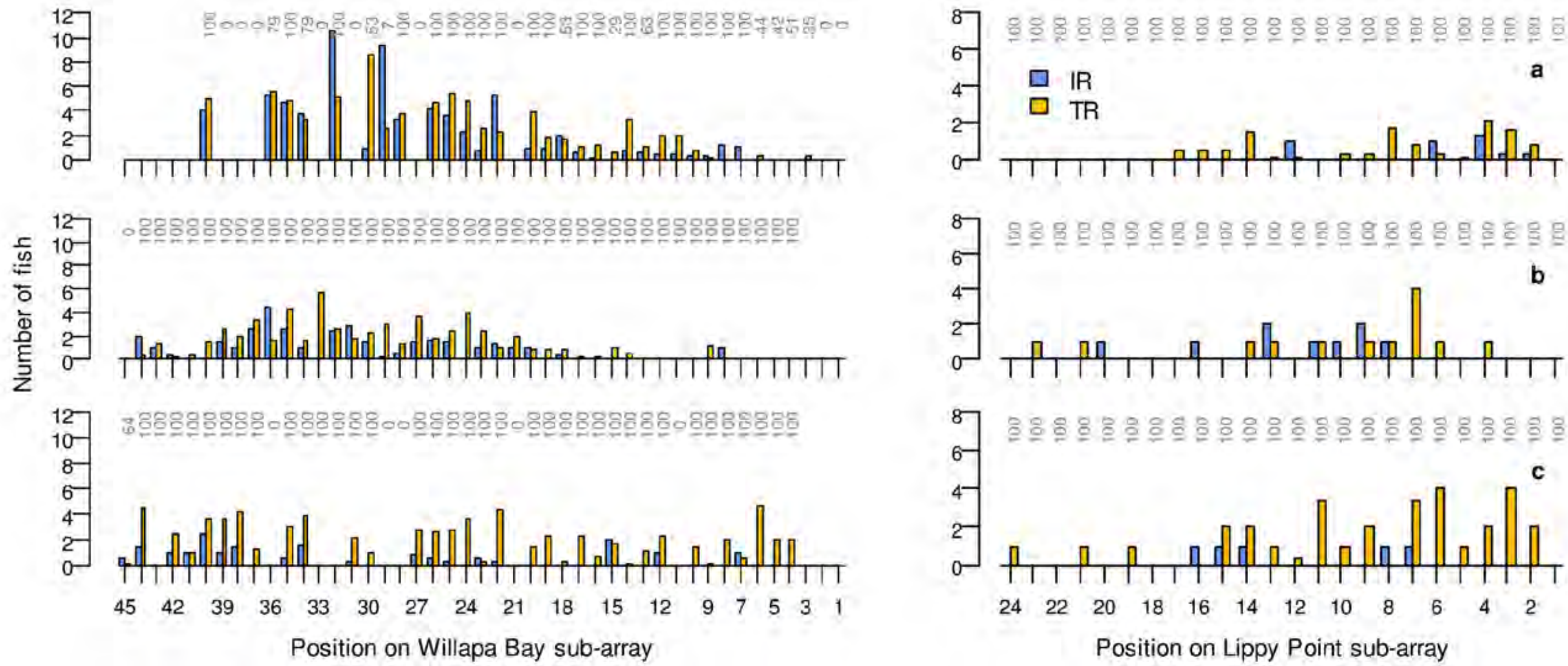


Supplementary Figure S2. Size frequency distribution of migrating Snake River basin hatchery yearling Chinook smolts sampled at Lower Granite Dam[2] (LGR) and acoustic tagged (AT) Dworshak spring Chinook in 2006 (a), 2008 (b), and 2009 (c). Blue bars in panel (b) represent the size distribution of untagged Dworshak spring Chinook taken from a sample at the hatchery prior to release (these data were only available in 2008). These Dworshak smolts were measured and released several weeks earlier than the acoustic tagged fish.



Supplementary Figure S3. Distribution of in-river (IR) and transported (TR) spring Chinook salmon smolts on the Willapa Bay and Lippy Point sub-arrays in 2006 (a), 2008 (b), and 2009 (c). Position 1 on the x-axis represents the eastern-most acoustic receiver nearest shore, and the final position represents the shelf break. If a fish was detected at more than one receiver, an equal proportion was allocated to all receivers detecting that fish, e.g., if an ID code was detected on two receivers, each receiver was assigned a value of 0.5. A total of 40 receivers were deployed at Willapa Bay in 2006 (to 32 km offshore), and 45 were deployed in 2008 and 2009 (to 36 km offshore). In 2008, receiver 45 was not operational; therefore, the sub-array was effectively 44 receivers in length. A total of 24 receivers were deployed at Lippy Point in all years (to 19 km offshore). The values above the bars indicate the proportion of time each receiver was operational during the migration.

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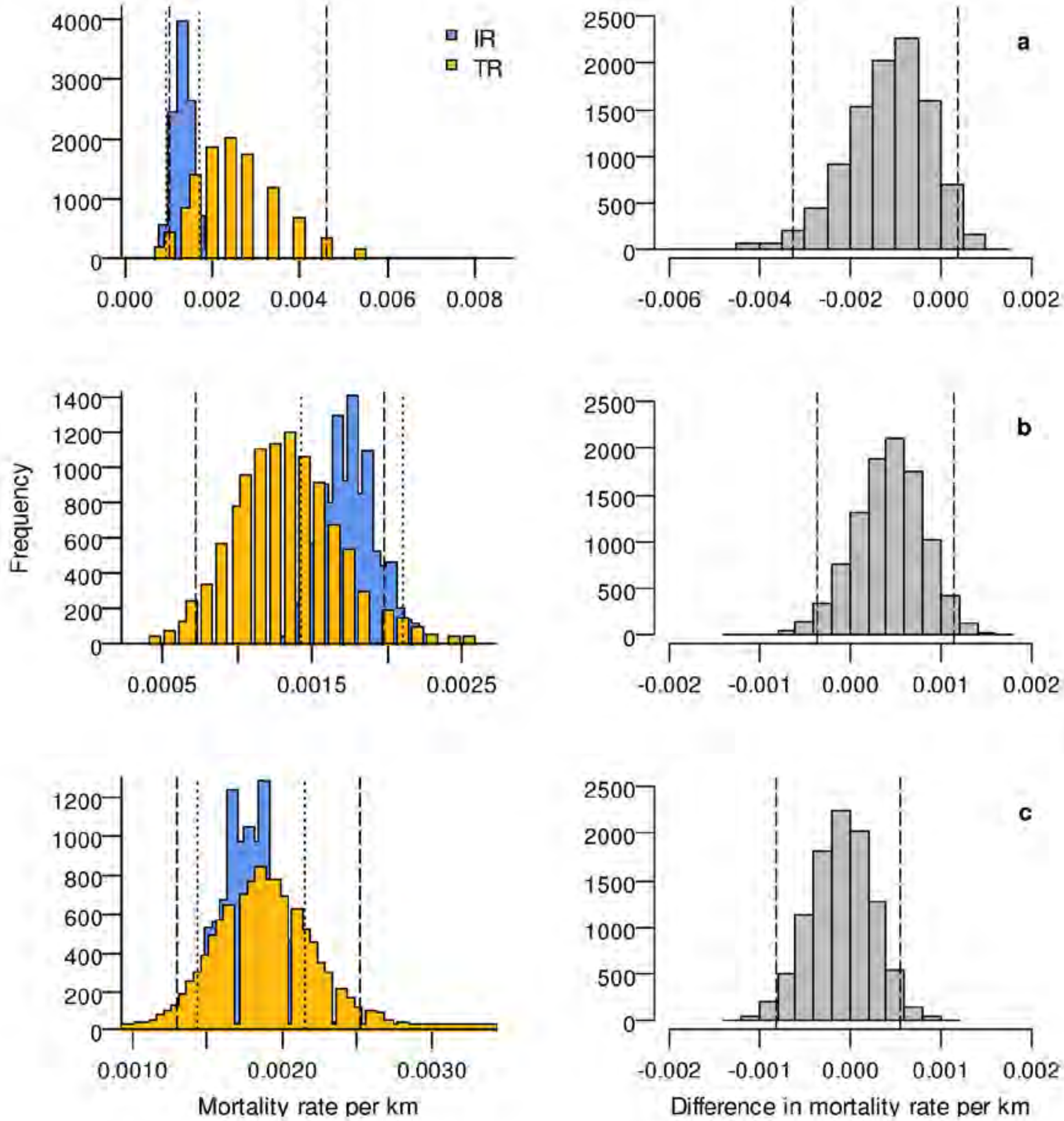

Supplementary Figure S4. Distribution of bootstrapped post-release instantaneous mortality rates per km of travel (left: higher positive values represent greater mortality) and difference in post-release instantaneous mortality rates (right) for tagged spring Chinook smolts in 2006 (a), 2008 (b) and 2009 (c). We assumed an exponential survival model $\hat{S}_i = e^{b_i d_i}$ and regressed the log-transformed survival estimates to the first detection site, $\ln(\hat{S}_i) = b_i d_i$, for each of the i treatment types against migration distance from the respective release sites, d_i. To assess uncertainty in the estimated regression coefficients, we used a Monte Carlo procedure to randomly generate 10,000 individual survival estimates for each treatment type using the estimated survival proportions from release to the first detection site, $\hat{S}_i$, and associated variances to define the binomial sampling distribution generating the data used in each

Monte Carlo run. We then took the 10,000 sets of generated survival estimates for each population, and calculated the log-transformed regression estimates to empirically define the distribution of instantaneous mortality rates, b_i per distance for the exponential survival model for each population (dashed and dotted lines in the left panel represent the 95% confidence interval for transported, TR, and in-river, IR, groups). Mortality rate for IR smolts was estimated from release at Kooskia NFH to the first detection site in Lake Bryan (below Lower Granite Dam, 190 km). Mortality rate for TR smolts was estimated from release in McGowan's Channel (below Bonneville Dam) to Willapa Bay in 2006 (264 km) and to the Astoria sub-array in 2008 and 2009 (201 km). To statistically compare mortality per km, we took the difference between the IR and TR distributions. The null hypothesis was that the post-release survival rate of TR smolts is equal to that of the IR smolts, which is equivalent to assuming that on average the difference in the regression coefficients, $b_1 - b_2$, is zero. We tested this null hypothesis for each of the simulated migration segments by evaluating whether the central 95% of the 10,000 survival rate differences generated (right; dashed lines) with the Monte Carlo method included zero. Post-release mortality rates were not significantly different for IR and TR smolts in any year.

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Supplementary Table S1. Detection probability ($\hat{p}$) for acoustic sub-arrays in the Columbia River below Bonneville Dam in McGowans Channel (MCG); the Columbia River estuary (Astoria, AST); the plume (Willapa Bay, WA, WIL); and the coastal ocean (Lippy Point, BC, LIP). Treatment groups were pooled at WIL, and p was fixed at LIP in all years. The AST sub-array was not deployed in 2006. IR=in-river, TR=transported, NA=not applicable. The $\hat{p}$ at WIL in 2006 was consistent with the 25% loss of the equipment at this site (largely to commercial fishing activities), i.e., if the assumed p for V9 tags was 0.90[1], and gear loss was 25%, then the expected $\hat{p}$ is 0.68 (0.90*0.75), similar to our estimated value. The $\hat{p}$ at WIL in 2008, when we had zero equipment loss during the fish migration season, was 0.74, which is consistent with the average $\hat{p}$ of V7 transmitters on bounded sub-arrays[1]. In 2009, however, $\hat{p}$ at WIL declined to 0.29, possibly due to gear loss due to fishing (12% loss), changes in acoustic transmitter programming, and/or biological fouling of some receivers.

Year	Group	Sub-array	$\hat{p}$	SE ($\hat{p}$)	95% CI
2006	IR	MCG	0.69	0.07	0.55-0.82
	IR & TR	WIL	0.71	0.15	0.48-0.93
	IR & TR	LIP	0.90	fixed	NA
2008	IR	MCG	0.15	0.03	0.09-0.22
	IR	AST	0.81	0.06	0.69-0.91
	TR	AST	0.77	0.05	0.66-0.86
	IR & TR	WIL	0.74	0.07	0.58-0.87
	IR & TR	LIP	0.67	fixed	NA
2009	IR	MCG	0.14	0.03	0.09-0.21
	IR	AST	0.64	0.11	0.44-0.82
	TR	AST	0.77	0.05	0.67-0.85
	IR & TR	WIL	0.29	0.07	0.20-0.44
	IR & TR	LIP	0.67	fixed	NA

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Supplementary Table S2. Summary of detections of acoustic tagged Dworshak spring Chinook salmon smolts. In-river (IR) migrating fish were released at Kooskia National Fish Hatchery; transported (TR) fish were released below Bonneville Dam. NA=not applicable. The Astoria acoustic receiver sub-array was not deployed in 2006.

			# Fish Detected				
Year	Release Group	# Fish Released	McGowans Channel	Astoria	Willapa Bay	Lippy Point	Graves Harbor
2006	IR 1	190	58	--	41	1	1
	IR 2	190	48	--	42	3	1
	TR 1	102	NA	--	48	8	0
	TR 2	101	NA	--	30	3	0
2008	IR 1	197	8	54	21	7	1
	IR 2	198	9	41	13	2	0
	TR 1	100	NA	59	31	6	0
	TR 2	99	NA	59	27	7	0
2009	IR 1	195	11	43	10	1	0
	IR 2	194	12	39	8	4	0
	TR 1	191	NA	120	41	20	1
	TR 2	201	NA	87	28	18	0

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Supplementary Methods

Smolt acquisition and acoustic tagging

We used spring Chinook salmon smolts reared at the Dworshak National Fish Hatchery (NFH), on the Clearwater River (a tributary of the Snake River) as the source population. Dworshak NFH is located above the four lower Snake River dams (as well as the four lower Columbia River dams) and thus, Dworshak smolts have the potential to be diverted into barges and transported to below Bonneville Dam from the three Snake River dams where transportation occurs (Lower Granite, Little Goose, and Lower Monumental), as well as McNary Dam in the lower Columbia River.

Because of space limitations at Dworshak Hatchery, in each year of the study (2006, 2008, and 2009) approximately 1,500 spring Chinook smolts were transferred to Kooskia NFH one to three months prior to tagging. In addition to ample working space, water temperatures at Kooskia NFH (12-13 °C) were warmer than water temperatures at Dworshak NFH (4-10 °C). The warmer temperatures facilitated the more rapid growth necessary to attain minimum body size requirements for tagging (see below). We also retained the fish for several weeks beyond the typical hatchery release date (~April 1) to ensure that a sufficient number of smolts exceeded the minimum size requirements for tagging. As a result, tagged in-river smolts migrated an additional 60 km in the Clearwater River, and three to six weeks later than conventionally released Dworshak spring Chinook smolts. Nevertheless, in all years, median date of passing Lower Granite Dam (the first dam smolts encountered in the Snake River) lay within the 55th to 85th passage index date percentiles for yearling hatchery Snake River spring Chinook[3].

In 2006, we used individually identifiable VEMCO V9-6L coded acoustic transmitters (9 x 21 mm, 3.1 g in air, 2 g in water) and in 2008-09 we used smaller V7-2L transmitters (7 mm x 20 mm, 1.6 g in air, 0.75 g in water). Tags transmitted a unique ID code and were programmed to provide operational lifespans long enough to cover the observed duration of the migration to the Lippy Point sub-array (up to three months). The larger, more powerful V9-6L transmitter used in 2006 had a greater detection radius than the smaller V7 tag used in 2008-09 This provided higher detection probabilities by the telemetry array, but imposed a greater tag burden on the animals.

The same surgical protocol was used in all years for both treatment types; a detailed description is provided in Rechisky and Welch[4]. In brief, portable surgical units were assembled on site, and fish surgery was carried out by experienced, veterinarian-trained staff. Fish were anaesthetized individually in 70 ppm MS-222 buffered with 140 ppm $NaHCO_3$. Fork length was measured to the nearest mm and weight was measured to the nearest tenth of a gram. A maintenance dose of buffered anaesthetic (50 ppm) 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. Each smolt was double tagged by placing a PIT and acoustic tag through the incision into the peritoneal cavity. Depending on tag type, one or two absorbable sutures was used to close the incision. Immediately following surgery, fish were placed into a recovery bath and monitored. Fish generally regained equilibrium and reactivity within minutes. After release, we uploaded the PIT tag data into the Columbia River Basin PIT Tag Information System (PTAGIS) database maintained by the Pacific States Marine Fisheries Commission (PSMFC, Portland, Oregon; http://www.ptagis.org).

To minimize subjective bias when allocating fish to treatment groups, we used a randomized procedure: each tagger netted groups of 10 random fish from the holding tank, which were then assigned a treatment type and release group. We choose to work with groups of 10 fish a) in order to minimize fish stress as all 10 were transferred from the recovery bath to the treatment tank at the same time, and b) because working with larger batches minimized the chance of releasing fish into the wrong experimental tank. As fish were tagged, a tally was kept to ensure that the distribution of fish size was approximately equal across treatment type and release groups. Once the majority of fish in each group was tagged, we selectively tagged fish one by one in order to match size distributions across groups.

In 2006, tagging of in-river (IR) smolts took place April 11-13 and 25-28 and the replicate release groups were released on May 1 and 8. Transported (TR) smolts were tagged from May 30 to June 1 in 2006, transported on June 6 and 14, and released from the barge the following evening. In 2008, all tagging took place from April 19-24. In-river fish were released on April 25 and May 2. The TR groups were transported on May 16 and 22, and released from the barge the following evening. (The use of a smaller transmitter allowed tagging of smaller fish, reducing the holding period, and advancing the release dates relative to 2006). In 2009, all tagging took place from April 13-22. In-river smolts were released on May 4 and 11. The TR groups were transported on May 26 and June 2 and released from the barge the following evening. As noted, a holding period for TR smolts is not consistent with the conventional practice of transporting migrating smolts immediately upon arrival at Snake River dams, but was implemented to match the time of arrival below Bonneville Dam with that of the in-river migrants (which must first migrate 650 km downriver). While at the hatchery, smolts were monitored and fed to satiation by hatchery staff daily.

Survival estimation

In each year of the study, we assess the goodness of fit (GOF) of our data with the bootstrap GOF test within Program MARK. To do so, we combined release groups and then fit the most general Cormack-Jolly-Seber[5-7] (CJS) model (survival, φ, and detection probability, *p*, estimated for each treatment type at each sub-array). If there was overdispersion due to lack of fit of the data to the model, it was corrected by dividing the model deviance by the mean expected deviance (from 1000 bootstrapped simulations) to yield an overdispersion factor, $\hat{c}$[8]. If $\hat{c}$ was greater than 1, the resulting standard errors on the estimates were inflated (multiplied) by the estimated $\hat{c}$ value. In 2006, the $\hat{c}$ overdispersion factor was 1.9. In 2008, there was no overdispersion ($\hat{c}$ was 0.94), and in 2009 $\hat{c}$ was 1.12. There was no overdispersion for the model where 2008 and 2009 were combined ($\hat{c}$=1) to estimate average survival in the LRE and plume separately, and $\hat{c}$ was 1.7 for the model where all three years were pooled to estimate average survival in the LRE and plume combined and the coastal ocean.

Survival in each migration segment varied independently for each treatment type and we made no additional assumptions about the cause of variability in $\hat{\varphi}$ (e.g., fish body size, travel time, etc.). Detection probability varied independently for each treatment type for each freshwater migration segment; however, we estimated common p values at Willapa Bay by pooling all study fish detected at that site in each year in order to compensate for reduced sample sizes caused by mortality which occurred during the migration. We also included in our models two additional in-river migrant groups (each N

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≅200) of Yakima River spring Chinook salmon smolts that were tagged with the same acoustic tag type (as part of a different comparison), in order to better quantify p of the Willapa Bay detection line[9].

Detection probability at Lippy Point

It was not possible to deploy a double array at Lippy Point, therefore the *p* of this sub-array was fixed in all years (see Methods). We did this for several reasons: a) CJS analyses of *p* for other fully intact marine sub-arrays with similar receiver geometry, bounded by landmasses on either side, and with ample detections beyond the sub-array in question (which renders them directly estimable) showed that marine detection rates are very consistent across multiple sites and multiple years (~0.90% for V9 transmitters and ~0.67% for V7 transmitters at three sites in four years[1]; b) all marine receivers were deployed at approximately equal spacing; c) the smolt distribution on the Lippy Point line was centred on the inner to middle continental shelf in all years, indicating that fish were confined to the shelf; and d) if estimates at Lippy Point are biased they should be equally biased for both treatment types as identical acoustic tags were used in each year. Because the key scientific test involves whether TR smolts have lower post-Bonneville Dam survival than the IR controls, some inaccuracy in this final *p* assumption is acceptable; however, we required the assumption that the two tagged groups behaved similarly (i.e., that travel rate and potential offshore emigration, beyond the shelf arrays was equal.

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RAPID COMMUNICATION / COMMUNICATION RAPIDE

Experimental measurement of hydrosystem-induced delayed mortality in juvenile Snake River spring Chinook salmon (*Oncorhynchus tshawytscha*) using a large-scale acoustic array

Erin L. Rechisky, David W. Welch, Aswea D. Porter, Melinda C. Jacobs, and Adrian Ladouceur

Abstract: Out-migrating Snake River salmon smolts must pass eight major hydro dams before reaching the Pacific Ocean. Direct mortality at the dams is generally low; however, the cumulative stress caused by dam passage is hypothesized to result in delayed mortality, which occurs beyond the impounded section of the river. We tested the delayed mortality hypothesis by comparing in-river and early ocean survival of hatchery-origin spring Chinook salmon (*Oncorhynchus tshawytscha*) from the Snake River to a mid-Columbia River population that passes through only four dams and has higher smolt to adult return rates. Smolts >140 mm fork length were implanted with acoustic transmitters and tracked with the Pacific Ocean Shelf Tracking (POST) array to as far as Alaska. There was no detectable difference in survivorship to the first ocean detection line, 274 km beyond the final dam (S_{Snake} = 29% ± 4%, S_{Yakima} = 28% ± 5%), indicating that the survival disparity observed in adult return rates may develop later in the marine life history phase. Our study is the first to estimate survival in the coastal ocean and demonstrates the utility of a large-scale array in testing previously intractable hypotheses.

Résumé : Les saumoneaux qui émigrent de la rivière Snake doivent traverser huit barrages hydroélectriques importants avant de rejoindre le Pacifique. La mortalité directe aux barrages est généralement basse; cependant, nous avançons l'hypothèse selon laquelle le stress cumulatif dû au passage des barrages cause une mortalité différée qui se produit au-delà la section de la rivière pourvue de barrages. Nous avons testé l'hypothèse de la mortalité différée en comparant la survie dans la rivière et au début de la période océanique chez des saumons chinook (*Oncorhynchus tshawytscha*) printaniers de pisciculture avec celle d'une population de la région médiane du Columbia qui ne traverse que quatre barrages et qui possède un taux de retour de saumoneaux à adultes plus élevé. Nous avons implanté des émetteurs acoustiques à des saumoneaux de longueur à la fourche >140 mm et avons suivi les poissons par l'intermédiaire du réseau POST (surveillance de la plate-forme du Pacifique) parfois jusqu'en Alaska. Il n'y a pas de différence décelable de survie au niveau de la première ligne océanique de détection à 274 km au-delà du dernier barrage (S_{Snake} = 29% ± 4%, S_{Yakima} = 28% ± 5%), ce qui indique que la différence de survie observée dans les taux de retour des adultes peut se développer plus tard durant la phase marine du cycle biologique. Notre étude est la première à estimer la survie dans l'océan côtier et elle démontre l'utilité d'un réseau à grande échelle pour tester des hypothèses jusqu'à maintenant irréductibles.

[Traduit par la Rédaction]

Introduction

Out-migrating Snake River Chinook salmon (*Oncorhynchus tshawytscha*) smolts must pass four major hydro dams in the Snake River and four in the lower Columbia River before reaching the Pacific Ocean. Although direct mortality at the dams has decreased in recent years (Muir et al. 2001), subsequent survival from out-migration until adult return is substantially lower for wild and hatchery Snake River spring

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Chinook salmon relative to some mainstem Columbia River populations (Berggren et al. 2008; Yakama Nation 2008). It has thus been hypothesized that delayed mortality may occur after passage out of the hydropower system (i.e., the impounded section of the rivers) because of the cumulative stress caused by dam passage (e.g., Budy et al. 2002; Schaller and Petrosky 2007). Therefore, to quantify delayed or indirect effects of dam passage, survival must be measured downstream of the final dam and preferably beyond fresh water.

The Pacific Ocean Shelf Tracking (POST) array (Welch et al. 2002) is a potentially continental-scale marine tracking array composed of individual acoustic receivers anchored to the ocean floor in a precise geometry. Each receiver records the date and time of uniquely coded acoustic tags passing nearby. In this study, cross-shelf ocean detection lines were located off southeast Alaska, British Columbia (around Vancouver Island), and Washington (40 km north of the Columbia River mouth), as well as in the Columbia and Snake rivers (Fig. 1). The potential tracking distance from the Snake River detection site to southeast Alaska was ~2300 km.

In 2006 we used the POST array to test the hypothesis that greater mortality is expressed in a population of hatchery-origin Snake River spring Chinook smolts after migrating through the impounded section of the river (eight dams) than that of a downstream population from the Yakima River (a tributary of the mid-Columbia River) that migrates through only four lower Columbia River dams. Smolt to adult return rates (SAR) of the Snake River population (Berggren et al. 2008) averaged only one-fifth that of the Yakima population (Yakama Nation 2008) for fish released between 1999 and 2005, and preliminary adult returns from the 2006 release year were consistent with prior years (SAR_{Yakima} = 2.7%; B. Bosch, Yakima–Klickitat Fisheries Project, 771 Pence Road, Yakima, WA 98908, USA, personal communication 2008; SAR_{Snake} = 0.38%, Berggren et al. 2008), providing a comparative test of whether this differential mortality develops shortly after they passed out of the hydrosystem. Our results provide the first estimates of survival and distribution in the ocean and substantially extend the period of life history during which is it possible to test whether delayed mortality occurs in juvenile salmon (Fig. 1).

Materials and methods

Populations used in the study

The Snake River population of spring Chinook used in this study was reared at the Dworshak National Fish Hatchery (NFH), on the Clearwater River (a tributary of the Snake River). Dworshak NFH spring Chinook from the Clearwater River are not a component of the Snake River evolutionary significant unit (ESU); however, their survival is routinely compared with other populations in the Snake River basin as well as with downstream Columbia River populations (see Berggren et al. 2008). Of the Snake River populations, Dworshak generally has the lowest SARs (Berggren et al. 2008), and therefore the difference in survival estimates should be particularly pronounced when compared with a population from outside of the Snake River basin. For logistical ease, Dworshak fish were transferred, tagged, and released at Kooskia NFH (60 km upstream of Dworshak NFH); distance to the Columbia River mouth is 870 km.

The Yakima population was reared at the Cle Elum Supplementation and Research Facility (CESRF) on the Yakima River. Migrating hatchery spring Chinook salmon released from CESRF acclimation sites were collected from the lower Yakima River at the Chandler Juvenile Monitoring Facility (CJMF; 194–249 km from the acclimation sites) and held for tagging. We collected fish at CJMF because mortality in the Yakima River has been as high as 80% in recent years (Yakama Nation 2008). Fish released from CJMF migrated 76 km down the Yakima River to enter the Columbia River just upstream from the Snake River – Columbia River confluence; distance to the Columbia River mouth is 615 km. Thus, both the Snake River and Yakima River populations shared a common migration path that passed through the four lower Columbia River dams before reaching the ocean listening line at Willapa Bay, a total distance of 910 and 655 km, respectively.

Tagging

We surgically implanted 794 smolts (two release groups of approximately 200 at each hatchery) with individually identifiable Vemco V9-6L acoustic transmitters (9 mm × 20 mm, 3.1 g in air, 2 g in water; Shad Bay, Nova Scotia, Canada). The tags were programmed to transmit a unique code at a mean interval of 60 s, and the rated battery life of the tag (4 months) was intended to exceed the likely migration time to the POST subarray in Alaska. A passive integrated transponder (PIT) tag was placed in the body cavity (through the incision) to ensure that tagged smolts were diverted back into the river at the dam bypass facilities. We set a minimum body size requirement of 140 mm fork length (FL), which meant that only the upper portion of the smolt size distribution could be tagged. The mean percent body weight of the transmitters was 8.3% (range = 2.6%–11.5%). The surgical procedure used to implant acoustic transmitters was approved by the Vancouver Island University Animal Care Committee.

Array location

Component subarrays were deployed within the Columbia River at McGowan's Channel at river kilometre (rkm) 224 (10 km below Bonneville Dam), in Lake Celilo at rkm 340 (7 km below John Day Dam), and in Lake Wallula at rkm 502 (21 km below the confluence of the upper Columbia and Snake rivers; Fig. 1). In the Snake River, receivers were installed in Lake Bryan at Snake River rkm 159 (14 km below Lower Granite Dam; total distance from the ocean was 681 km). At each of these locations, receivers were deployed as paired lines to assist in evaluating detection probability and to provide a survival measurement below three of the major hydroelectric dams.

Oceanic components of the POST array at Willapa Bay (southern Washington), Lippy Point (northwest Vancouver Island, British Columbia), and Graves Harbor (southeast Alaska) were deployed as single lines and extended from nearshore to the edge of the continental shelf (200 m depth), a distance of up to 30 km (Fig. 1).

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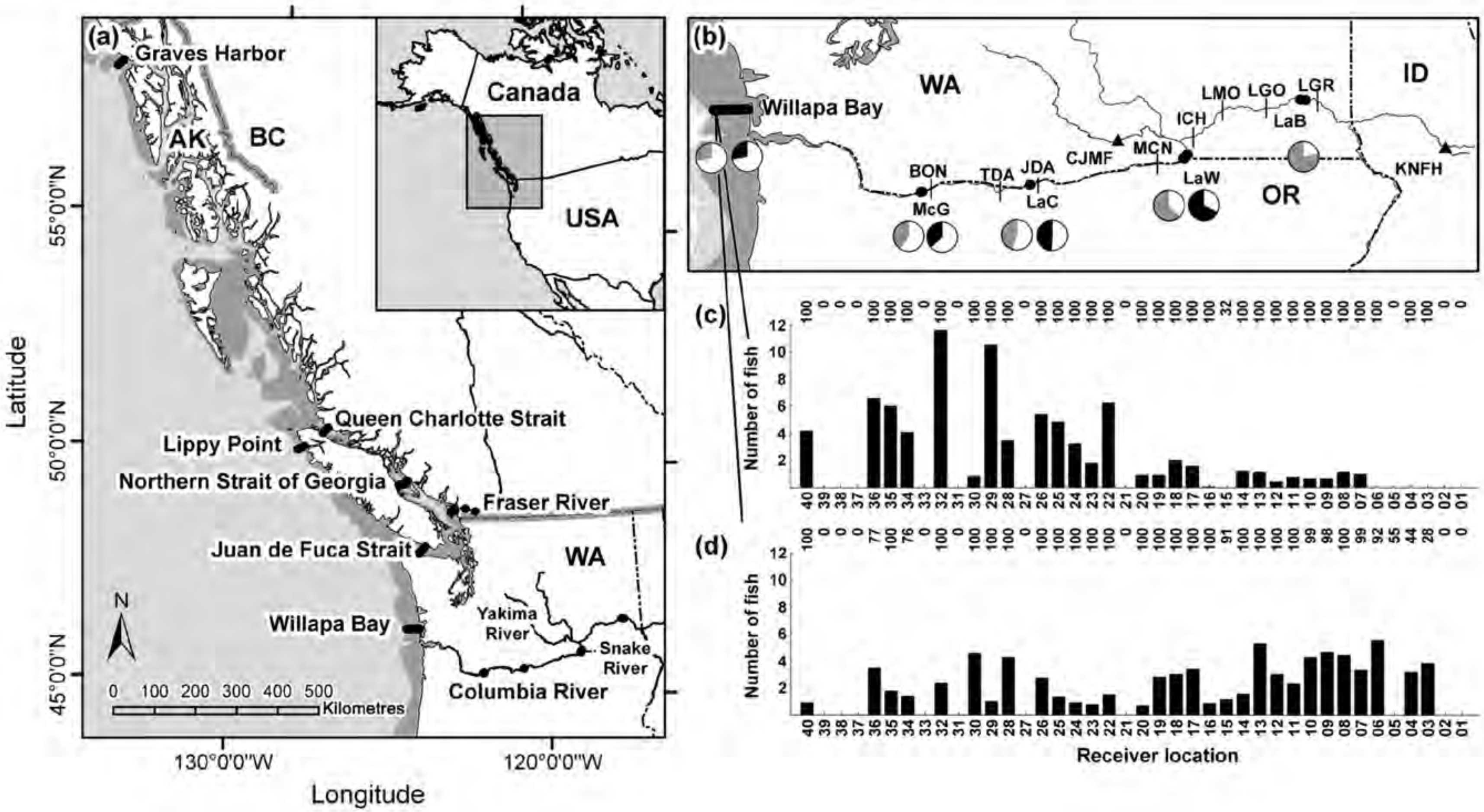

Fig. 1. Panel (*a*) shows the 2006 Pacific Ocean Shelf Tracking (POST) acoustic array (black dots and thick black lines). The continental shelf (depths < 200 m) is shaded. Panel (*b*) shows the location of the release sites (CJMF, Chandler Juvenile Monitoring Facility; KNFH, Kooskia National Fish Hatchery), detection sites (McG, McGowan's Channel; LaC, Lake Celilo; LaW, Lake Wallula; LaB, Lake Bryan), and dams (BON, Bonneville; TDA, The Dalles; JDA, John Day; MCN, McNary; ICH, Ice Harbor; LMO, Lower Monumental; LGO, Little Goose; LGR, Lower Granite) within the Yakima, lower Snake, and Columbia rivers. Pie charts represent the proportion of Chinook salmon (*Oncorhynchus tshawytscha*) surviving to each detection site (Dworshak, grey; Yakima, black). Panels (*c*) and (*d*) show the cross-shelf distribution of Snake River and Yakima River smolts on the Willapa Bay line, respectively. Numbers above the bars represent the percentage of time the receiver was operational during the migration.

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Table 1. Mean survival for Snake River (Dworshak) and Yakima River (Cle Elum Supplementation and Research Facility (CESRF)) spring Chinook salmon (*Oncorhynchus tshawytscha*) implanted with V9-6L acoustic transmitters and passive integrated transponder (PIT) tags in 2006.

Detection site	Segment distance (km)	Dams passed per segment	Est. n	Survival probability	Cumulative survival	Detection probability
Snake River						
LaB	189	1	308	0.78±0.02	0.78±0.02	0.97±0.02
LaW	179	3	245	0.78±0.02	0.61±0.03	0.92±0.03
LaC	162	2	176	0.79±0.02	0.48±0.04	0.56±0.06
McG	116	2	162	0.82±0.06	0.40±0.05	0.72±0.07
WiB	263	0	109	0.74±0.08	0.29±0.04	0.69±0.08
Yakima River						
LaB	NA	NA	NA	NA	NA	NA
LaW	113	0	258	0.70±0.03	0.70±0.03	1.00±0
LaC	162	2	186	0.72±0.03	0.51±0.03	0.77±0.05
McG	116	2	139	0.70±0.02	0.36±0.04	0.86±0.05
WiB	263	0	106	0.78±0.10	0.28±0.05	0.69±0.08

Note: Segment distance to the first detection site is measured from release location; all others are measured from previous detection site (LaB, Lake Bryan; LaW, Lake Wallula; LaC, Lake Celilo; McG, McGowan's Channel; WiB, Willapa Bay). Survival estimates are ±standard error (SE); NA, not applicable. Snake River smolts were released on 1 May (N = 198; mean fork length (FL) = 146.9 mm, range = 140–208 mm) and 8 May (N = 198; mean FL =145.6 mm, range = 140 192 mm); Yakima River smolts released on 30 May (N = 199; mean FL = 154.5 mm, range = 140–173 mm) and 6 June (N = 199; mean FL = 154.5 mm, range = 140–168 mm). The two release dates for Yakima River smolts were chosen in an attempt to have their arrival at Bonneville Dam coincide with the Snake River release groups. Yakima River smolts entered the Columbia River upstream of confluence with Snake River and therefore were not detected on the Lake Bryan line in the Snake River.

Survival analysis

Estimates of smolt survival (Φ) and detection probability (p) at each detection site were calculated using the Cormack–Jolly–Seber (CJS) model for live recaptured animals implemented in Program MARK (White and Burnham 1999). This model jointly estimates survival and detection within a likelihood framework. Because sample size beyond Willapa Bay was low, it was not possible to reliably estimate survival to British Columbia or Alaska. Therefore, we mainly focus on estimates of survival and detection to the ocean line at Willapa Bay.

For in-river lines, we recognized basic CJS model assumptions (equal survival probability, equal recapture probability, no tag loss, and instantaneous sampling); however, for oceanic lines that are not bounded on the offshore end (continental slope), we required two additional assumptions: (*i*) as fish migrate they cross over the acoustic detection lines that span the width of the continental shelf; and (*ii*) the majority of the fish departing the Columbia River swim north. These assumptions are supported by evidence from numerous ocean sampling programs (e.g., Fisher and Pearcy 1995; Brodeur et al. 2004; Bi et al. 2007).

To estimate overdispersion in the data, we used a median $\hat{c}$ procedure (White and Burnham 1999) to test the goodness of fit (GOF) of our global model ($\Phi_{\text{population}\times\text{line}}\,p_{\text{population}\times\text{line}}$) and then corrected for this overdispersion ($\hat{c}$ = 2.1) across all candidate models. We hypothesized that distance and number of dams within a migration segment (Table 1) may affect survival, so we modeled additive effects of each external covariate ($\Phi_{\text{population+distance}}$; $\Phi_{\text{population+dam number}}$), as well as the additive effects of both covariates ($\Phi_{\text{population+distance+dam number}}$), in addition to the fully varying CJS global model. Because of the low number of fish detected at Vancouver Island and Alaska, we included in our models two additional treatment groups (each N = 100) of spring Chinook smolts from Dworshak NFH, tagged with the same acoustic tag, that were released below Bonneville Dam during the spring out-migration to better quantify the detection probability of the Willapa Bay detection line. The survival estimate of this group was modeled in the same way across models ($\Phi_{\text{group}\times\text{line}}$) and did not influence survival estimates for run-of-river smolts. Recapture parameters were modeled to vary with population and line, except at Willapa Bay where all populations were pooled.

We used an information theoretic approach (i.e., Akaike's information criterion (AIC)) to select the most parsimonious model. In general, the model with the lowest AIC value (which accounts for the number of model parameters, n_{pars}) has more support in the data, and if the ΔAIC of the other candidate models is greater than 2, then these models (i.e., hypotheses) have little or no support. We report survival estimates from the model that had the most support.

Cross-shelf distribution

For each population we used a χ^2 GOF test to determine if the cross-shelf ocean distribution adjacent to Willapa Bay was significantly different from the null hypothesis of a uniform distribution. To perform the tests, we counted the number of unique ID codes detected at each of the 40 receivers for each population. If a fish was detected at more than one receiver, a proportion was allocated to the receiver (e.g., if an ID code was detected on two receivers, each receiver was assigned a value of 0.5). If a receiver was displaced during the migration (e.g., by fishing activity), then that receiver was omitted from the data set (30 active receivers were used in the final analysis). To meet the requirements of the χ^2 test, we pooled data into 15 groups.

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Results and discussion

Survival

The most parsimonious model based on an information theoretic approach was the model that constrained survival solely as a function of distance travelled ($\Phi_{population+distance}$, AIC = 1677.0, n_{pars} = 14). Although this model had considerably more support than the global model ($\Phi_{population \times line}$, AIC = 1687.7, ΔAIC = 10.7, n_{pars} = 21), the added effect of distance on survival was negative for Dworshak smolts ($\Phi \cdot km^{-1}$ = 0.9993) as expected, but positive for the Yakima population ($\Phi \cdot km^{-1}$ = 1.0007). This was a surprising result for the Yakima population but was likely caused by low survival in the lower Yakima River (the shortest migration segment, which also lacked dams), combined with higher survival in the lower Columbia River and ocean (the longest segment). The model that constrained survival as a function of dam number also had support in the data ($\Phi_{population+dam\ number}$, AIC = 1677.2, ΔAIC = 0.2, n_{pars} = 14); however, the rate of survival per dam was slightly >1 for both populations, indicating that there was no negative survival effect due to the number of dams passed in a migration segment. The lack of effect of the number of dams passed on direct in-river survival may be a reflection of the improvements of fish passage in the hydrosystem (Muir et al. 2001), so that any remaining negative effect of the dams may be too small to be measurable once the effect of distance is accounted for. There was little support for a model that constrained survival as a function of number of dams within a migration segment and distance travelled ($\Phi_{population+distance+dam\ number}$, AIC = 1680.5, ΔAIC = 3.5, n_{pars} = 16).

Survival of Snake River smolts ranged between 74% and 82% for individual river segments and between 70% and 78% for Yakima smolts (Table 1). Survivorship of Snake and Yakima smolts to McGowan's Channel, located just below Bonneville Dam (the final dam), was 40% and 36%, respectively. There was no detectable difference in survivorship from release to Willapa Bay between populations (S_{Snake} = 29%, S_{Yakima} = 28%; Table 1), and the mean time for smolts to reach this line after passing Bonneville Dam was ~5 days for both. Therefore, delayed mortality was not evident after several days in the coastal ocean at a point located 274 km beyond the hydrosystem. Although we tagged only larger individuals, and migration time was delayed by several weeks relative to untagged runs, these survivorship estimates were very similar to independent PIT tag estimates of survival of Dworshak (see Welch et al. 2008) and Yakima (D. Lind, Yakima–Klickitat Fisheries Project, 771 Pence Road, Yakima, WA 98908, USA, personal communication 2007) spring Chinook salmon in 2006.

Tagged Chinook salmon were also detected on acoustic lines on the west coast of Vancouver Island and Alaska. The large distance between ocean detection sites (~500 and 1000 km, respectively), the relatively low numbers detected on these lines, and the fact that the detected smolts arrived at both locations within 2 days of line deployment prevented us from reliably estimating survival to these locations. However, the detection of four Snake and two Yakima smolts on the Vancouver Island line, some 1500 km distant from the release site (30 days travel time from Willapa Bay for both populations), and the detection of two Snake River smolts on the Alaska line (and none from the Yakima population), some 2500 km from the release site, is inconsistent with the delayed mortality hypothesis.

Coastal ocean distribution

The cross-shelf distribution of the Snake River population was significantly different from the null hypothesis of a uniform distribution (χ^2 GOF test; $p < 0.01$), while the Yakima population was not ($p = 0.57$; Figs. 1*a*, 1*b*), with the Snake population more concentrated on the offshore portion of the line.

Study limitations

Several factors should be considered when interpreting our data. (*i*) We were limited to tagging smolts >140 mm FL, (*ii*) tagged fish were released 2–4 weeks after the main hatchery releases, (*iii*) tagged smolts were detected on the outermost receiver at Willapa Bay, suggesting that some smolts may migrate beyond the offshore extent of the subarray, and (*iv*) arrival to the first ocean line was not simultaneous for the two populations despite our attempts to do so. Future work should address these limitations by using smaller tags, extending the marine components of the array farther offshore (to depths ≥ 200 m), and by modifying release strategies to better synchronize release dates and arrival times in the ocean.

Conclusions

Lower river and early marine survival data for Columbia River basin Chinook salmon is essential for assessing the hypothesized delayed effects of dam passage on smolt survival. In this study, we found no evidence that delayed mortality was expressed by Snake River smolts (>140 mm FL) by the time they had reached the first ocean subarray, some 274 km from Bonneville dam, when compared with a size-matched group from the Yakima River population. This result is based on the assumption that smolts turn north after ocean entry and is supported by the high proportion of smolts detected on the Willapa Bay line subsequent to passing the detection line below Bonneville Dam. The mean time of arrival from below Bonneville Dam to Willapa Bay (5 days) puts an initial lower limit on the period when differential mortality may be expressed in these populations. Our results imply that if delayed mortality causes the disparity in adult return rates of hatchery-origin Snake River spring Chinook salmon, it is at a time and place more distant from the Columbia River; however, it is plausible that delayed mortality may operate on smaller fish (<140 mm FL) that were not tested here. Our result that the number of dams passed within a migration segment did not affect survival also supports the findings that direct in-river survival of salmon smolts has increased in recent decades (Muir et al. 2001), possibly to the level of an undammed river (Welch et al. 2008). We note that our study was not designed to measure very small effects on mortality, as it was focused on making the first large-scale measurements of migratory survival for salmon originating from the Columbia River. It is not correct to conclude that the dams currently play no role in affecting survival, simply that any contributory effect appears to be small.

The differing marine distributions of the two populations at Willapa Bay provides a potential mechanism in support of the alternative hypothesis that populations from the same river basin can have different responses to ocean conditions (e.g., Levin 2003). It remains unclear whether the entire size range of these two populations, as well as wild smolts, have similar survival and behavior as the smolts reported here. The technical development of the POST array allowed us to make a direct scientific test of a key hypothesis concerning delayed mortality of a population of Snake River spring Chinook salmon in the ocean. As such, it marks an important scientific milestone. Advances in the array design, however, will allow us to study marine survival over the complete size range of naturally occurring spring Chinook smolts, as well as other endangered populations of salmon originating from the Columbia River basin.

Acknowledgements

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LETTER

Nonrepresentative fish and ocean migration assumptions confound inferences in Rechisky et al.

Close examination of the methods, assumptions, and results of Rechisky et al. (1) indicate that their results are confounded by nonrepresentative tagging, rearing, and release factors, and that critical assumptions are inconsistent with available data. Thus, the authors' conclusions regarding hydrosystem-related delayed mortality are overreaching and unsupportable.

Nonrepresentative fish with acoustic tags were 10–20 mm longer, were released 21–83 d later, and were released 55–249 rkm further downriver than their corresponding hatchery populations of inference. Length at tagging, timing of release (2), and migration distance have all been shown to influence survival rates of Chinook salmon at multiple life stages. Any of these factors alone confound comparisons with the populations of inference, let alone the combination of all three.

Rechisky et al. (1) report that estimation of detection probabilities for the Lippy Point subarray was not possible because of too few detections of tagged smolts at the distant Alaska subarray. This assumption weakens the reliability of survival estimates used to draw conclusions concerning delayed mortality. The sensitivity analysis used to explore the effects of alternative assumptions is narrow in view of the large uncertainty in detection probability.

Rechisky et al. (1) assume that all fish migrated North on the continental shelf at depths shallower than 200 m and through the Lippy Point subarray. If this assumption is not valid, the reported survival estimates will be biased low. Studies by McMichael et al. (3) and Schreck et al. (4) indicate that this assumption is likely violated. The degree of bias is unknown.

Contrary to Rechisky et al. (1), in-river survival varies between 25% and 83% and is influenced by hydrosystem conditions (2). Ocean survival rates and smolt-to-adult survival rates are also influenced by hydrosystem conditions (2, 5). These studies demonstrate that hydrosystem management actions influence survival at multiple life stages.

Rechisky et al. (1) found no evidence that Snake River hatchery Chinook smolts experienced lower survival rates in the early ocean than those from the Yakima River that migrated through fewer dams. The authors acknowledge these estimates represented tagged groups whose size, holding, and timing of release had been significantly manipulated to accommodate acoustic tags. As a result, tagged fish were not representative of the hatchery populations of inference. Similarly, the size-distribution of the hatchery study fish was larger than all but a small fraction of the wild individuals, concurrent with differences in migration timing between study fish and wild fish. The study was short term (3 y) and the migration conditions that study fish experienced were different from migration conditions experienced by most wild and hatchery fish. Because of low sample sizes and poor detection efficiency, untested, critical assumptions about detection probabilities and ocean migration patterns were required. Thus, the findings of Rechisky et al. on delayed hydrosystem mortality for wild or hatchery fish are highly questionable.

Steven Haeseker[1]

US Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA 98683

1 Rechisky EL, Welch DW, Porter AD, Jacobs-Scott MC, Winchell PM (2013) Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean. *Proc Natl Acad Sci USA* 110(17):6883–6888.

2 Haeseker SL, McCann JA, Tuomikoski J, Chockley B (2012) Assessing freshwater and marine environmental influences on life-stage-specific survival rates of Snake River spring-summer Chinook salmon and steelhead. *Trans Am Fish Soc* 141(1):121–138.

3 McMichael GA, et al. (2011) *Migratory Behavior and Survival of Juvenile Salmonids in the Lower Columbia River, Estuary, and Plume in 2010, PNNL-20443* (Pacific Northwest National Laboratory, Richland, WA).

4 Schreck CB, Karnowski MD, Clemens BJ (2005) *Evaluation of Post-Release Losses and Barging Strategies that Minimize Post-Release Mortality.* DACW68-00-C-0028 (Oregon Cooperative Fish and Wildlife Research Unit, Corvallis, OR).

5 Petrosky CE, Schaller HA (2010) Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead. *Ecol Freshwat Fish* 19(4): 520–536.

Author contributions: S.H. analyzed data and wrote the paper.

The author declares no conflict of interest.

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From: Erin Rechisky

Sent: Wed Apr 01 13:09:47 2015

To: Creason,Anne M (BPA) - KEWL-4

Subject: RE: Spatial and temporal covariability in early ocean survival of Chinook salmon (Oncorhynchus tshawytscha) along the west coast of North America

Importance: Normal

Hi Anne,

Thanks for this. I saw a talk at the SOE meeting a few years ago that incorporated some of this work and I contacted Patrick for Figure 4 so I could show the decline in survival was happening coast-wide, not just the Columbia.

(b)(5) [redacted]

Erin

From: Creason,Anne M (BPA) - KEWL-4 [mailto:amcreason@bpa.gov]
Sent: Tuesday, March 31, 2015 3:54 PM
To: Erin Rechisky

Subject: FW: Spatial and temporal covariability in early ocean survival of Chinook salmon (Oncorhynchus tshawytscha) along the west coast of North America

Very interesting. Curious to hear what your take is on this one.

They are looking at hatchery returns from California to Alaska. [redacted]

From: Eric Hertz

Sent: Tue Apr 07 19:18:41 2015

To: ralexander@lgl.com; shannon.anderson@dfo-mpo.gc.ca; davebea@uw.edu; ibeveridge@lgl.com; brian.beckman@noaa.gov; rick.brodeur@noaa.gov; Brian.Burke@noaa.gov; alan.byrne@idfg.idaho.gov; campblac@dfw.wa.gov; bconnors@essa.com; amcreason@bpa.gov; Elizabeth.Daly@oregonstate.edu; elan.downey@cahs-bc.ca; rmflagg@uvic.ca; kurt.fresh@noaa.gov; jennifer.gosselin@noaa.gov; sean.hayes@noaa.gov; lizj@ssraa.org; kym.jacobson@noaa.gov; jenkins@psc.org; juanes@uvic.ca; jpkarnezis@bpa.gov; iris.kemp@gmail.com; neala.kendall@dfw.wa.gov; lapointe@psc.org; peter.w.lawson@noaa.gov; Nick.Leone@dfo-mpo.gc.ca;[redacted]@msn.com; mckinnell@shaw.ca; mvmcphee@alaska.edu; cheryl.morgan@oregonstate.edu; jamal.moss@noaa.gov;[redacted]@comcast.net; Don.Noakes@viu.ca; joe.orsi@noaa.gov; erin.rechisky@kintama.com; gordrees@uvic.ca; megan.sabal@noaa.gov; asastri@uvic.ca; mschmidt@lltk.org; [redacted]@gmail.com; david.teel@noaa.gov; thomas.wainwright@noaa.gov; dmwebber@vemco.com; laurie.weitkamp@noaa.gov; jgw3@uw.edu; Margaret.Wright@dfo-mpo.gc.ca; jen.zamon@noaa.gov; mara.zimmerman@dfw.wa.gov; dower@uvic.ca; cecile.vanwoensel@cahs-bc.ca; willduguid@hotmail.com; camfresh@uvic.ca;[redacted]@gmail.com; mgamble@u.washington.edu; shrushow@sfu.ca; journey@uw.edu; litzm@onid.orst.edu; mmalick@sfu.ca; melissa.nottingham@dfo-mpo.gc.ca; emp11@uw.edu[redacted]@gmail.com; dstormer@uvic.ca; bill.peterson@noaa.gov; brian.wells@noaa.gov; david.welch@kintama.com; beamishr@pac.dfo-mpo.gc.ca; Ed.Farley@noaa.gov; gruggerone@nrccorp.com; jhassrick@usbr.gov; jessica.miller@oregonstate.edu; nate.mantua@noaa.gov

Cc: Marc.Trudel@dfo-mpo.gc.ca

Subject: 2014-2015 Bibliography of juvenile salmon publications for NPAFC

Importance: Normal

Attachments: NPAFC Juvenile salmon bibliography 2015.docx

Dear colleagues,

Marc Trudel and I are putting together a bibliography of publications on the marine ecology of North American juvenile salmon for the North Pacific

Anadromous Fish Commission. We put together a similar publication over the time period of 2006-2014 (http://www.npafc.org/new/publications/Documents/PDF%202014/1520%28Canada%29.pdf) as part of a review we presented at the Third NPAFC International Workshop on Factors Affecting Production of Juvenile Salmon held in Honolulu in 2013 and now we would like to update it for 2014-2015 papers.

I've attached the bibliography thus far. If we have missed any of your 2014-2015 papers, or you have any papers in press, please let us know and we will add these papers to the bibliography.

Thank you,

Eric

Araujo, H. A., Candy, J. R., Beacham, T. D., White, B., & Wallace, C. (2014). Advantages and challenges of genetic stock identification in fish stocks with low genetic resolution. *Transactions of the American Fisheries Society*, *143*(2), 479–488. http://doi.org/10.1080/00028487.2013.855258

Genetic stock identification (GSI) is widely applied to mixed-stock fisheries for many commercially exploited species. However, the accuracy of GSI depends on the level of differentiation among stocks. To evaluate our ability to estimate contributions in mixed-stock fisheries of Pink Salmon *Oncorhynchus gorbuscha*, a species with limited population genetic differentiation, we analyzed 46 odd-year Pink Salmon stocks belonging to a baseline of genotypes from southern British Columbia, the Fraser River, and Puget Sound. Samples were obtained without replacement from the baseline (known mixtures), and 16 microsatellite loci were used for analysis with two software packages (cBayes and ONCOR) to evaluate the accuracy of using this marker set to identify the correct region, subregion, and spawning site. The correct subregion was identified for Pink Salmon from southern British Columbia and Puget Sound. However, incorrect assignments were observed for the Fraser River subregions and the stock-specific estimates. In addition, we used simulated baselines with the average genetic differentiation index F (ST) ranging from 0.0007 to 0.04 (the range of F (ST) values observed in Pink Salmon stocks) to identify biases in the GSI software programs. The results suggested that stock-level genetic identification is subject to significant biases (>15%) when the average F (ST) among baseline stocks is less than 0.01. ONCOR was more accurate than cBayes in identifying the correct stock at small mean F (ST) values (<0.01), but there was no significant difference between the software packages at larger F (ST) values. Our results can help to improve GSI methods and to identify their limitations, especially for stocks with low genetic separation.

Beacham, T. D., Beamish, R. J., Candy, J. R., Wallace, C., Tucker, S., Moss, J. H., & Trudel, M. (2014a). Stock-specific migration pathways of juvenile Sockeye Salmon in British Columbia waters and in the Gulf of Alaska. *Transactions of the American Fisheries Society*, *143*(6), 1386–1403. http://doi.org/10.1080/00028487.2014.935476

We outlined the route and relative timing of juvenile Sockeye Salmon *Oncorhynchus nerka* migration by analyzing stock composition and relative CPUE in marine sampling conducted in coastal British Columbia and the Gulf of Alaska. Variation at 14 microsatellites was analyzed for 10,500 juvenile Sockeye Salmon obtained from surveys conducted during 1996–2011. Using a 404-population baseline, we identified the sampled individuals to 47 populations or stocks of origin. Stock compositions of the mixtures increased in diversity in more northerly sampling locations, indicating a general northward movement of juveniles. The primary migration route of Columbia River and Washington stocks was northward along the west coast of Vancouver Island, with a majority of the juveniles subsequently migrating through Queen Charlotte Sound and Dixon Entrance. Fraser River stocks migrated principally through the Strait of Georgia and Johnstone Strait. Some Fraser River populations, such as the Cultus Lake population, appeared to spend little time rearing in the Strait of Georgia, as individuals from this population were primarily observed in July samples from Hecate Strait, Dixon Entrance, and Southeast Alaska. Other Fraser River populations, such as the Chilko Lake and Quesnel Lake populations, were widely distributed during July surveys, as they were observed from the Gulf of Alaska to the Strait of Georgia. For the British Columbia central coast and Owikeno Lake stocks, not all individuals migrated northward in the summer: some individuals were still present in local areas during the fall and winter after spring entry into the marine environment. Juvenile Fraser River

Sockeye Salmon dominated the catch of juveniles at the Yakutat, Prince William Sound, Kodiak Island, and Alaska Peninsula sampling locations. There was a wide divergence among stocks in dispersion among sampling locations.

Beacham, T. D., Beamish, R. J., Candy, J. R., Wallace, C., Tucker, S., Moss, J. H., & Trudel, M. (2014b). Stock-specific size of juvenile Sockeye Salmon in British Columbia waters and the Gulf of Alaska. *Transactions of the American Fisheries Society*, *143*(4), 876–889. http://doi.org/10.1080/00028487.2014.889751

The variation at 14 microsatellites was analyzed for 10,500 juvenile Sockeye Salmon *Oncorhynchus nerka* obtained from coastal British Columbia and Gulf of Alaska surveys during 1996–2011. A 404-population baseline was used to determine the individual identifications of the fish sampled, with individuals being identified to 47 populations or stocks of origin. Columbia River and Washington juveniles were consistently larger than those from British Columbia and Alaska. During July, larger individuals from the same Fraser River stock were observed in more northerly locations compared with those in the Strait of Georgia. There was a relationship between the timing of northward migration from the Strait of Georgia and juvenile body size, with individuals from larger populations or stocks migrating earlier than individuals from smaller stocks which remain resident for longer. There was a wide divergence among stocks in juvenile size and dispersion among sampling locations.

Beacham, T. D., Candy, J.C., Sato, S., & Urawa, S. (2014). Microsatellite identification of sockeye salmon rearing in the Bering Sea during 2009-2013. NPAFC Doc. 1511. 18 pp. (Available at http://www.npafc.org).

Stock composition of sockeye salmon (*Oncorhynchus nerka*) caught in the southern central Bering Sea during Japanese research cruises in the summers of 2009, 2011, 2012, and 2013 was estimated through an analysis of microsatellite variation. Variation at 14 microsatellites was analyzed for immature sockeye salmon, and a 404-population baseline spanning Japan, Russia, Alaska, Canada, and Washington State was used to determine the stock composition of the fish sampled. Alaskan-origin sockeye salmon were the most abundant in the catch, comprising 86.1% of all sockeye salmon caught (United States total 86.1%), with the catch dominated by sockeye salmon of Bristol Bay origin. Russian-origin salmon accounted for an average of 10.6% of the annual catch, while Canadian-origin sockeye salmon accounted for 3.4% of the annual catch.

Beakes, M. P., Sharron, S., Charish, R., Moore, J. W., Satterthwaite, W. H., Sturm, E., Wells, B. K., Sogard, S. M. & Mangel, M. (2014). Using scale characteristics and water temperature to reconstruct growth rates of juvenile steelhead *Oncorhynchus mykiss*. *Journal of Fish Biology*, *84*(1), 58–72. http://doi.org/10.1111/jfb.12254

Juvenile steelhead *Oncorhynchus mykiss* from a northern California Central Valley population were reared in a controlled laboratory experiment. Significantly different rates of growth were observed among fish reared under two ration treatments and three temperature treatments (8, 14 and 20° C). Wider circulus spacing and faster deposition was associated with faster growth. For the same growth rate, however, circulus spacing was two-fold wider and deposited 36% less frequently in the cold compared to the hot temperature treatment. In a multiple linear regression, median circulus spacing and water temperature accounted for 68% of the variation in observed O. mykiss growth. These results corroborate previous research on scale characteristics and growth, while providing novel evidence that highlights the importance of water temperature in these relationships. Thus, this study establishes the utility of using scale analysis as a relatively non-invasive method for inferring growth in salmonids.

Bennett, T. R., Roni, P., Denton, K., McHenry, M., & Moses, R. (2014). Nomads no more: early juvenile coho salmon migrants contribute to the adult return. *Ecology of Freshwater Fish*, 24: 264–275. http://doi.org/10.1111/eff.12144

The downstream movement of coho salmon fry and parr in the fall, as distinct from the spring migration of smolts, has been well documented across the range of the species. In many cases, these fish overwinter in freshwater, but they sometimes enter marine waters. It has long been assumed that these latter fish did not survive to return as adults and were "surplus" to the stream's carrying capacity. From 2004 to 2010, we passive integrated transponder tagged 25,981 juvenile coho salmon in three streams in Washington State to determine their movement, survival and the contribution of various juvenile life histories to the adult escapement. We detected 86 returning adults, of which 32 originated from fall/winter migrants. Half of these fall/winter migrants spent ~1 year in the marine environment, while the other half spent ~2 years. In addition, the median return date for fall/winter migrants was 16 days later than spring migrants. Our results indicated that traditional methods of spring-only smolt enumeration may underestimate juvenile survival and total smolt production, and also overestimate spring smolt-to-adult return (SAR). These are important considerations for coho salmon life cycle models that assume juvenile coho salmon have a fixed life history or use traditional parr-to-smolt and SAR rates.

Brodeur, R. D., Buchanan, J. C., Emmett, R. C. (2014). Pelagic and demersal fish predators on juvenile and adult forage fishes in the northern California Current: spatial and temporal variations. *CalCOFI Report, 55*, 96-116.

A requisite for reliable food web models and ecosystem-based management in regions such as the California Current is the availability of diet information on key predators. In upwelling ecosystems, much of the lower trophic level energy may be transferred through a relatively small set of very abundant pelagic forage fish taxa, such as anchovies, sardines, smelts, and herring. In addition the pelagic juvenile stages of some important midwater and demersal fishes (Pacific hake and rockfishes) may act as forage fishes during a more limited time period each year. In this paper, we review what is known about the utilization of these forage species by larger fish predators and elasmobranchs in the Northern California Current (NCC) from northern Washington to northern California (Cape Mendocino) to examine spatial and temporal variations in the kinds and sizes of forage fishes consumed. We found that predation on forage fishes was highly variable in space and time, and was often dependent on the size of the prey available as well as the predator. Pacific hake and spiny dogfish have the potential to be dominant forage fish predators due to their high biomass but other species such as arrowtooth flounder and Pacific halibut can be important due to their high proportion of forage fish in the diet. We also highlight where diet information is limited or lacking, and areas where regular fish diet monitoring could be useful for ecosystem-based management.

Brosnan, I. G., Welch, D. W., Rechisky, E. L., & Porter, A. D. (2014). Evaluating the influence of environmental factors on yearling Chinook salmon survival in the Columbia River plume (USA). *Marine Ecology Progress Series*, *496*, 181–196. http://doi.org/10.3354/meps10550

The impact of oceanographic processes on early marine survival of Pacific salmon is typically estimated upon adult return, 1 to 5 yr after ocean entry, and many 1000s of kilometers after initial exposure. Here, we use direct estimates of early marine survival obtained from acoustic-tagged yearling Chinook salmon *Oncorhynchus tshawytscha* that entered the Columbia River plume (USA) after migrating down the river and then north to the coastal waters off Willapa Bay, Washington. Plume residence time averaged 7 d, and was of such short duration that predation, rather than feeding and growth conditions, was the likely primary cause of mortality. Plume survival ranged from 0.13 to 0.86, but was stable when scaled by plume residence time, and we find that a simple exponential decay model adequately describes plume survival. Plume survival, and perhaps adult returns, could be improved by reducing plume residence time if the drivers controlling residence time were amenable to management control. However, we show that a statistical model of plume residence time that includes only sea-surface temperature far outperforms models that include river discharge and coastal upwelling. Timing hatchery releases using marine environmental forecasts could potentially improve smolt survival by minimizing their residence time in regions of poor survival. Acoustic telemetry may be used to evaluate the value and effectiveness of such approaches.

Burke, B. J., Anderson, J. J., & Baptista, A. M. (2014). Evidence for multiple navigational sensory capabilities of Chinook salmon. *Aquatic Biology*, *20*(1), 77–90. http://doi.org/10.3354/ab00541
To study the complex coastal migrations patterns exhibited by juvenile Columbia River Chinook salmon as they enter and move through the marine environment, we created an individual-based model in a coupled Eulerian-Lagrangian framework. We modeled 5 distinct migration strategies and compared the resulting spatial distributions to catch data collected during May and June in 3 years. Two strategies produced fish distributions similar to those observed in May but only one also produced the observed June distributions. In both strategies, salmon distinguish north from south (i.e. they have a compass sense), and they control their position relative to particular landmarks, such as the river mouth. With these 2 abilities, we posit that salmon follow spatially explicit behavior rules that prevent entrapment in strong southward currents and advection offshore. Additionally, the consistent spatio-temporal distributions observed among years suggest that salmon use a clock sense to adjust their swim speed, within and among years, in response to progress along their migration.

Campbell, L. A., Bottom, D. L., Volk, E. C., & Fleming, I. A. (2015). Correspondence between scale morphometrics and scale and otolith chemistry for interpreting juvenile salmon life histories. *Transactions of the American Fisheries Society*, *144*(1), 55–67. http://doi.org/10.1080/00028487.2014.963253
Fish scales have long been used to reconstruct fine-scale habitat transitions such as the movement of juvenile fish from freshwater, estuary, and ocean environments. Despite the importance of life history information to fisheries management and conservation, few studies have validated that scale morphology accurately describes fish movement between these habitats. Therefore, we tested the accuracy of using scale morphometric criteria to identify the movement of juvenile Chinook Salmon *Oncorhynchus tshawytscha* from freshwater to marine portions of the Columbia River estuary by comparing scale morphometric classification, scale chemistry, and otolith chemistry. Nearly one-half of all fish collected in the saline portion of the estuary and approximately one-quarter in the freshwater portion exhibited morphometric patterns (i.e., scale

checks and intermediate growth) often associated with periods of estuary rearing. Depending upon the criteria used to define scale checks, otolith chemical results indicated that 33–53% of fish would have been misclassified as estuary residents based solely on their scale patterns. Moreover, many individuals who had resided in strontium-rich estuary water did not form a visible check (37%) on their scales to coincide with estuary entry. We estimated from otolith chemistry that these fish had either entered at or near the size at which scale formation occurs (35–42 mm) or had recently migrated to the saline portion of the estuary (<30 d) before new scale material could be formed and calcified. Scale chemistry alone was a good indicator of entrance into the saline portion of the estuary. Scale chemistry responded to the strontium-enriched salt water, and explained 86% of the variation found in otolith chemistry. Scale morphometric classification did not provide the fine-scale resolution that scale and, even more so, otolith chemistry provided for describing the proportion of juvenile Chinook salmon using the saline portion of the Columbia River estuary.

Carr-Harris, C., Gottesfeld, A. S., & Moore, J. W. (2015). Juvenile salmon usage of the Skeena River estuary. *PLoS ONE*, *10*(3), e0118988. http://doi.org/10.1371/journal.pone.0118988
Migratory salmon transit estuary habitats on their way out to the ocean but this phase of their life cycle is more poorly understood than other phases. The estuaries of large river systems in particular may support many populations and several species of salmon that originate from throughout the upstream river. The Skeena River of British Columbia, Canada, is a large river system with high salmon population- and species-level diversity. The estuary of the Skeena River is under pressure from industrial development, with two gas liquefaction terminals and a potash loading facility in various stages of environmental review processes, providing motivation for understanding the usage of the estuary by juvenile salmon. We conducted a juvenile salmonid sampling program throughout the Skeena River estuary in 2007 and 2013 to investigate the spatial and temporal distribution of different species and populations of salmon. We captured six species of juvenile anadromous salmonids throughout the estuary in both years, and found that areas proposed for development support some of the highest abundances of some species of salmon. Specifically, the highest abundances of sockeye (both years), Chinook in 2007, and coho salmon in 2013 were captured in areas proposed for development. For example, juvenile sockeye salmon were 2–8 times more abundant in the proposed development areas. Genetic stock assignment demonstrated that the Chinook salmon and most of the sockeye salmon that were captured originated from throughout the Skeena watershed, while some sockeye salmon came from the Nass, Stikine, Southeast Alaska, and coastal systems on the northern and central coasts of British Columbia. These fish support extensive commercial, recreational, and First Nations fisheries throughout the Skeena River and beyond. Our results demonstrate that estuary habitats integrate species and population diversity of salmon, and that if proposed development negatively affects the salmon populations that use the estuary, then numerous fisheries would also be negatively affected.

Celewycz, A. G., Fergusson, E. A. Moss, J. H. & Orsi, J. A. (2014). High seas salmonid coded-wire tag recovery data, 2013. NPAFC Doc. 1528. 37 p. (Available at http://www.npafc.org).
Information on high seas recoveries of salmonids (*Oncorhynchus* spp.) tagged with coded-wire tags (CWTs) has been reported annually to the International North Pacific Fisheries Commission (1981-1992) and to the North Pacific Anadromous Fish Commission (NPAFC, 1993-present). Data from these CWT recoveries are also reported to the Regional Mark Processing Center

(RMPC, http://www.rmpc.org) of the Pacific States Marine Fisheries Commission (PSMFC) for inclusion into their Regional Mark Information System (RMIS) Database. This document lists recovery data for 324 CWT salmonids that will be reported to PSMFC/RMPC for the first time. These CWTs were recovered from 1) the U.S. groundfish trawl fishery in the Gulf of Alaska (GOA) as sampled by observers (10 Chinook salmon, *O.tshawytscha*) in 2012 and 2013, 2) the U.S. groundfish trawl fishery in the GOA as sampled in a CWT tunnel detector test conducted at a Kodiak processing plant (71 Chinook salmon) in 2012, 3) Salmon Excluder Device testing in the GOA (40 Chinook salmon) in 2013, 4) rockfish trawl fishery in the GOA (113 Chinook salmon) in 2013), 4) the U.S. groundfish trawl fishery in the eastern Bering Sea-Aleutian Islands (BSAI, 7 Chinook salmon) in 2012 and 2013, and 5) U.S. trawl research in the GOA (68 Chinook salmon and 15 coho salmon, *O. kisutch*) in 2012. No new CWT recoveries from either the at-sea Pacific hake (*Merluccius productus*) trawl fishery in the Northern Pacific Ocean off Washington/Oregon (WA/OR) or the West Coast trawl fishery off Washington/Oregon/California (WA/OR/CA) have been reported to the RMPC since 2011. No new CWT recoveries from foreign high seas research have been reported to the RMPC since 2010.

Chamberlin, J. W., & Quinn, T. P. (2014). Effects of natal origin on localized distributions of Chinook salmon, *Oncorhynchus tshawytscha,* in the marine waters of Puget Sound, Washington. *Fisheries Research*, *153*, 113–122. http://doi.org/10.1016/j.fishres.2014.01.008
The inland marine waters of Puget Sound, Washington, and the Strait of Georgia and associated waters of British Columbia (the Salish Sea) have long been recognized as alternative rearing habitat to the continental shelf for Chinook and coho salmon. Recent analyses have indicated that these fish (termed residents) comprise a substantial fraction of the Chinook salmon populations originating from Puget Sound rivers. However, the extent to which these resident salmon remain within their natal region or move within Puget Sound has not been studied. Analysis of two decades of coded-wire tagging data revealed several clear patterns. First, the salmon showed spatial distributions that varied systematically with area of origin. In general, they were caught in the vicinity of their origin, indicating limited net movement during several years at large; however this pattern was not universal. Second, recovery distributions were highly influenced by marine age and showed region specific spatial patterns, with the largest differences between the youngest (marine age 1) and oldest (marine age 4) individuals.

Claiborne, A. M., Miller, J. A., Weitkamp, L. A., Teel, D. J., & Emmett, R. L. (2014). Evidence for selective mortality in marine environments: the role of fish migration size, timing, and production type. *Marine Ecology Progress Series*, *515*, 187–202. http://doi.org/10.3354/meps10963
The underlying causes of mortality during critical life stages of fish are not well understood, nor is it clear if these causes are similar for naturally versus artificially propagated (i.e. hatchery) individuals. To assess the importance of selective mortality related to production type (hatchery vs. naturally produced) and size at and timing of marine entry, we compared attributes of juvenile Chinook salmon *Oncorhynchus tshawytscha* from the upper Columbia River summer- and fall-run genetic stock group captured in the Columbia River estuary with back-calculated attributes of survivors captured in marine waters. We used genetic stock identification, otolith chemistry and structure, and physical tags to determine stock of origin, size at and timing of marine entry, and production type. Fish emigrated from fresh water in May to September and the majority of fish collected in the estuary (87%) had arrived within 3 d of capture. In 1 of 2 yr,

timing of marine entry for both production types differed between the estuary and ocean: the ocean catch included a greater proportion of juveniles that emigrated in late July than the estuary catch. There was no evidence of selective mortality of smaller juveniles during early marine residence in hatchery or natural juveniles, but the mean percentage (±SE) of hatchery fish in ocean collections was 16 ± 5.8% less than in the estuary, which could indicate reduced survival compared to naturally produced fish. Results from this study highlight the need to understand the effects of hatchery rearing and how hatchery propagation may influence survival during later critical life-history transitions.

Copeland, T., Venditti, D. A., & Barnett, B. R. (2014). The importance of juvenile migration tactics to adult recruitment in stream-type Chinook Salmon populations. *Transactions of the American Fisheries Society*, *143*(6), 1460–1475. http://doi.org/10.1080/00028487.2014.949011

The existence of multiple migration tactics within a population has been observed for several fish species, and they may contribute differentially to adult recruitment. Relative contribution by juveniles using the same habitats on different schedules is variable; therefore, understanding and conserving this diversity should be important to fisheries managers. We investigated adult recruitment by two distinct juvenile migration tactics in several spawning populations of stream-type Chinook Salmon *Oncorhynchus tshawytscha* in Idaho: those leaving the spawning grounds as subyearlings during June through November (downstream rearing, or DSR, type) and those emigrating from natal areas 1 year after emergence (natal reach rearing, or NRR, type). The DSR type had greater juvenile abundance in all populations, although the NRR type exhibited better survival from the natal reach to the migratory corridor. The DSR type had greater survival from smoltification to adult return to freshwater compared with the NRR type. More DSR emigrants than NRR emigrants returned to freshwater as adults, although the difference was influenced by cohort and population. Adult recruits to stream-type Chinook Salmon populations in Idaho are comprised mostly of DSR emigrants, i.e., fish that dispersed from their natal habitats and reared in reaches downstream. This finding is ubiquitous, although the size of the effect depends on cohort and population. We demonstrated that juvenile Chinook Salmon in Idaho do indeed use downstream rearing habitats effectively, thereby increasing recruitment of adults back to the spawning gravels in these populations. This study illustrates how dispersive life histories are essential to achieve the full productive potential of migratory stream fish populations.

Craig, B. E., Simenstad, C. A., & Bottom, D. L. (2014). Rearing in natural and recovering tidal wetlands enhances growth and life-history diversity of Columbia Estuary tributary coho salmon *Oncorhynchus kisutch* population. *Journal of Fish Biology*, *85*(1), 31–51. http://doi.org/10.1111/jfb.12433

This study provides evidence of the importance of tributary tidal wetlands to local coho salmon *Oncorhynchus kisutch* populations and life-history diversity. Subyearling and, to a lesser extent, yearling *O. kisutch* life histories utilized various estuary habitats within the Grays River, a tidal freshwater tributary of the Columbia River estuary, including restoring emergent wetlands and natural forested wetlands. Migration timing data, size distributions, estuary residence and scale patterns suggest a predominance of subyearling migrant life histories, including several that involve extended periods of estuary rearing. Estuarine-rearing subyearling *O. kisutch* exhibited the greatest overall growth rates; the highest growth rates were seen in fish that utilized restoring emergent wetlands. These results contrast with studies conducted in the main-stem Columbia

River estuary, which captured few *O. kisutch*, of which nearly all were hatchery-origin yearling smolts. Restoration and preservation of peripheral and tributary wetland habitats, such as those in the Grays River, could play an important role in the recovery of natural *O. kisutch* populations in the Columbia River and elsewhere.

Daly, E. A., Scheurer, J. A., Brodeur, R. D., Weitkamp, L. A., Beckman, B. R., & Miller, J. A. (2014). Juvenile Steelhead distribution, migration, feeding, and growth in the Columbia River estuary, plume, and coastal waters. ***Marine and Coastal Fisheries*****,** ***6*****(1), 62–80. http://doi.org/10.1080/19425120.2013.869284**

Relative to extensive research on the freshwater stages of steelhead *Oncorhynchus mykiss* life history, little is known about the species' estuarine and early marine phases despite the decline of numerous populations, including several from the Columbia River. Comparisons of the distribution, diet, and growth of juvenile steelhead collected during surveys of the Columbia River estuary and coastal waters in May, June, and September 1998–2011 were analyzed for comparisons between fish caught in the estuary and ocean and between hatchery (marked) and putative wild (unmarked) fish. Almost all catches of juvenile steelhead in the ocean occurred during the May surveys (96%). Juvenile steelhead were consistently caught at the westernmost stations (>55 km from shore), indicating an offshore distribution. Based on otolith structure and chemistry, we determined that these juveniles had been in marine waters for an average of only 9.8 d (SD = 10.2). Some of the steelhead that had been in marine waters for 1–3 d were captured at the westernmost edge of survey transects, indicating rapid offshore migration. Estuary-caught fish ate fewer prey types and consumed far less food than did ocean-caught fish, which ate a variety of prey, including juvenile fishes, euphausiids, and crab megalopae. Estuary- and ocean-caught unmarked fish exhibited higher feeding intensities, fewer empty stomachs, and better condition than hatchery fish. Growth hormone levels (insulin-like growth factor 1 [IGF-1]) in unmarked fish and hatchery fish varied annually, with unmarked fish having slightly higher overall values. In general, the FL, condition, stomach fullness, and IGF-1 of ocean-caught steelhead increased with distance offshore. Unlike juveniles of other salmonid species, steelhead appeared to quickly migrate westward from coastal rivers and showed patterns of increased feeding and growth in offshore waters. An understanding of the estuarine and ocean ecology of steelhead smolts may assist in the management of threatened steelhead populations.Received

David, A. T., Ellings, C. S., Woo, I., Simenstad, C. A., Takekawa, J. Y., Turner, K. L., Smith, A.L., & Takekawa, J. E. (2014). Foraging and growth potential of juvenile Chinook Salmon after tidal restoration of a large river delta. ***Transactions of the American Fisheries Society*****,** ***143*****(6), 1515–1529. http://doi.org/10.1080/00028487.2014.945663**

We evaluated whether restoring tidal flow to previously diked estuarine wetlands also restores foraging and growth opportunities for juvenile Chinook Salmon *Oncorhynchus tshawytscha*. Several studies have assessed the value of restored tidal wetlands for juvenile Pacific salmon *Oncorhynchus* spp., but few have used integrative measures of salmon performance, such as habitat-specific growth potential, to evaluate restoration. Our study took place in the Nisqually River delta, Washington, where recent dike removals restored tidal flow to 364 ha of marsh—the largest tidal marsh restoration project in the northwestern contiguous United States. We sampled fish assemblages, water temperatures, and juvenile Chinook Salmon diet composition and consumption rates in two restored and two reference tidal channels during a 3-year period after restoration; these data were used as inputs to a bioenergetics model to compare Chinook Salmon foraging performance and growth potential between the restored and reference channels. We found that foraging performance and growth potential of juvenile Chinook Salmon were similar between restored and reference tidal channels. However, Chinook Salmon densities were significantly lower in the restored channels than in the reference channels, and growth potential was more variable in the restored channels due to their more variable and warmer (2°C) water temperatures. These results indicate that some—but not all—ecosystem attributes that are important for juvenile Pacific salmon can recover rapidly after large-scale tidal marsh restoration.

Doubleday, A. J., & Hopcroft, R. R. (2014). Interannual patterns during spring and late summer of larvaceans and pteropods in the coastal Gulf of Alaska, and their relationship to pink salmon survival. *Journal of Plankton Research*, fbu092. http://doi.org/10.1093/plankt/fbu092

Larvacean (=appendicularian) and pteropod (*Limacina helicina*) composition and abundance were studied with physical variables each May and late summer across 11 years (2001–2011), along a transect that crosses the continental shelf of the sub-Arctic Gulf of Alaska (GoA) and five stations within Prince William Sound (PWS). Collection with 53-µm plankton nets allowed the identification of larvaceans to species: five occurred in the study area. Temperature was the driving variable in determining larvacean community composition, yielding pronounced differences between spring and late summer, while individual species were also affected differentially by salinity and chlorophyll-a concentration. During the spring *Oikopleura labradoriensis* and *Fritillaria borealis* were most abundant, being present at all stations. Late summer had highest abundances of *Oikopleura dioica* at nearshore stations, while *F. borealis* dominated numerically at outer stations. The 53-µm plankton nets collected higher abundances of *Oikopleura* spp., *Fritillaria* spp. and *L. helicina* than coarser 150- and 505-µm plankton nets. *Limacina helicina* abundance had a significant interaction effect among years, seasons and station location. *Limacina helicina* abundance in nearby PWS explained 30% of the variability in pink salmon survival; however, no significant correlations existed with larvacean or *L. helicina* abundances from the GoA stations.

Evans, A. F., Hostetter, N. J., Collis, K., Roby, D. D., & Loge, F. J. (2014). Relationship between juvenile fish condition and survival to adulthood in Steelhead. *Transactions of the American Fisheries Society*, *143*(4), 899–909. http://doi.org/10.1080/00028487.2014.901248

Understanding how individual characteristics are associated with survival is important to programs aimed at recovering fish populations of conservation concern. To evaluate whether individual fish characteristics observed during the juvenile life stage were associated with the probability of returning as an adult, juvenile steelhead *Oncorhynchus mykiss* from two distinct population segments (DPSs; Snake River and upper Columbia River) were captured, photographed to determine external condition (body injuries, descaling, signs of disease, fin damage, and ectoparasites), measured, classified by rearing type (hatchery, wild), marked with a PIT tag, and released to continue out-migration to the Pacific Ocean during 2007–2010. The PIT tags of returning adults were interrogated in fishways at hydroelectric dams on the lower Columbia River 1–3 years following release as juveniles. Juvenile-to-adult survival models were investigated independently for each DPS and indicated that similar individual fish characteristics were important predictors of survival to adulthood for both steelhead populations. The data analysis provided strong support for survival models that included explanatory variables for fish length, rearing type, and external condition, in addition to out-migration year and timing. The probability of a juvenile surviving to adulthood was positively related to length and was higher for wild fish compared with hatchery fish. Survival was lower for juveniles with body injuries, fin damage, and external signs of disease. Models that included variables for descaling and ectoparasite infestation, however, had less support than those that incorporated measures of body injuries, fin damage, and disease. Overall, results indicated that individual fish characteristics recorded during the juvenile life stage can be used to predict adult survivorship in multiple steelhead populations.

Ferriss, B. E., Trudel, M., & Beckman, B. R. (2014). Regional and inter-annual trends in marine growth of juvenile salmon in coastal pelagic ecosystems of British Columbia, Canada. *Marine Ecology Progress Series*, *503*, 247–261. http://doi.org/10.3354/meps10726
We measured insulin-like growth factor 1 (IGF1) concentrations (a proxy for growth) from juvenile coho *Oncorhynchus kisutch*, sockeye *O. nerka*, chum *O. keta*, and Chinook salmon *O. tshawytscha* collected in 8 regions of British Columbian coastal waters, in June of 2009, 2010, and 2011. We found annual differences in IGF1 for all 4 species, as well as species-specific regional differences in IGF1 concentrations in coho, chum, and sockeye salmon. Sockeye and chum salmon had consistently higher levels in the northern regions of the Dixon Entrance, Haida Gwaii, Hecate Strait, and lower levels in Queen Charlotte Strait. Regional differences in coho, chum, and sockeye salmon were highly correlated (R2 = 0.61–0.75). These results demonstrate that salmon growth responds to local environmental variability on a scale of several hundred kilometers. Thus, IGF1 measures should generate insight into fish production on relatively local regional and temporal scales, and these same measures may allow the assessment of how habitats vary on these same scales.

Fisher, J. P., Weitkamp, L. A., Teel, D. J., Hinton, S. A., Orsi, J. A., Farley, E. V., Morris, J. F. T., Thiess, M. E., Sweeting, R. M., & Trudel, M. (2014). Early ocean dispersal patterns of Columbia River Chinook and Coho Salmon. *Transactions of the American Fisheries Society*, *143*(1), 252–272. http://doi.org/10.1080/00028487.2013.847862
Several evolutionarily significant units (ESUs) of Columbia River asin Chinook Salmon *Oncorhynchus tshawytscha* and Coho Salmon *O. kisutch* are listed as threatened or endangered under the U.S. Endangered Species Act. Yet little is known about the spatial and temporal distributions of these ESUs immediately following ocean entry, when year-class success may be determined. We documented differences in dispersal patterns during the early ocean period among groups defined by ESU, adult run timing, and smolt age. Between 1995 and 2006, 1,896 coded-wire-tagged juvenile fish from the Columbia River basin were recovered during 6,142 research trawl events along the West Coast of North America. Three distinct ocean dispersal patterns were observed: (1) age-1 (yearling) mid and upper Columbia River spring-run and Snake River spring–summer-run Chinook Salmon migrated rapidly northward and by late summer were not found south of Vancouver Island; (2) age-0 (subyearling) lower Columbia River fall, upper Columbia River summer, upper Columbia River fall, and Snake River fall Chinook Salmon dispersed slowly, remaining mainly south of Vancouver Island through autumn; and (3) age-1 lower Columbia River spring, upper Columbia River summer, and upper Willamette River spring Chinook Salmon and Coho Salmon were widespread along the coast from summer through fall, indicating a diversity of dispersal rates. Generally, the ocean dispersal of age-1 fish was faster and more extensive than that of age-0 fish, with some age-1 fish

migrating as fast as 10–40 km/d (0.5–3.0 body lengths/s). Within groups, interannual variation in dispersal was moderate. Identification of the distinct temporal and spatial ocean distribution patterns of juvenile salmon from Columbia River basin ESUs is important in order to evaluate the potential influence of changing ocean conditions on the survival and long term sustainability of these fish populations.

Friedland, K. D., Ward, B. R., Welch, D. W., & Hayes, S. A. (2014). Postsmolt growth and thermal regime define the marine survival of Steelhead from the Keogh River, British Columbia. *Marine and Coastal Fisheries*, *6*(1), 1–11. http://doi.org/10.1080/19425120.2013.860065

The population of anadromous steelhead *Oncorhynchus mykiss* in the Keogh River has been studied intensively, in part because of its pattern of declining recruitment, which is largely attributed to poor marine survival. Climate variability has changed the productivity of salmonid species in all regions of the North Pacific, with areas alternately shifting between periods of enhanced and depressed productivity. The mechanisms governing marine survival and adult recruitment are central to contemporary resource management concerns but are also of concern with regard to the long-term prospects of managing biodiversity. We provide evidence that postsmolt growth contributes to the pattern of marine survival of Keogh River steelhead over the period corresponding to smolt years 1977–1999. Size at ocean entry did not appear to have sufficient contrast to significantly affect survival. However, assessment of scale growth suggested that the fish's initial growth at sea is not as important as the sustained growth conditions during summer and fall of the postsmolt year. The return rate of steelhead was negatively correlated with sea surface temperature in the ocean domains that were assumed to provide postsmolt nursery habitat, suggesting that growth is directly affected by warming conditions or that ocean warming affects the food web upon which steelhead depend. Steelhead appear to respond to changing climate and growth regimes in a manner similar to that of their North Atlantic analog, the Atlantic Salmon *Salmo salar*. Comparative data show that eastern basin Atlantic Salmon populations are negatively affected by a thermal regime of increasing temperature during the postsmolt year, suggesting a relationship between postsmolt growth and survival.

Garza, J. C., Gilbert-Horvath, E. A., Spence, B. C., Williams, T. H., Fish, H., Gough, S. A., Anderson, J. H., Hamm, D., Anderson, E. C. (2014). Population structure of Steelhead in coastal California. *Transactions of the American Fisheries Society*, *143*(1), 134–152. http://doi.org/10.1080/00028487.2013.822420

Steelhead *Oncorhynchus mykiss* are the most widespread of the Pacific salmonids *Oncorhynchus* spp. and are found in nearly all basins within their native range around the northern Pacific Rim. Here, we elucidate genetic population structure of steelhead in coastal basins from most of their coastal-California range using variation at 15 microsatellite loci. Juvenile fish from 60 streams in 40 river basins were sampled in a single year from a single cohort. As samples of juvenile salmonids often contain sibling groups, a method was implemented to identify and eliminate all but one member of larger sibships. This, in conjunction with a rigorous sampling protocol and hierarchical sampling design, provided substantially improved resolution for understanding patterns of migration and demography. A pattern of isolation by distance was evident, as indicated by both phylograms that were largely concordant with geography and a significant regression of genetic distance on geographic distance, indicating that population structure is largely determined by migration that is dependent upon geographic distance. Within-basin genetic distances tended to be smaller than those between basins, although there was substantial overlap between them. Using a Bayesian clustering method to evaluate signals of population structure above the level of a river basin, four geographic sites were identified where genetic composition shifted abruptly. These areas largely correspond to major geographic features of the coastline: San Francisco and Humboldt bays and two extended sections of coast (the so-called Lost Coast and Russian Gulch areas) with no streams reaching inland more than several kilometers. Only one of these boundaries is concordant with the current delineation of steelhead Distinct Population Segments designated under the U.S. Endangered Species Act. Finally, there was a strong correlation between latitude and genetic variation, with fewer alleles present in the south, a pattern consistent with generally smaller population sizes in the south.

Gladics, A. J., Suryan, R. M., Brodeur, R. D., Segui, L. M., & Filliger, L. Z. (2014). Constancy and change in marine predator diets across a shift in oceanographic conditions in the Northern California Current. *Marine Biology*, 1–15. http://doi.org/10.1007/s00227-013-2384-4

Variable ocean conditions can greatly impact prey assemblages and predator foraging in marine ecosystems. Our goal was to better understand how a change in ocean conditions influenced dietary niche overlap among a suite of midtrophic-level predators. We examined the diets of three fishes and one seabird off central Oregon during two boreal summer upwelling periods with contrasting El Niño (2010) and La Niña (2011) conditions. We found greater niche specialization during El Niño and increased niche overlap during La Niña in both the nekton and micronekton diet components, especially in the larger, more offshore predators. However, only the two smaller, more nearshore predators exhibited interannual variation in diet composition. Concurrent trawl surveys confirmed that changes in components of predator diets reflected changes in the prey community. Using multiple predators across diverse taxa and life histories provided a comprehensive understanding of food-web dynamics during changing ocean conditions.

Godwin, S. C., Dill, L. M., Reynolds, J. D., & Krkošek, M. (2015). Sea lice, sockeye salmon, and foraging competition: lousy fish are lousy competitors. *Canadian Journal of Fisheries and Aquatic Sciences*. http://doi.org/10.1139/cjfas-2014-0284

Pathogens threaten wildlife globally, but these impacts are not restricted to direct mortality from disease. For fish, which experience periods of extremely high mortality during their early life history, infections may primarily influence population dynamics and conservation through indirect effects on ecological processes such as competition and predation. We conducted a competitive foraging experiment using out-migrating juvenile Fraser River sockeye salmon (*Oncorhynchus nerka*) to determine whether fish with high abundances of parasitic sea lice (*Caligus clemensi* and *Lepeophtheirus salmonis*) have reduced competitive abilities when foraging. Highly infected sockeye were 20% less successful at consuming food, on average, than lightly infected fish. Competitive ability also increased with fish body size. Our results provide the first evidence that parasite exposure may have negative indirect effects on fitness of juvenile sockeye salmon, and suggest that indirect effects of pathogens may be of key importance for the conservation of marine fish.

Goetz, F. A., Jeanes, E., Moore, M. E., & Quinn, T. P. (2015). Comparative migratory behavior and survival of wild and hatchery steelhead (*Oncorhynchus mykiss*) smolts in riverine, estuarine, and marine habitats of Puget Sound, Washington. *Environmental Biology of Fishes*, *98*(1), 357–375. http://doi.org/10.1007/s10641-014-0266-3

Declines in the survival of steelhead (*Oncorhynchus mykiss*) populations in protected waters of Washington and British Columbia have drawn attention to the need for more information on migratory patterns and losses in river, estuary, and nearshore habitats. Accordingly, acoustic telemetry was used to quantify movements by wild and hatchery steelhead smolts released from 2006 to 2009 in the Green River, and tracked through Puget Sound, Washington. Survival varied by release group and migration segment but overall survival rates from release to the Strait of Juan de Fuca were 9.7 % for wild and 3.6 % for hatchery fish. These rates are low relative to similar studies on steelhead. Survival was higher for wild fish along all migration segments than hatchery-origin fish; the greatest loss for both groups coincided with the slowest travel rates as fish first entered the estuary and as they exited Puget Sound. Wild fish travelled faster than hatchery fish in the river (15.1 vs. 4.4 km/d) with the fastest travel in the lower river (41 vs. 20.2 km/d) and slowest immediately after release (3.7 vs. 2.4 km/d). The travel rates of wild and hatchery fish became progressively more similar over time: 15.4 vs. 10.6 km/d in the estuary, and 10.3 vs. 9.3 km/d in nearshore areas. Movement was primarily nocturnal in the river, nearly equal between day and night in the upper estuary, and predominately diurnal in the lower estuary and nearshore waters, with no difference between wild and hatchery fish. The migration in marine water showed an early offshore movement and a strong northward and westward orientation, and all fish exited the Strait of Juan de Fuca rather than the Strait of Georgia. The findings support research suggesting that declines in wild and hatchery steelhead populations may be caused primarily by factors in the early marine period.

Harstad, D. L., Larsen, D. A., & Beckman, B. R. (2014). Variation in minijack rate among hatchery populations of Columbia River basin Chinook Salmon. *Transactions of the American Fisheries Society*, *143*(3), 768–778. http://doi.org/10.1080/00028487.2014.886621

In Columbia River spring and summer Chinook Salmon *Oncorhynchus tshawytscha*, age of male maturation ranges from age 1 (microjack), 2 (minijack), 3 (jack), to 4 or 5 (adult) years. The presence of minijacks has been noted in several experimental studies and documented for a few hatchery programs; but, a comprehensive survey of their occurrence in hatchery production programs has never been conducted. We measured the proportion of minijacks among males released from several spring- and summer-run Chinook Salmon hatchery programs throughout the Columbia River basin among brood years 1999–2010. The hatcheries surveyed included both segregated (uses only hatchery-origin spawners in broodstock) and integrated (includes some degree of natural-origin spawners in broodstock) programs. Minijacks were found in all programs monitored, and rates varied approximately 10-fold across release groups, ranging from 7.9% to 71.4% of males in spring Chinook Salmon programs and from 4.1% to 40.1% of males in summer Chinook Salmon programs. Cumulative growth (i.e., size at release) was found to be positively correlated with minijack rate, but for only the integrated Chinook Salmon programs. Domestication selection may have occurred in segregated spring Chinook Salmon programs, increasing the threshold size for maturation and lowering minijack rates. Elevated minijack rates in Chinook Salmon hatchery programs result in a direct reduction in both the number of male smolts released and potential adult males available for harvest and spawning.

Hill, A. D., Daly, E. A., & Brodeur, R. D. (2015). Diet variability of forage fishes in the Northern California Current System. *Journal of Marine Systems*. http://doi.org/10.1016/j.jmarsys.2014.08.006

As fisheries management shifts to an ecosystem-based approach, understanding energy pathways and trophic relationships in the Northern California Current (NCC) will become increasingly important for predictive modeling and understanding ecosystem response to changing ocean conditions. In the NCC, pelagic forage fishes are a critical link between seasonal and interannual variation in primary production and upper trophic groups. We compared diets among dominant forage fish (sardines, anchovies, herring, and smelts) in the NCC collected in May and June of 2011 and June 2012, and found high diet variability between and within species on seasonal and annual time scales, and also on decadal scales when compared to results of past studies conducted in the early 2000s. Copepoda were a large proportion by weight of several forage fish diets in 2011 and 2012, which differed from a preponderance of Euphausiidae found in previous studies, even though all years exhibited cool ocean conditions. We also examined diet overlap among these species and with co-occurring subyearling Chinook salmon and found that surf smelt diets overlapped more with subyearling Chinook diets than any other forage fish. Herring and sardine diets overlapped the most with each other in our interdecadal comparisons and some prey items were common to all forage fish diets. Forage fish that show plasticity in diet may be more adapted to ocean conditions of low productivity or anomalous prey fields. These findings highlight the variable and not well-understood connections between ocean conditions and energy pathways within the NCC.

Hostetter, N. J., Evans, A. F., Cramer, B. M., Collis, K., Lyons, D. E., & Roby, D. D. (2015). Quantifying avian predation on fish populations: integrating predator-specific deposition probabilities in tag recovery studies. *Transactions of the American Fisheries Society*, *144*(2), 410–422. http://doi.org/10.1080/00028487.2014.988882

Accurate assessment of specific mortality factors is vital to prioritize recovery actions for threatened and endangered species. For decades, tag recovery methods have been used to estimate fish mortality due to avian predation. Predation probabilities derived from fish tag recoveries on piscivorous waterbird colonies typically reflect minimum estimates of predation due to an unknown and unaccounted-for fraction of tags that are consumed but not deposited on-colony (i.e., deposition probability). We applied an integrated tag recovery modeling approach in a Bayesian context to estimate predation probabilities that accounted for predator-specific tag detection and deposition probabilities in a multiple-predator system. Studies of PIT tag deposition were conducted across three bird species nesting at seven different colonies in the Columbia River basin, USA. Tag deposition probabilities differed significantly among predator species (Caspian terns *Hydroprogne caspia*: deposition probability = 0.71, 95% credible interval [CRI] = 0.51–0.89; double-crested cormorants *Phalacrocorax auritus*: 0.51, 95% CRI = 0.34–0.70; California gulls *Larus californicus*: 0.15, 95% CRI = 0.11–0.21) but showed little variation across trials within a species or across years. Data from a 6-year study (2008–2013) of PIT-tagged juvenile Snake River steelhead *Oncorhynchus mykiss* (listed as threatened under the Endangered Species Act) indicated that colony-specific predation probabilities ranged from less than 0.01 to 0.17 and varied by predator species, colony location, and year. Integrating the predator-specific deposition probabilities increased the predation probabilities by a factor of approximately 1.4 for Caspian terns, 2.0 for double-crested cormorants, and 6.7 for California gulls compared with traditional minimum predation rate methods, which do not account for deposition probabilities. Results supported previous findings on the high predation impacts from strictly piscivorous waterbirds nesting in the Columbia River estuary (i.e., terns and cormorants), but our findings also revealed greater impacts of a generalist predator species (i.e., California gulls) than were previously documented. Approaches used in this study allow for direct comparisons among multiple fish mortality factors and considerably improve the reliability of tag recovery models for estimating predation probabilities in multiple-predator systems.

Irvine, J. R., Michielsens, C. J. G., O'Brien, M., White, B. A., & Folkes, M. (2014). Increasing dominance of odd-year returning Pink Salmon. *Transactions of the American Fisheries Society*, *143*(4), 939–956. http://doi.org/10.1080/00028487.2014.889747
The hypothesis that abundance patterns differ between even- and odd-year returning Pink Salmon *Oncorhynchus gorbuscha* was examined using data from the eastern and western North Pacific Ocean, northern and southern British Columbia, and biologically based conservation units, which are Canadian groupings of salmon that are genetically and/or ecologically distinct from each other. Detailed data from (mostly) southern British Columbia were examined to test hypotheses that the differences between even- and odd-year broodlines were due to fishing, broodline interactions, limitations in freshwater or the ocean, and/or density dependence. The odd-year broodline has become increasingly predominate over the genetically distinct even-year broodline on both sides of the Pacific and in five of six British Columbia regions. Five analytical approaches revealed abundances were generally increasing for odd-year conservation units and declining or stable for even-year conservation units. Recent increases in odd-year spawner abundance in southern British Columbia were correlated with decreased fishery exploitation, but exploitation was higher for odd-year than for even-year salmon, refuting the hypothesis that differential exploitation is responsible for the changing dominance. Significant negative interactions between even- and odd-year broodlines were found in several of the British Columbia regions tested, but there was little evidence of competition between broodlines in the marine environment. Odd-year populations in the Fraser River increased despite density-dependent reductions in freshwater production, while there was no indication of changes in marine productivity. Our results, combined with literature findings indicating a more southerly glacial refugium for odd-year than for even-year Pink Salmon and temperature-related survival differences between these broodlines, suggest that recent climate conditions are benefiting odd-year returning Pink Salmon more than even-year salmon, especially in the southern part of their range.

Jones, K. K., Cornwell, T. J., Bottom, D. L., Campbell, L. A., & Stein, S. (2014). The contribution of estuary-resident life histories to the return of adult *Oncorhynchus kisutch*. *Journal of Fish Biology*, *85*(1), 52–80. http://doi.org/10.1111/jfb.12380
This study evaluated estuarine habitat use, life-history composition, growth and survival of four successive broods of coho salmon *Oncoryhnchus kisutch* in Salmon River, Oregon, U.S.A. Subyearling and yearling *O. kisutch* used restored and natural estuarine wetlands, particularly in the spring and winter. Stream-reared yearling smolts spent an average of 2 weeks in the estuary growing rapidly before entering the ocean. Emergent fry also entered the estuary in the spring, and some resided in a tidal marsh throughout the summer, even as salinities increased to > 20. A significant portion of the summer stream-resident population of juvenile *O. kisutch* migrated out of the catchment in the autumn and winter and used estuary wetlands and adjacent streams as alternative winter-rearing habitats until the spring when they entered the ocean as yearling

smolts. Passive integrated transponder (PIT) tag returns and juvenile life-history reconstructions from otoliths of returning adults revealed that four juvenile life-history types contributed to the adult population. Estuarine-associated life-history strategies accounted for 20–35% of the adults returning to spawn in the four brood years, indicating that a sizable proportion of the total *O. kisutch* production is ignored by conventional estimates based on stream habitat capacity. Juvenile *O. kisutch* responses to the reconnection of previously unavailable estuarine habitats have led to greater life-history diversity in the population and reflect greater phenotypic plasticity of the species in the U.S. Pacific Northwest than previously recognized.

Kilduff, D. P., Botsford, L. W., & Teo, S. L. H. (2014). Spatial and temporal covariability in early ocean survival of Chinook salmon (*Oncorhynchus tshawytscha*) along the west coast of North America. *ICES Journal of Marine Science: Journal Du Conseil*, fsu031. http://doi.org/10.1093/icesjms/fsu031

Knowledge of the spatial and temporal extent of covariation in survival during the critical ocean entry stage will improve our understanding of how changing ocean conditions influence salmon productivity and management. We used data from the Pacific coastwide coded-wire tagging program to investigate local and regional patterns of ocean survival of Chinook salmon (*Oncorhynchus tshawytscha*) from the Central Valley of California to southeastern Alaska from 1980–2006. Ocean survival of fish migrating as subyearlings covaried strongly from Vancouver Island to California. Short-term correlations between adjacent regions indicated this covariability increased, beginning in the early 1990s. Chinook salmon survivals exhibited a larger spatial scale of variability (50% correlation scale: 706 km) than those reported for other northeast Pacific Ocean salmon. This scale is similar to that of environmental variables related to ecosystem productivity, such as summer upwelling (50% correlation scale: 746 km) and sea surface temperature (50% correlation scale: 500–600 km). Chinook salmon ocean survival rates from southeastern Alaska and south of Vancouver Island were not inversely correlated, in contrast to earlier observations based on catch data, but note that our data differ in temporal and spatial coverage from those studies. The increased covariability in Chinook salmon ocean survival suggests that the marine phase contributes little to the reduction in risk across populations attributable to the portfolio effect. In addition, survival of fish migrating as yearlings from the Columbia River covaried with Chinook salmon survival from the northernmost regions, consistent with our understanding of their migration patterns.

Kondzela, C. M., Guthrie III, C. M., Marvin, C. T., Whittle, J. A., Nguyen, H. T., Ramsower, C. & Guyon, J.R. (2014). Stock composition analysis of juvenile chum and Chinook salmon captured on the 2012 Bering Sea and Chukchi Sea research surveys. NPAFC Doc. 1521. 13 pp. (Available at http://www.npafc.org).

Juvenile chum (*Oncorhynchus keta*) and Chinook salmon (*O. tshawytscha*) were collected in the Bering and Chukchi seas as part of the 2012 U.S. BASIS/Arctic Ecosystem Integrated Survey (Arctic EIS) cruises. Juvenile chum salmon were more commonly encountered on the survey and 1,222 juveniles were genotyped for 11 microsatellite markers to determine their stock of origin. The most northern sample set was relatively small; juvenile chum salmon collected in the Chukchi Sea were predominantly from the Kotzebue Sound stock group. Juvenile chum salmon collected in the northern Bering Sea near Norton Sound were predominantly of Norton Sound origin. Yukon River chum salmon were present in both survey areas of the Bering Sea, but were more prevalent between lat. 60-63°N. Juvenile Chinook salmon were not encountered in the

Chukchi Sea, but a small sample of 81 juveniles from the Bering Sea was genotyped for 43 single nucleotide polymorphism (SNP) markers. Most of the Chinook salmon were from the Upper Yukon, Coastal Western Alaska, and Middle Yukon stock groups. This study determined the freshwater origin of juvenile chum and Chinook salmon from the northern Bering and Chukchi seas during late-summer/fall based on genetic data and may be used to help guide future surveys of juvenile salmon abundance in western Alaska.

Li, L., Pitcher, T. J., & Devlin, R. H. (2014). Potential risks of trophic impacts by escaped transgenic salmon in marine environments. *Environmental Conservation*, *FirstView*, 1–10. http://doi.org/10.1017/S0376892914000319
There is significant concern about potential ecological effects of introduced organisms, including non-indigenous species and those created by genetic modification. This paper presents an Ecopath with Ecosim modelling approach, designed to examine long-term trophic effects of growth hormone (GH) transgenic coho salmon should they ever escape to a coastal salmonid ecosystem, namely the Strait of Georgia in British Columbia (Canada). The model showed that the effects of introduced GH transgenic coho salmon varied with their biomass, diet, structure of the invaded ecosystem, and environmental conditions. Occasional escapes of non-reproductive salmon did not have a significant impact on the example ecosystem. However, effects of GH coho salmon varied with their diet when large numbers of these fish were present in the simulated ecosystem (for example, when they constituted 20% of total current aquaculture production in the area). Further, climate-driven changes in the biomass of low trophic levels (bottom-up effects) could have a greater impact on the ecosystem than the introduction of large numbers of GH coho salmon. A new version of Ecopath with Ecosim's Monte Carlo approach showed that the model predictions were robust to GH coho salmon's Ecopath parameters, but more sensitive to vulnerabilities of prey to GH coho salmon. Modelling ecosystem effects of genetically modified organisms provides a complementary approach for risk assessments when data from nature are not readily obtainable.

Liberoff, A. L., Miller, J. A., Riva-Rossi, C. M., Hidalgo, F. J., Fogel, M. L., & Pascual, M. A. (2014). Transgenerational effects of anadromy on juvenile growth traits in an introduced population of rainbow trout (*Oncorhynchus mykiss*). *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(3), 398–407. http://doi.org/10.1139/cjfas-2013-0466
We determined whether the propensity for anadromy was related to maternal phenotype in a population of partially anadromous rainbow trout (*Oncorhynchus mykiss*). We identified the maternal phenotype (anadromous versus resident) of wild juveniles from two successive cohorts using stable isotope analysis ($\delta^{15}N$) of muscle tissue and (or) strontium to calcium ratios in the otolith core. We also tested the hypothesis that juvenile size and growth are related to maternal migratory history. For both cohorts, juvenile size at capture and growth, as determined using otolith and scale structural analyses, were strongly related to maternal migratory history. Offspring of anadromous mothers were larger and grew faster than resident offspring. Back-calculated length at age 1 of anadromous and resident adults provided support for a positive association between body size and anadromy, indicating that larger offspring are more prone to displaying anadromy. We conclude that maternal anadromy, which influences adult size and egg quality, affects the propensity of progeny to migrate, thus perpetuating the anadromous tactic across generations and influencing the establishment and persistence of anadromy

Litz, M. N. C., Emmett, R. L., Bentley, P. J., Claiborne, A. M., & Barcelo, C. (2014). Biotic and abiotic factors influencing forage fish and pelagic nekton community in the Columbia River plume (USA) throughout the upwelling season 1999-2009. *Ices Journal of Marine Science*, *71*(1), 5–18. http://doi.org/10.1093/icesjms/fst082
Large river plumes modify coastal environments and can impact production across multiple trophic levels. From 1999 to 2009, the assemblages of forage fish, predator fish, and other pelagic nekton were monitored in coastal waters associated with the Columbia River plume. Surveys were conducted at night to target vertically migrating species, and community structure evaluated to better understand ecological interactions. Distinct inshore and offshore communities were identified during spring and summer that were correlated with ocean temperature, salinity, plume volume, and upwelling intensity. Resident euryhaline forage fish species, such as smelts, anchovy, herring, market squid, juvenile salmon, and spiny dogfish, showed a high affinity for inshore habitat and the lower salinity plume during spring. Highly migratory species, such as sardine, piscivorous hake, sharks, and mackerels, were associated with warmer, saltier waters offshore, during strong upwelling periods in summer. Overall, our study of pelagic nekton revealed that temporal dynamics in abundance and community composition were associated with seasonal abiotic phenomenon, but not interannual, large-scale oceanographic processes. Forage fish assemblages differed seasonally and spatially from the assemblages of major piscivorous predators. This finding suggests a potential role of the plume as refuge for forage fish from predation by piscivorous fish in the northern California Current.

Losee, J. P., Fisher, J., Teel, D. J., Baldwin, R. E., Marcogliese, D. J., & Jacobson, K. C. (2014). Growth and condition of juvenile coho salmon *Oncorhynchus kisutch* relate positively to species richness of trophically transmitted parasites. *Journal of Fish Biology*, *85*(5), 1665–1681. http://doi.org/10.1111/jfb.12525
The aims of this study were first, to test the hypothesis that metrics of fish growth and condition relate positively to parasite species richness (SR) in a salmonid host; second, to identify whether SR differs as a function of host origin; third, to identify whether acquisition of parasites through marine v. freshwater trophic interactions was related to growth and condition of juvenile salmonids. To evaluate these questions, species diversity of trophically transmitted parasites in juvenile coho salmon *Oncorhynchus kisutch* collected off the coast of the Oregon and Washington states, U.S.A. in June 2002 and 2004 were analysed. Fish infected with three or more parasite species scored highest in metrics of growth and condition. Fish originating from the Columbia River basin had lower SR than those from the Oregon coast, Washington coast and Puget Sound, WA. Parasites obtained through freshwater or marine trophic interactions were equally important in the relationship between SR and ocean growth and condition of juvenile *O. kisutch* salmon.

Losee, J. P., Miller, J. A., Peterson, W. T., Teel, D. J., & Jacobson, K. C. (2014). Influence of ocean ecosystem variation on trophic interactions and survival of juvenile coho and Chinook salmon. *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(11), 1747–1757. http://doi.org/10.1139/cjfas-2014-0043
The community of trophically transmitted marine parasites of juvenile coho (*Oncorhynchus kisutch*) and Chinook (*Oncorhynchus tshawytscha*) salmon across 8 years (2002–2009) was related to indices of physical and biological ocean conditions and adult returns. When the biomass of lipid-poor, southern origin copepods in the coastal ocean was high during juvenile

salmon outmigration from fresh water (April–June), yearling coho and Chinook salmon harbored a different trophically transmitted parasite fauna and exhibited lower survival compared with years when the southern copepod biomass was low. As copepods are key intermediate hosts in many marine parasite life cycles, these results support a trophic linkage between the copepod community and salmon prey. Interannual variation in the parasite community was correlated with survival of coho salmon ($r = -0.67$) measured 1 year later and adult returns of Upper Columbia River summer and fall Chinook salmon ($r = -0.94$) 3 years from the time of ocean entry.

Malick, M. J., Cox, S. P., Mueter, F. J., & Peterman, R. M. (2015). Linking phytoplankton phenology to salmon productivity along a north/south gradient in the Northeast Pacific Ocean. ***Canadian Journal of Fisheries and Aquatic Sciences.*** **http://doi.org/10.1139/cjfas-2014-0298**

We investigated spatial and temporal components of phytoplankton dynamics in the Northeast Pacific Ocean to better understand the mechanisms linking biological oceanographic conditions to productivity of 27 pink salmon (*Oncorhynchus gorbuscha*) stocks. Specifically, we used spatial covariance functions in combination with multi-stock spawner-recruit analyses to model relationships among satellite-derived chlorophyll a concentrations, initiation date of the spring phytoplankton bloom, and salmon productivity. For all variables, positive spatial covariation was strongest at the regional scale (0-800 km) with no covariation beyond 1500 km. Spring bloom timing was significantly correlated with salmon productivity for both northern (Alaska) and southern (British Columbia) populations, although the correlations were opposite in sign. An early spring bloom was associated with higher productivity for northern populations and lower productivity for southern populations. Furthermore, the spring bloom initiation date... Furthermore, the spring bloom initiation date was always a better predictor of salmon productivity than mean chlorophyll-a concentration. Our results suggest that changes in spring bloom timing resulting from natural climate variability or anthropogenic climate change could potentially cause latitudinal shifts in salmon productivity.

McKinnell, S., Curchitser, E., Groot, K., Kaeriyama, M., & Trudel, M. (2014). Oceanic and atmospheric extremes motivate a new hypothesis for variable marine survival of Fraser River sockeye salmon. ***Fisheries Oceanography, 23*****(4), 322–341. http://doi.org/10.1111/fog.12063**

In spite of a relatively optimistic pre-season forecast, the total return of adult sockeye salmon (*Oncorhynchus nerka*) to the Fraser River (British Columbia, Canada) in 2009 was the lowest recorded since quantitative records began in the late 1940s. A plausible mechanism is proposed that links a sequence of extreme oceanic and climatic events to poor marine survival. It began with record-setting snow packs in the coastal mountain range during the winter of 2007 that led to the development of unprecedented oceanographic conditions in the spring of 2007 from Queen Charlotte Strait in central British Columbia to Southeast Alaska. When combined with equally extreme atmospheric anomalies in the region in the spring of 2007, with a winter wind regime persisting through July, a coastal surface ocean with characteristics that are known to be associated with lower marine survival was established. Most of the sockeye salmon that were expected to return to the Fraser River as adults in 2009 passed through this atypical ocean as juveniles on their migration to the open ocean in 2007. A trophic gauntlet hypothesis is proposed as a new paradigm to describe the oceanic environment faced by sockeye salmon after they emigrate northward from the Strait of Georgia. The hypothesis identifies a new type of high nutrient low chlorophyll region that can explain how oceanographic extremes at critical locations along the migration route beyond the Strait of Georgia can reduce marine survival in some years.

Melnychuk, M. C., Korman, J., Hausch, S., Welch, D. W., McCubbing, D. J. F., & Walters, C. J. (2014). Marine survival difference between wild and hatchery-reared steelhead trout determined during early downstream migration. ***Canadian Journal of Fisheries and Aquatic Sciences*, *71*(6), 831–846. http://doi.org/10.1139/cjfas-2013-0165**
We observed large survival differences between wild and hatchery-reared steelhead trout (*Oncorhynchus mykiss*) during the juvenile downstream migration immediately after release, which persisted through adult life. Following a railway spill of sodium hydroxide into the Cheakamus River, British Columbia, a short-term conservation hatchery rearing program was implemented for steelhead. We used acoustic telemetry and mark–recapture models to estimate survival of wild and (or) hatchery-reared steelhead during 4 years of the smolt migration, with both groups released in 2008. After adjusting for estimated freshwater residualization, 7%–13% of wild smolts and 30%–40% of hatchery smolts died in the first 3 km of the migration. Estimated survival from release to ocean entry was 71%–84% for wild fish and 26%–40% for hatchery fish and to exit from the Strait of Georgia system was 22%–33% for wild fish and 3.5%–6.7% for hatchery fish. A calculated 2.3-fold survival difference established during the downstream migration was similar to that after the return of adult spawners, as return rates were 8.0% for wild fish and 4.1% for hatchery fish. Contrary to current understanding, a large proportion of salmon mortality in the smolt-to-adult period, commonly termed "marine mortality", may actually occur prior to ocean entry.

Miller, K. M., Teffer, A., Tucker, S., Li, S., Schulze, A. D., Trudel, M., Juanes, F., Tabata, A., Kaukinen, K. H., Ginther, N. G., Ming, T. J., Cooke, S. J., Hipfner, J. M., Patterson, D. A. & Hinch, S. G. (2014). Infectious disease, shifting climates, and opportunistic predators: cumulative factors potentially impacting wild salmon declines. ***Evolutionary Applications*, *7*(7), 812–855. http://doi.org/10.1111/eva.12164**
Emerging diseases are impacting animals under high-density culture, yet few studies assess their importance to wild populations. Microparasites selected for enhanced virulence in culture settings should be less successful maintaining infectivity in wild populations, as once the host dies, there are limited opportunities to infect new individuals. Instead, moderately virulent microparasites persisting for long periods across multiple environments are of greatest concern. Evolved resistance to endemic microparasites may reduce susceptibilities, but as barriers to microparasite distributions are weakened, and environments become more stressful, unexposed populations may be impacted and pathogenicity enhanced. We provide an overview of the evolutionary and ecological impacts of infectious diseases in wild salmon and suggest ways in which modern technologies can elucidate the microparasites of greatest potential import. We present four case studies that resolve microparasite impacts on adult salmon migration success, impact of river warming on microparasite replication, and infection status on susceptibility to predation. Future health of wild salmon must be considered in a holistic context that includes the cumulative or synergistic impacts of multiple stressors. These approaches will identify populations at greatest risk, critically needed to manage and potentially ameliorate the shifts in current or future trajectories of wild populations.

Miller, J. A., Teel, D. J., Peterson, W. T., & Baptista, A. M. (2014). Assessing the relative importance of local and regional processes on the survival of a threatened salmon population. ***PLoS ONE*****,** ***9*****(6), e99814. http://doi.org/10.1371/journal.pone.0099814**
Research on regulatory mechanisms in biological populations often focuses on environmental covariates. An integrated approach that combines environmental indices with organismal-level information can provide additional insight on regulatory mechanisms. Survival of spring/summer Snake River Chinook salmon (*Oncorhynchus tshawytscha*) is consistently low whereas some adjacent populations with similar life histories experience greater survival. It is not known if populations with differential survival respond similarly during early marine residence, a critical period in the life history. Ocean collections, genetic stock identification, and otolith analyses were combined to evaluate the growth-mortality and match-mismatch hypotheses during early marine residence of spring/summer Snake River Chinook salmon. Interannual variation in juvenile attributes, including size at marine entry and marine growth rate, was compared with estimates of survival and physical and biological metrics. Multiple linear regression and multi-model inference were used to evaluate the relative importance of biological and physical metrics in explaining interannual variation in survival. There was relatively weak support for the match-mismatch hypothesis and stronger evidence for the growth-mortality hypothesis. Marine growth and size at capture were strongly, positively related to survival, a finding similar to spring Chinook salmon from the Mid-Upper Columbia River. In hindcast models, basin-scale indices (Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO)) and biological indices (juvenile salmon catch-per-unit-effort (CPUE) and a copepod community index (CCI)) accounted for substantial and similar portions of variation in survival for juvenile emigration years 1998–2008 (R^2>0.70). However, in forecast models for emigration years 2009–2011, there was an increasing discrepancy between predictions based on the PDO (50–448% of observed value) compared with those based on the NPGO (68–212%) or biological indices (CPUE and CCI: 83–172%). Overall, the PDO index was remarkably informative in earlier years but other basin-scale and biological indices provided more accurate indications of survival in recent years.

Munsch, S. H., Cordell, J. R., Toft, J. D., & Morgan, E. E. (2014). Effects of seawalls and piers on fish assemblages and juvenile salmon feeding behavior. ***North American Journal of Fisheries Management*****,** ***34*****(4), 814–827. http://doi.org/10.1080/02755947.2014.910579**
Shoreline modifications, such as seawall armoring and piers, are ubiquitous along developed waterfronts worldwide, and recent research suggests that their ecological effects are primarily negative. We utilized snorkel surveys to quantify the effects of seawalls and piers on fish in nearshore habitats of an urbanized estuary in Puget Sound, Washington. We observed 17 species of fish and 4 species of crab during April–August 2012 at sites modified by seawalls and piers and at reference beach sites with minimal anthropogenic structures. Species assemblages at modified sites were significantly different from those at reference beaches. At modified sites, fish distribution and assemblage structure varied with proximity to the shade cast by piers; overall fish abundances were reduced under piers, and the greatest abundances were observed at high tides in areas directly adjacent to piers. Juvenile Pacific salmon *Oncorhynchus* spp. were the dominant fish species, and piers reduced their presence and feeding, indicating that areas under piers provide less-valuable habitat to salmon species. Piers may interrupt movements of juvenile salmon when they use shallow waters along shorelines to migrate from freshwater to marine habitats, as juvenile salmon tend to avoid shade under piers, especially at high tides. Our results

show that shoreline modifications can alter species assemblage structure, thus potentially creating novel combinations and abundances of species, and can reduce habitat function for species that utilize these and similar habitats elsewhere.

Neher, T. D. H., Rosenberger, A. E., Zimmerman, C. E., Walker, C. M., & Baird, S. J. (2014). Use of glacier river-fed estuary channels by juvenile Coho Salmon: transitional or rearing habitats? *Environmental Biology of Fishes*, *97*(7), 839–850. http://doi.org/10.1007/s10641-013-0183-x

Estuaries are among the most productive ecosystems in the world and provide important rearing environments for a variety of fish species. Though generally considered important transitional habitats for smolting salmon, little is known about the role that estuaries serve for rearing and the environmental conditions important for salmon. We illustrate how juvenile coho salmon *Oncorhynchus kisutch* use a glacial river-fed estuary based on examination of spatial and seasonal variability in patterns of abundance, fish size, age structure, condition, and local habitat use. Fish abundance was greater in deeper channels with cooler and less variable temperatures, and these habitats were consistently occupied throughout the season. Variability in channel depth and water temperature was negatively associated with fish abundance. Fish size was negatively related to site distance from the upper extent of the tidal influence, while fish condition did not relate to channel location within the estuary ecotone. Our work demonstrates the potential this glacially-fed estuary serves as both transitional and rearing habitat for juvenile coho salmon during smolt emigration to the ocean, and patterns of fish distribution within the estuary correspond to environmental conditions.

Neville, C. M., Beamish, R. J., & Chittenden, C. M. (2015). Poor survival of acoustically-tagged juvenile Chinook Salmon in the Strait of Georgia, British Columbia, Canada. *Transactions of the American Fisheries Society*, *144*(1), 25–33. http://doi.org/10.1080/00028487.2014.954053

The collapse of the commercial fishery and the major decline in catches in the recreational fishery for Chinook Salmon *Oncorhynchus tshawytscha* in the Strait of Georgia since the mid-1990s represents a major economic loss to British Columbia. Early marine residence is critical for survival of Chinook Salmon, but measuring the amount of mortality has been difficult. Acoustic tags can be used to measure marine mortality and study migratory behavior. We surgically implanted 278 juvenile Chinook Salmon with acoustic tags to monitor when and how many tagged fish moved out of the Strait of Georgia. Only eight tagged fish were detected leaving the Strait of Georgia, indicating that there could have been substantial mortality of the tagged juvenile Chinook Salmon within the strait. Tagging mortality was minimal, and the detection of tags was shown not to be a major source of error in this study. A major change in population structure between the spring and fall tagging periods meant that it was unlikely that most of the fish tagged in June and July remained within the Strait of Georgia. The decline in abundance of juvenile Chinook Salmon in November 2008 also indicates that the lack of detections of all tagged fish is unlikely a consequence of fish remaining in the Strait of Georgia. This information and the low catches in winter surveys indicated that most juvenile Chinook salmon were no longer in the strait in the late fall and winter. If the tagged fish were representative of the untagged fish, the current brood-year strength probably is largely determined within the Strait of Georgia.

Osterback, A.-M. K., Frechette, D. M., Hayes, S. A., Bond, M. H., Shaffer, S. A., & Moore, J. W. (2014). Linking individual size and wild and hatchery ancestry to survival and predation risk of threatened steelhead (*Oncorhynchus mykiss*). *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(12), 1877–1887. http://doi.org/10.1139/cjfas-2014-0097

We examined the role of individual size and origin (wild versus hatchery) to predation risk and marine survival for threatened juvenile steelhead (*Oncorhynchus mykiss*) in a coastal California watershed. In this study, we found that individual size and origin were strongly associated with increased predation risk of steelhead by a generalist avian predator (western gull, Larus occidentalis) and associated with survival to reproduction by tracking the fate of juvenile steelhead tagged with passive integrated transponder (PIT) tags. Across six cohorts (2005–2010), larger steelhead (>170 mm fork length (FL)) experienced marine survival rates at least 60 times higher than the smallest individuals. Predation risk by western gulls was highest for intermediate-sized fish (145–190 mm FL), which was at least ten times higher than the predation risk of the smallest individuals and four times higher than the predation risk of the largest individuals. Wild steelhead experienced both higher predation risk and higher survival rates than hatchery fish of the same size. Although gulls disproportionately remove intermediate-sized wild steelhead from the population, they also remove large wild individuals that may otherwise experience the highest adult return rates. Instead of focusing on population size alone, conservation measures could also be guided towards the recovery of larger and wild individuals, whose survival is paramount for population recovery

Peacock, S. J., Connors, B. M., Krkošek, M., Irvine, J. R., & Lewis, M. A. (2014). Can reduced predation offset negative effects of sea louse parasites on chum salmon? *Proceedings of the Royal Society of London B: Biological Sciences*, *281*(1776), 20132913. http://doi.org/10.1098/rspb.2013.2913

The impact of parasites on hosts is invariably negative when considered in isolation, but may be complex and unexpected in nature. For example, if parasites make hosts less desirable to predators then gains from reduced predation may offset direct costs of being parasitized. We explore these ideas in the context of sea louse infestations on salmon. In Pacific Canada, sea lice can spread from farmed salmon to migrating juvenile wild salmon. Low numbers of sea lice can cause mortality of juvenile pink and chum salmon. For pink salmon, this has resulted in reduced productivity of river populations exposed to salmon farming. However, for chum salmon, we did not find an effect of sea louse infestations on productivity, despite high statistical power. Motivated by this unexpected result, we used a mathematical model to show how a parasite-induced shift in predation pressure from chum salmon to pink salmon could offset negative direct impacts of sea lice on chum salmon. This shift in predation is proposed to occur because predators show an innate preference for pink salmon prey. This preference may be more easily expressed when sea lice compromise juvenile salmon hosts, making them easier to catch. Our results indicate how the ecological context of host–parasite interactions may dampen, or even reverse, the expected impact of parasites on host populations.

Perry, R. W., Plumb, J. M., & Huntington, C. W. (2015). Using a laboratory-based growth model to estimate mass- and temperature-dependent growth parameters across populations of juvenile Chinook Salmon. *Transactions of the American Fisheries Society*, *144*(2), 331–336. http://doi.org/10.1080/00028487.2014.996667

To estimate the parameters that govern mass- and temperature-dependent growth, we conducted a meta-analysis of existing growth data from juvenile Chinook Salmon *Oncorhynchus tshawytscha* that were fed an ad libitum ration of a pelleted diet. Although the growth of juvenile Chinook Salmon has been well studied, research has focused on a single population, a narrow range of fish sizes, or a narrow range of temperatures. Therefore, we incorporated the Ratkowsky model for temperature-dependent growth into an allometric growth model; this model was then fitted to growth data from 11 data sources representing nine populations of juvenile Chinook Salmon. The model fit the growth data well, explaining 98% of the variation in final mass. The estimated allometric mass exponent (b) was 0.338 (SE = 0.025), similar to estimates reported for other salmonids. This estimate of b will be particularly useful for estimating mass-standardized growth rates of juvenile Chinook Salmon. In addition, the lower thermal limit, optimal temperature, and upper thermal limit for growth were estimated to be 1.8°C (SE = 0.63°C), 19.0°C (SE = 0.27°C), and 24.9°C (SE = 0.02°C), respectively. By taking a meta-analytical approach, we were able to provide a growth model that is applicable across populations of juvenile Chinook Salmon receiving an ad libitum ration of a pelleted diet.

Peterson, W. T., Fisher, J. L., Peterson, J. O., Morgan, C. A., Burke, B. J., & Fresh, K. L. (2014). Applied fisheries oceanography: Ecosystem indicators of ocean conditions inform fisheries management in the California Current. ***Oceanography, 27*****(4), 80–89. http://dx.doi.org/10.5670/oceanog.2014.88**

Fisheries oceanography is the study of ecological relationships between fishes and the dynamics of their marine environments and aims to characterize the physical, chemical, and biological factors that affect the recruitment and abundance of harvested species. A recent push within the fisheries management community is toward ecosystem-based management. Here, we show how physical and biological oceanography data can be used to generate indicators of ocean conditions in an ecosystem context, and how these indicators relate to the recruitment of salmonids, sablefish, sardines, and rockfish in the California Current.

Plumb, J. M., & Moffitt, C. M. (2015). Re-estimating temperature-dependent consumption parameters in bioenergetics models for juvenile Chinook Salmon. ***Transactions of the American Fisheries Society*****,** ***144*****(2), 323–330. http://doi.org/10.1080/00028487.2014.986336**

Researchers have cautioned against the borrowing of consumption and growth parameters from other species and life stages in bioenergetics growth models. In particular, the function that dictates temperature dependence in maximum consumption (Cmax) within the Wisconsin bioenergetics model for Chinook Salmon *Oncorhynchus tshawytscha* produces estimates that are lower than those measured in published laboratory feeding trials. We used published and unpublished data from laboratory feeding trials with subyearling Chinook Salmon from three stocks (Snake, Nechako, and Big Qualicum rivers) to estimate and adjust the model parameters for temperature dependence in Cmax. The data included growth measures in fish ranging from 1.5 to 7.2 g that were held at temperatures from 14°C to 26°C. Parameters for temperature dependence in Cmax were estimated based on relative differences in food consumption, and bootstrapping techniques were then used to estimate the error about the parameters. We found that at temperatures between 17°C and 25°C, the current parameter values did not match the observed data, indicating that Cmax should be shifted by about 4°C relative to the current implementation under the bioenergetics model. We conclude that the adjusted parameters for

Cmax should produce more accurate predictions from the bioenergetics model for subyearling Chinook Salmon.

Price, M. H. H., & Connors, B. M. (2014). Evaluating relationships between wild Skeena River Sockeye Salmon productivity and the abundance of spawning channel enhanced Sockeye smolts. *PLoS ONE*, *9*(4). http://doi.org/10.1371/journal.pone.0095718

The enhancement of salmon populations has long been used to increase the abundance of salmon returning to spawn and/or to be captured in fisheries. However, in some instances enhancement can have adverse impacts on adjacent non-enhanced populations. In Canada's Skeena watershed, smolt-to-adult survival of Babine Lake sockeye from 1962–2002 was inversely related to the abundance of sockeye smolts leaving Babine Lake. This relationship has led to the concern that Babine Lake smolt production, which is primarily enhanced by spawning channels, may depress wild Skeena (Babine and non-Babine) sockeye populations as a result of increased competition between wild and enhanced sockeye smolts as they leave their natal lakes and co-migrate to sea. To test this hypothesis we used data on Skeena sockeye populations and oceanographic conditions to statistically examine the relationship between Skeena sockeye productivity (adult salmon produced per spawner) and an index of Babine Lake enhanced smolt abundance while accounting for the potential influence of early marine conditions. While we had relatively high power to detect large effects, we did not find support for the hypothesis that the productivity of wild Skeena sockeye is inversely related to the abundance of enhanced sockeye smolts leaving Babine Lake in a given year. Importantly, life-time productivity of Skeena sockeye is only partially explained by marine survival, and likely is an unreliable measure of the influence of smolt abundance. Limitations to our analyses, which include: (1) the reliance upon adult salmon produced per spawner (rather than per smolt) as an index of marine survival, and (2) incomplete age structure for most of the populations considered, highlight uncertainties that should be addressed if understanding relationships between wild and enhanced sockeye is a priority in the Skeena.

Putman, N. F., Meinke, A. M., & Noakes, D. L. G. (2014). Rearing in a distorted magnetic field disrupts the "map sense" of juvenile steelhead trout. *Biology Letters*, *10*(6), 20140169. http://doi.org/10.1098/rsbl.2014.0169

We used simulated magnetic displacements to test orientation preferences of juvenile steelhead trout (*Oncorhynchus mykiss*) exposed to magnetic fields existing at the northernmost and southernmost boundaries of their oceanic range. Fish reared in natural magnetic conditions distinguished between these two fields by orienting in opposite directions, with headings that would lead fish towards marine foraging grounds. However, fish reared in a spatially distorted magnetic field failed to distinguish between the experimental fields and were randomly oriented. The non-uniform field in which fish were reared is probably typical of fields that many hatchery fish encounter due to magnetic distortions associated with the infrastructure of aquaculture. Given that the reduced navigational abilities we observed could negatively influence marine survival, homing ability and hatchery efficiency, we recommend further study on the implications of rearing salmonids in unnatural magnetic fields.

Putman, N. F., Scanlan, M. M., Billman, E. J., O'Neil, J. P., Couture, R. B., Quinn, T. P., Lohmann, K. J. & Noakes, D. L. G. (2014). An inherited magnetic map guides ocean

navigation in juvenile Pacific salmon. *Current Biology*, *24*(4), 446–450. http://doi.org/10.1016/j.cub.2014.01.017
Migratory marine animals exploit resources in different oceanic regions at different life stages, but how they navigate to specific oceanic areas is poorly understood [1–3]. A particular challenge is explaining how juvenile animals with no prior migratory experience are able to locate specific oceanic feeding habitats that are hundreds or thousands of kilometers from their natal sites [1–7]. Although adults reproducing in the vicinity of favorable ocean currents can facilitate transport of their offspring to these habitats [7–9], variation in ocean circulation makes passive transport unreliable, and young animals probably take an active role in controlling their migratory trajectories [10–13]. Here we experimentally demonstrate that juvenile Chinook salmon (*Oncorhynchus tshawytscha*) respond to magnetic fields like those at the latitudinal extremes of their ocean range by orienting in directions that would, in each case, lead toward their marine feeding grounds. We further show that fish use the combination of magnetic intensity and inclination angle to assess their geographic location. The "magnetic map" of salmon appears to be inherited, as the fish had no prior migratory experience. These results, paired with findings in sea turtles [12–21], imply that magnetic maps are phylogenetically widespread and likely explain the extraordinary navigational abilities evident in many long-distance underwater migrants.

Quinn, T. P., Bond, M., & Slater, S. (2014). Use of stable isotopes and otolith micro-chemistry to evaluate migration in male Chinook Salmon, *Oncorhynchus tshawytscha*, from an Alaskan river. *Northwest Science*, *88*(4), 360–366. http://doi.org/10.3955/046.088.0409
In salmonid fishes, males display much more variation in age and size at maturity than females, including a greater proportion of non-anadromous individuals, and those spending fewer years at sea than females. The life history of Chinook salmon is especially variable among Pacific salmon species, including non-anadromous (precocious parr) and early maturing anadromous males (jacks) but these have been studied primarily in populations towards the central and southern part of their range. In this study we investigated reports of small and putatively non-anadromous male Chinook salmon in Lake Creek, Alaska, using otolith microchemistry and stable isotopes. Small males (ca. 300–350 mm fork length) displayed otolith Sr:Ca ratios and $\delta^{15}N$ values consistent with anadromy; indeed, the $\delta^{15}N$ values of these "mini-jacks" that had spent a year at sea and larger jacks (ca. 500 mm) were more enriched than those of the larger, older conspecifics. Thus the multiple alternative anadromous male life history patterns reported in southern populations (and often associated with rapid pre-smolt growth in hatcheries) are present in more northerly wild populations of Chinook salmon as well. Moreover, variation in stable isotopes indicated differences in marine distribution related to age (with younger fish closer to the coast), and otolith microchemistry suggested that some of the young males may have moved to low salinity water during their period of marine residence.

Quinn, T. P., Shaffer, J. A., Brown, J., Harris, N., Byrnes, C., & Crain, P. (2014). Juvenile Chinook salmon, *Oncorhynchus tshawytscha*, use of the Elwha river estuary prior to dam removal. *Environmental Biology of Fishes*, *97*(6), 731–740. http://doi.org/10.1007/s10641-013-0173-z
The estuary of the Elwha River, on Washington's Olympic Peninsula, has been degraded and simplified over the past century from sediment retention behind two large dams, levee construction, and channelization. With the removal of Elwha Dam and initiation of Glines

Canyon Dam's removal in fall 2011, sediment deposits will change the estuary and affect anadromous and nearshore marine fishes. Juvenile Chinook salmon commonly use estuaries and the river's population is part of an Evolutionarily Significant Unit listed as Threatened under the U.S. Endangered Species Act. This study reports on monthly sampling in part of the river's estuary from March 2007 through September 2011 to characterize the seasonal changes in relative abundance of yearlings and sub-yearlings, and size distributions prior to dam removal. Most (69 %) of the yearlings were caught in April, when this life history type was released from the hatchery, and to a lesser extent in May (28 %) and June (3 %). Yearlings caught in the estuary were smaller than those released from the hatchery (means: 153 mm ± 28 SD vs. 175 mm ± 5 SD), suggesting more rapid departure by larger fish. Sub-yearlings were much more abundant in the estuary, and were caught from March through November, increasing in mean fork length by 8.7 mm month-1. The hatchery-origin sub-yearlings were not marked externally and so were not distinguishable from natural origin fish. However, 39 % of the sub-yearlings were caught prior to June, when sub-yearlings were released from the hatchery, indicating substantial use of the estuary by natural-origin fish. Thus, even in a reduced state after a century of dam operation, the highly modified estuary was used over many months by juvenile Chinook salmon. The information on juvenile Chinook salmon prior to dam removal provides a basis for comparison to patterns in the future, when the anticipated increase in estuarine complexity may further enhance habitat use by juvenile Chinook salmon.

Quiñones, R. M., Holyoak, M., Johnson, M. L., & Moyle, P. B. (2014). Potential factors affecting survival differ by run-timing and location: linear mixed-effects models of Pacific Salmonids (*Oncorhynchus* spp.) in the Klamath River, California. *PLoS ONE*, *9*(5). http://doi.org/10.1371/journal.pone.0098392

Understanding factors influencing survival of Pacific salmonids (*Oncorhynchus* spp.) is essential to species conservation, because drivers of mortality can vary over multiple spatial and temporal scales. Although recent studies have evaluated the effects of climate, habitat quality, or resource management (e.g., hatchery operations) on salmonid recruitment and survival, a failure to look at multiple factors simultaneously leaves open questions about the relative importance of different factors. We analyzed the relationship between ten factors and survival (1980–2007) of four populations of salmonids with distinct life histories from two adjacent watersheds (Salmon and Scott rivers) in the Klamath River basin, California. The factors were ocean abundance, ocean harvest, hatchery releases, hatchery returns, Pacific Decadal Oscillation, North Pacific Gyre Oscillation, El Niño Southern Oscillation, snow depth, flow, and watershed disturbance. Permutation tests and linear mixed-effects models tested effects of factors on survival of each taxon. Potential factors affecting survival differed among taxa and between locations. Fall Chinook salmon *O. tshawytscha* survival trends appeared to be driven partially or entirely by hatchery practices. Trends in three taxa (Salmon River spring Chinook salmon, Scott River fall Chinook salmon; Salmon River summer steelhead trout *O. mykiss*) were also likely driven by factors subject to climatic forcing (ocean abundance, summer flow). Our findings underscore the importance of multiple factors in simultaneously driving population trends in widespread species such as anadromous salmonids. They also show that the suite of factors may differ among different taxa in the same location as well as among populations of the same taxa in different watersheds. In the Klamath basin, hatchery practices need to be reevaluated to protect wild salmonids.

Rebenack, J. J., Ricker, S., Anderson, C., Wallace, M., & Ward, D. M. (2015). Early emigration of juvenile Coho Salmon: Implications for population monitoring. *Transactions of the American Fisheries Society*, *144*(1), 163–172. http://doi.org/10.1080/00028487.2014.982258
Salmon monitoring programs often measure juvenile production by operating migrant traps downstream of spawning and rearing areas during smolt migration. However, this approach does not account for individuals that move downstream of trapping locations prior to smolt sampling. We used a mark-recapture study with passive integrated transponder tagging to estimate the proportion of Coho Salmon *Oncorhynchus kisutch* juveniles, tagged in the fall in a Northern California stream, that migrated to rearing habitat downstream of a seasonally operated trap before spring smolt sampling. Emigrants were detected by using the migrant trap, located near the upstream limit of tidal influence, and continuously operated antennas located in tidal wetlands downstream of the trap. For all three cohorts sampled (2010, 2011, 2012), we identified two distinct emigration periods (not including fry emigrants that emigrated in spring at a size too small to tag): a fall-winter period, when early emigrant parr moved into a restored tidal wetland (early emigrants); and a spring period, when smolts emigrated (smolt emigrants). There was little movement in the intervening period. Emigration timing varied depending on the location in the basin where fish were tagged; locations in the lower main stem generally produced more early emigrants, while locations in the upper basin produced more smolt emigrants. Across locations, early emigrants accounted for 2-25% of the fall-marked juveniles from 2010, 8-29% from 2011, and 7-13% in 2012. Smolt emigrants accounted for 15-49% of the fall-marked juveniles from 2010, 13-14% from 2011, and 3-35% from 2012. The consistent occurrence of early emigration in this and other recent studies brings into question estimates of smolt abundance and demographic rates (e.g., overwinter and marine survival) that do not account for this life history variant.

Rechisky, E. L., Welch, D. W., Porter, A. D., Hess, J. E., & Narum, S. R. (2014). Testing for delayed mortality effects in the early marine life history of Columbia River Basin yearling Chinook salmon. *Marine Ecology Progress Series*, *496*, 159–180. http://doi.org/10.3354/meps10692
Juvenile Snake River Chinook salmon *Oncorhynchus tshawytscha* pass through 8 major hydroelectric dams during their >700 km migration to the sea, or are transported downriver to avoid these dams. Both of these anthropogenic processes may decrease fitness and lead to delayed mortality in the estuary and coastal ocean, and thus reduce the rate at which adults return to spawn. Using a large-scale telemetry array, we tested whether there was support for (1) hydrosystem-induced delayed mortality (hydro-DM) of yearlings migrating from the Snake River relative to yearlings migrating from the mid-Columbia River, and (2) transportation-induced delayed mortality (transport-DM) for transported Snake River yearlings relative to yearlings which migrated in-river. We also tested for differential early marine survival between yearlings migrating from the Snake and upper Columbia Rivers. In 2010, seaward migrating yearling Chinook were captured at dam bypasses and origin was based on capture location; in 2011, dam-caught fish were identified using genetic stock identification. Survival of all groups during the initial 750 km, >1 mo long migration through the estuary and coastal ocean to northwestern Vancouver Island ranged between 14 and 19% in 2010 and was lower in 2011 (1.5-8%). We found no support for hydro-DM, as survival of in-river migrating Snake and mid-Columbia River yearlings was indistinguishable. We found mixed results for our transportation study, with no support for transport-DM in 2010, and weak support in 2011. Our study provides

further evidence that freshwater management strategies may not increase the rate of Chinook salmon returning to the Snake River if prior freshwater experience has no substantial influence on subsequent survival in the ocean.

Reese, D. C., & Brodeur, R. D. (2015). Species associations and redundancy in relation to biological hotspots within the northern California Current ecosystem. *Journal of Marine Systems*. *In press*. http://doi.org/10.1016/j.jmarsys.2014.10.009
The dynamic nature of biological hotspots, while well recognized, is not well understood. We hypothesize that the persistence of hotspots in the northern California Current System (CCS), despite seasonal and annual changes in the nekton community species composition, is related to associations among species and their functional redundancy. To address this hypothesis, sampling was conducted during June and August of 2000 and 2002 within two hotspots occurring between Newport, Oregon and Crescent City, California in the coastal CCS. Associations were examined to identify potentially complementary and redundant species. The strongest negative associations were between jellyfish and fish species, with strong positive associations evident among several fish species. Dominant species varied seasonally and annually, although evidence indicated replacement of dominant species by other similar species with respect to functional group and preferred habitat. This finding suggests that the persistence of these biological hotspots is related to species redundancy and is an important attribute contributing to stability within this highly variable system.

Reum, J. C. P., Hovel, R. A., & Greene, C. M. (2015). Estimating continuous body size-based shifts in delta N-15-delta C-13 space using multivariate hierarchical models. *Marine Biology*, *162*(2), 469–478. http://doi.org/10.1007/s00227-014-2574-8
Stable isotopes (delta N-15 and delta C-13) offer one representation of an individual's trophic niche and are important tools for elucidating ecological patterns and testing a diversity of hypotheses. Because delta N-15 and delta C-13 values are often obtained from the same sample, they compose a bivariate response that researchers commonly analyze using multivariate statistical methods. However, stable isotope data sets often exhibit hierarchical structure whereby samples may be clustered or grouped at multiple levels either as an artifact of sampling design or due to structure inherent in the sampled population (e.g., samples from individuals grouped according to life history stages, social groups, ages, or sizes classes). Ignoring such structure can result in overly optimistic confidence intervals and heighten the risk of observing significant differences where none exist. To address these issues, we suggest researchers utilize multivariate hierarchical models, which are a simple extension of univariate hierarchical methods. The models account for potential dependencies between delta N-15 and delta C-13 values, permit valid predictions of shifts in delta N-15-delta C-13 space related to predictor variables, provide more accurate estimates of parameter uncertainty, and improved inferences on coefficients that correspond to groups with small to moderate quantities of data. We demonstrate advantages of multivariate hierarchical models by examining size-dependent shifts in delta N-15-delta C-13 space in outmigrating post-smolt Chinook salmon sampled from an estuarine habitat. Given the prevalence of complex structure in ecological stable isotope data sets, multivariate hierarchical models should hold considerable value to food web and stable isotope ecologists.

Roegner, G. C., & Teel, D. J. (2014). Density and condition of subyearling Chinook Salmon in the lower Columbia River and estuary in relation to water temperature and genetic stock

of origin. ***Transactions of the American Fisheries Society*, *143*(5), 1161–1176. http://doi.org/10.1080/00028487.2014.918055**
We examined the hypotheses that density and morphometric condition of subyearling juvenile Chinook Salmon *Oncorhynchus tshawytscha* would decline during periods of high water temperature in the lower Columbia River and estuary. The hypotheses were tested using salmon density measurements and a condition anomaly calculated from residuals of the length–weight linear regression based on 5,536 subyearlings collected from brackish estuarine and tidal freshwater (TFW) habitats. We captured Chinook Salmon at all temperatures encountered (4.2–23.5°C). In the TFW zone, densities were highest at optimal temperatures and lowest at suboptimal and supraoptimal temperatures; in the estuary, density did not differ among temperature regimes. Fish condition was lowest in winter, when temperatures were suboptimal, and highest in summer, when temperatures were supraoptimal. Pairwise comparisons of fish condition between periods of optimal temperature (spring) and supraoptimal or stressful temperature (summer) showed little change in the estuary but a large, positive increase with temperature in the TFW zone. Similarly, we examined seasonal differences in the condition of 50–60-mm fry and again found condition to be lowest in winter and highest in summer. Finally, using genetic information, we identified stock-specific differences in migration timing and concluded that most large yearlings and many subyearlings migrated in late winter or spring and therefore were never exposed to high temperatures. Other prevalent stocks persisted in the estuary during periods of elevated temperature; however, the condition of those fish also tended to be higher or neutral in summer than in spring. High temperatures appeared to influence migration timing, as evidenced by reduced density in TFW reaches during summer. However, we found little support for the hypothesis that condition of juvenile Chinook Salmon is reduced during periods of high water temperature in the lower Columbia River and estuary.

Rohde, J., Fresh, K. L., & Quinn, T. P. (2014). Factors affecting partial migration in Puget Sound Coho Salmon. ***North American Journal of Fisheries Management*, *34*(3), 559–570. http://doi.org/10.1080/02755947.2014.892548**
Partial migration, the behavior pattern in which a portion of a population migrates while others do not, is a widespread phenomenon with ecological and evolutionary consequences. Most Coho Salmon *Oncorhynchus kisutch* from Puget Sound, Washington, migrate to feed over the continental shelf or offshore in the North Pacific Ocean, but some remain in the semiestuarine waters of Puget Sound and are termed residents. The objective of this study was to determine which of several factors influenced residency in Puget Sound Coho Salmon. Coded wire tag recovery data showed that resident Coho Salmon were smaller than their migratory counterparts, and we used this size difference and the relative catch patterns along the coast and in Puget Sound to classify Coho Salmon caught in Puget Sound between November and August as residents. We then analyzed the effects of location of origin, day of release, weight at release, hatchery or wild rearing, and year on the proportion of fish caught as residents. Based on 268 release groups between 1975 and 1992, we classified 3.4% of fish recovered as residents, 61.3% as migrants, and 35.3% as ambiguous because they were recovered in Puget Sound in September and October, when residents and migrants were mixed. The proportion of residents varied as a function of year, basin, and day of the year. Releases into south Puget Sound produced the highest proportion of residents, and resident fish tended to be recovered in the basin where they entered Puget Sound. While other factors may influence residency in Coho Salmon, the effects of day of release and location of origin may be useful for management of these populations, as the

tendency to remain in Puget Sound or migrate to the coast affects the fisheries in which the fish are taken and their growth rate, their uptake of contaminants, and their role in food webs.

Ruggerone, G. T., & Connors, B. M. (2015). Productivity and life history of sockeye salmon in relation to competition with pink and sockeye salmon in the North Pacific Ocean. *Canadian Journal of Fisheries and Aquatic Sciences*. http://doi.org/10.1139/cjfas-2014-0134
Sockeye salmon populations from Southeast Alaska through British Columbia to Washington State have experienced similar declines in productivity over the past two decades, leading to economic and ecosystem concerns. Because the declines have spanned a wide geographic area, the primary mechanisms driving them likely operate at a large, multi-regional scale at sea. However, identification of such mechanisms has remained elusive. Using hierarchical models of stock-recruitment dynamics, we tested the hypothesis that competition between pink and sockeye salmon for prey has led to reduced growth and productivity and delayed maturation of up to 36 sockeye populations spanning the region during the past 55 years. Our findings indicate the abundance of North Pacific pink salmon in the second year of sockeye life at sea is a key factor contributing to the decline of sockeye salmon productivity, including sockeye in the Fraser River where an increase from 200 to 400 million pink salmon is predicted to reduce sockeye recruitment by 39%. Additionally, length-at-age of Fraser River sockeye salmon declined with greater sockeye and pink salmon abundance, and age-at-maturity increased with greater pink salmon abundance. Our analyses provide evidence that interspecific competition for prey can affect growth, age and survival of sockeye salmon at sea.

Sandell, T. A., Teel, D. J., Fisher, J., Beckman, B., & Jacobson, K. C. (2014). Infections by *Renibacterium salmoninarum* and *Nanophyetus salmincola* Chapin are associated with reduced growth of juvenile Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), in the Northeast Pacific Ocean. *Journal of Fish Diseases*, http://doi.org/10.1111/jfd.12243
We examined 1454 juvenile Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), captured in nearshore waters off the coasts of Washington and Oregon (USA) from 1999 to 2004 for infection by *Renibacterium salmoninarum, Nanophyetus salmincola* Chapin and skin metacercariae. The prevalence and intensities for each of these infections were established for both yearling and subyearling Chinook salmon. Two metrics of salmon growth, weight residuals and plasma levels of insulin-like growth factor-1, were determined for salmon infected with these pathogens/parasites, both individually and in combination, with uninfected fish used for comparison. Yearling Chinook salmon infected with *R. salmoninarum* had significantly reduced weight residuals. Chinook salmon infected with skin metacercariae alone did not have significantly reduced growth metrics. Dual infections were not associated with significantly more severe effects on the growth metrics than single infections; the number of triple infections was very low and precluded statistical comparison. Overall, these data suggest that infections by these organisms can be associated with reduced juvenile Chinook salmon growth. Because growth in the first year at sea has been linked to survival for some stocks of Chinook salmon, the infections may therefore play a role in regulating these populations in the Northeast Pacific Ocean.

Satterthwaite, W. H., Carlson, S. M., Allen-Moran, S. D., Vincenzi, S., Bograd, S. J., & Wells, B. K. (2014). Match-mismatch dynamics and the relationship between ocean-entry timing and

relative ocean recoveries of Central Valley fall run Chinook salmon. ***Marine Ecology Progress Series*, *511*, 237–248. http://doi.org/10.3354/meps10934**
The match-mismatch hypothesis suggests there is an optimal window for organisms to undergo key life cycle events. Here, we test the importance of match-mismatch dynamics in the timing of salmon arrival to the ocean, relative to ecosystem phenology, for the ocean survival rates of hatchery-origin fall run Chinook salmon originating from California's Central Valley. Specifically, we considered tag recovery data for releases of coded-wire tagged fish released into the San Francisco Estuary during the years 1978 to 2010. We determined a time lag for each release relative to the local spring transition date (initiation of net upwelling). Additionally, we obtained information on fish condition and size at release, the number of fish released corresponding to distinct tag codes, and yearly stock-specific harvest rate estimates. We used generalized linear models, generalized additive models, and cross-validation to identify the best-supported models for the effects of release timing and other covariates on age-3 ocean fishery recovery rates, a proxy of ocean survival rates. Release time is a useful predictor of within-year variation in survival rates, above and beyond the effects of size at release, presence of disease, and the use of net pens, and the lag relative to spring transition was a slightly better predictor than year-day. The optimal release timing appeared to occur around the end of May, and the optimal time lag appeared to be approximately 70 to 115 d after the spring transition date. However, timing is only one of many factors that affected within- and among-year variation in survival.

Schaller, H. A., Petrosky, C. E., & Tinus, E. S. (2014). Evaluating river management during seaward migration to recover Columbia River stream-type Chinook salmon considering the variation in marine conditions. ***Canadian Journal of Fisheries and Aquatic Sciences*, *71*(2), 259–271. http://doi.org/10.1139/cjfas-2013-0226**
Evidence suggests Snake River stream-type Chinook salmon (*Oncorhynchus tshawytscha*) experience substantial delayed mortality in the marine environment as a result of their outmigration experience through the Federal Columbia River Power System (FCRPS). We analyzed mortality patterns using methods that incorporated downriver reference populations passing fewer dams, and temporal approaches that were independent of reference populations. Our results from the alternative spatial and temporal methods consistently corroborated with spawner–recruit residuals and smolt-to-adult survival rate data sets, indicating that Snake River salmon survived about one quarter as well as the reference populations. Temporal analysis indicated that a high percentage (76%) of Snake River juvenile salmon that survived the FCRPS subsequently died in the marine environment as a result of their outmigration experience. Through this and previous studies, it is evident that delayed hydrosystem mortality increases with the number of powerhouse passages and decreases with the speed of outmigration. Therefore, a promising conservation approach would be to explore management experiments that evaluate these relationships by increasing managed spill levels at the dams during the spring migration period.

Spangenberg, D., Larsen, D. A., Gerstenberger, R., Brun, C., & Beckman, B. R. (2014). The effects of variation in rearing conditions on growth, smolt development, and minijack rate in yearling Chinook Salmon: a hatchery scale experiment. ***Transactions of the American Fisheries Society*, *143*(5), 1220–1230. http://doi.org/10.1080/00028487.2014.931304**

In this investigation a single genetic stock of Hood River, Oregon, Chinook Salmon *Oncorhynchus tshawytscha* was reared at three different hatchery facilities over three brood years (2008–2010) and monitored for size, growth rate, gill Na+,K+-ATPase activity, condition factor, whole body energetics, and precocious male maturation (age-2 minijack rate). This experimental design provided a unique opportunity to isolate environmental from genetic effects on salmonid life history. Differences in the seasonal thermal regimes and associated growth profiles among the three facilities resulted in modest differences in smolt development but significant variation in size at release (range = 18 g body weight, 118 mm FL to 31 g body weight, 142 mm FL) and minijack rates (range = 4.8–57.1%) among groups. Previous studies have found a positive relationship between body size at release and minijack rates. However, in this investigation the release group with the largest mean body size consistently had the lowest minijack rates. This unique result may be due to the more natural thermal regime and feeding profile experienced by fish at this facility compared with that of the other two facilities and highlights the importance and potential benefits of adhering to a more "wildlike" growth profile in hatchery supplementation programs.

Stocks, A. P., Pakhomov, E. A., & Hunt, B. P. V. (2014). A simple method to assess the marine environment residence duration of juvenile sockeye salmon (*Oncorhynchus nerka*) using laser ablation. *Canadian Journal of Fisheries and Aquatic Sciences*, *71*(10), 1437–1446. http://doi.org/10.1139/cjfas-2014-0073
Monitoring habitat utilization and early marine growth of sockeye salmon juveniles (*Oncorhynchus nerka*) in fjords of the Pacific Northwest is currently hampered by difficulties in estimating residence times, limiting scientific advances in certain aspects of this species' fisheries management and conservation. Combining otolith microchemistry and conventional daily ring counts, we were able to obtain the date of first entry and the residence time of sockeye juveniles in Rivers Inlet, British Columbia. This operationally inexpensive method builds upon variable microelement concentrations in fresh- and saltwater environments: barium (Ba) and strontium (Sr) concentrations within the sockeye otoliths differed between the freshwater and seawater growth zones; Ba concentrations in the freshwater growth zone were significantly higher than those in the seawater growth zone, while Sr concentrations in the former were significantly lower than in the latter. The concentrations of these elements within otoliths were determined quantitatively at high spatial resolution using in situ laser ablation inductively coupled with a plasma mass spectrometer (ICPMS) providing a record of the ambient environmental conditions experienced by individual fish. Exploratory analysis of a 3-year data set showed that the mean residence time of sockeye juveniles in Rivers Inlet varied between 3 and 6 weeks between years.

Sutherland, B. J., Koczka, K. W., Yasuike, M., Jantzen, S. G., Yazawa, R., Koop, B. F., & Jones, S. R. (2014). Comparative transcriptomics of Atlantic *Salmo salar*, chum *Oncorhynchus keta* and pink salmon *O. gorbuscha* during infections with salmon lice *Lepeophtheirus salmonis*. *BMC Genomics*, *15*(1), 200. http://doi.org/10.1186/1471-2164-15-200
Salmon species vary in susceptibility to infections with the salmon louse (*Lepeophtheirus salmonis*). Comparing mechanisms underlying responses in susceptible and resistant species is important for estimating impacts of infections on wild salmon, selective breeding of farmed salmon, and expanding our knowledge of fish immune responses to ectoparasites. Herein we report three *L. salmonis* experimental infection trials of co-habited Atlantic *Salmo salar*, chum

Oncorhynchus keta and pink salmon *O. gorbuscha*, profiling hematocrit, blood cortisol concentrations, and transcriptomic responses of the anterior kidney and skin to the infection.

Tanasichuk, R. W., Grayson, J., Yakimishyn, J., Taylor, S., & Dagley, G. D. (2014). The Early Marine Biology of the Hatchery/Wild Juvenile Salmonid (*Oncorhynchus* sp.) Community in Barkley Sound, Canada. *The Open Fish Science Journal*, *7*(1), 8–22.
We conducted 11 purse seine/beachseine surveys over the summers of 2000 and 2001 to learn about the migration timing, distribution, and diet of hatchery chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*), and wild chinook, coho, sockeye (*O. nerka*) and chum (*O. keta*) juvenile salmon, in Barkley Sound, West Coast Vancouver Island. Juvenile salmon partitioned Barkley Sound by time and space, and by diet except for hatchery and wild coho. The analysis of migration timing included historic data for 1987-89, and results showed that timing differed between species and was consistent over years. Sockeye and chum dominated the juvenile salmon community until mid-June and hatchery and wild chinook dominated subsequently. Fish tended to be dispersed contagiously. Results of correlation analyses of catch suggested that fish of different origins and species did not co-occur. The euphausiid *Thysanoessa spinifera* was an important prey item but different fish species selected different sizes of *T. spinifera* at different times. The diet overlap between hatchery and wild coho did not affect return. Migration timing for sockeye and wild coho seems to reflect a strategy to enter the ocean when the biomass of the size fraction of *T. spinifera* that each species selects is likely to be maximal. Descriptions of migration timing, fish interactions, and diet provide information which appears to be useful for learning about the biological basis of salmon return variability.

Teel, D. J., Bottom, D. L., Hinton, S. A., Kuligowski, D. R., McCabe, G. T., McNatt, R., Roegner, G. C., Stamatiou, L. A., & Simenstad, C. A. (2014). Genetic identification of Chinook Salmon in the Columbia River estuary: stock-specific distributions of juveniles in shallow tidal freshwater habitats. *North American Journal of Fisheries Management*, *34*(3), 621–641. http://doi.org/10.1080/02755947.2014.901258
Extensive efforts are underway to restore and conserve nearshore shallow water habitats in the Columbia River estuary with the intent of increasing the estuary's capacity to provide food, refuge, and other crucial ecosystem functions for juvenile salmon. Juvenile Chinook Salmon *Oncorhynchus tshawytscha*, including those from the five Evolutionarily Significant Units listed as threatened or endangered under the U.S. Endangered Species Act, are particularly expected to benefit from the habitat improvements. However, information on the temporal and spatial estuarine distributions of juveniles from specific populations or stocks is lacking and impedes restoration planning for at-risk salmon. We conducted a series of surveys to sample juvenile Chinook Salmon occupying shallow-water habitats with sandy beaches in six hydrogeomorphic reaches across the tidal freshwater portion of the estuary and also at one long-term reference site near the estuary mouth. Sites were sampled bimonthly over 26 months during 2010–2012 to capture seasonal patterns of stock-specific habitat use. Genetic stock identification analyses were conducted on the samples using microsatellite DNA loci and genotypic data representing spawning populations from throughout the Columbia River basin. We identified three tidal freshwater areas that could be distinguished by genetic stock composition. Lower tidal freshwater reaches were dominated by fall-run juveniles from West Cascade tributaries (>70%), upper reaches had a large proportion of fish from the upper Columbia River summer–fall stock (>60%), and middle reaches were characterized by greater stock diversity with no single stock

contributing more than 30% in each reach. Stock-specific juvenile habitat use differed by season, life history type, and between natural and hatchery-produced fish. Data from this study provide improved descriptions of the near-shore estuary habitat use of several Columbia River genetic stocks of Chinook Salmon that can assist managers in the design and selection of estuary restoration projects.

Thayer, J. A., Field, J. C., & Sydeman, W. J. (2014). Changes in California Chinook salmon diet over the past 50 years: relevance to the recent population crash. *Marine Ecology Progress Series*, *498*, 249–U561. http://doi.org/10.3354/meps10608

Salmon are affected by variation in ocean productivity; thus, improved understanding of mechanisms behind variability in ocean survival should help management of these ecologically and economically important populations. Based on a cooperative fisheries research program, we compared central California Chinook salmon *Oncorhynchus tshawytscha* adult food habits from spring and summer in the mid-2000s with historical records from 1955 and the 1980s. Diet diversity decreased through time, and was particularly low in May and June of the 2000s. Previously important prey, including juvenile rockfish *Sebastes* spp., krill *Euphausiidae*, Pacific herring *Clupea pallesi* and market squid *Doryteuthis opalsecens*, declined or disappeared from the diet, while Pacific sardine *Sardinops sagax* became very important prey in the 2000s; anchovy *Engraulis mordax* remained important throughout the study. Diet composition was correlated with regional mid-water trawls of prey abundance and also with local sea surface temperature (SST). Diet composition was related to the Sacramento Index of fall-run Chinook ocean abundance with a lag of 1 or 2 yr, and reflected the importance of prey availability during the second ocean year and smolt ocean-entry period, respectively. Spring is peak ocean entry for fall-run Chinook smolts, so declining prey diversity (specifically in May and June in the mid-2000s) may be related to recent population crashes. Seasonally, winter and fall diet data further demonstrated the significance of temporal variation in specific prey. This study highlights the importance of marine predator-prey interactions at an appropriate temporal resolution for understanding salmonid population dynamics.

Thompson, J. N., & Beauchamp, D. A. (2014). Size-selective mortality of Steelhead during freshwater and marine life stages related to freshwater growth in the Skagit River, Washington. *Transactions of the American Fisheries Society*, *143*(4), 910–925. http://doi.org/10.1080/00028487.2014.901253

We evaluated freshwater growth and survival from juvenile (ages 0–3) to smolt (ages 1–5) and adult stages in wild steelhead *Oncorhynchus mykiss* sampled in different precipitation zones of the Skagit River basin, Washington. Our objectives were to determine whether significant size-selective mortality (SSM) in steelhead could be detected between early and later freshwater stages and between each of these freshwater stages and returning adults and, if so, how SSM varied between these life stages and mixed and snow precipitation zones. Scale-based size-at-annulus comparisons indicated that steelhead in the snow zone were significantly larger at annulus 1 than those in the mixed rain–snow zone. Size at annuli 2 and 3 did not differ between precipitation zones, and we found no precipitation zone × life stage interaction effect on size at annulus. Significant freshwater and marine SSM was evident between the juvenile and adult samples at annulus 1 and between each life stage at annuli 2 and 3. Rapid growth between the final freshwater annulus and the smolt migration did not improve survival to adulthood; rather, it appears that survival in the marine environment may be driven by an overall higher growth rate set earlier in life, which results in a larger size at smolt migration. Efforts for recovery of threatened Puget Sound steelhead could benefit by considering that SSM between freshwater and marine life stages can be partially attributed to growth attained in freshwater habitats and by identifying those factors that limit growth during early life stages.

Thorson, J. T., Scheuerell, M. D., Buhle, E. R., & Copeland, T. (2014). Spatial variation buffers temporal fluctuations in early juvenile survival for an endangered Pacific salmon. *Journal of Animal Ecology*, *83*(1), 157–167. http://doi.org/10.1111/1365-2656.12117
Spatial, phenotypic and genetic diversity at relatively small scales can buffer species against large-scale processes such as climate change that tend to synchronize populations and increase temporal variability in overall abundance or production. This portfolio effect generally results in improved biological and economic outcomes for managed species. Previous evidence for the portfolio effect in salmonids has arisen from examinations of time series of adult abundance, but we lack evidence of spatial buffering of temporal variability in demographic rates such as survival of juveniles during their first year of life. We therefore use density-dependent population models with multiple random effects to represent synchronous (similar among populations) and asynchronous (different among populations) temporal variability as well as spatial variability in survival. These are fitted to 25 years of survey data for breeding adults and surviving juveniles from 15 demographically distinct populations of Chinook salmon (*Oncorhynchus tshawytscha*) within a single metapopulation in the Snake River in Idaho, USA. Model selection identifies the most support for the model that included both synchronous and asynchronous temporal variability, in addition to spatial variability. Asynchronous variability (log-SD = 0·55) is approximately equal in magnitude to synchronous temporal variability (log-SD = 0·67), but much lower than spatial variability (log-SD = 1·11). We also show that the pairwise correlation coefficient, a common measure of population synchrony, is approximated by the estimated ratio of shared and total variance, where both approaches yield a synchrony estimate of 0·59. We therefore find evidence for spatial buffering of temporal variability in early juvenile survival, although between-population variability that persists over time is also large. * We conclude that spatial variation decreases interannual changes in overall juvenile production, which suggests that conservation and restoration of spatial diversity will improve population persistence for this metapopulation. However, the exact magnitude of spatial buffering depends upon demographic parameters such as adult survival that may vary among populations and is proposed as an area of future research using hierarchical life cycle models. We recommend that future sampling of this metapopulation employ a repeated-measure sampling design to improve estimation of early juvenile carrying capacity.

Tucker, S., Thiess, M. E., Morris, J. F. T., Mackas, D., Peterson, W. T., Candy, J. R., Beacham, T. D., Iwamoto, E. M., Teel, D. J., Peterson, M. & Trudel, M. (2015). Coastal distribution and consequent factors influencing production of endangered Snake River Sockeye Salmon. *Transactions of the American Fisheries Society*, *144*(1), 107–123. http://doi.org/10.1080/00028487.2014.968292
Snake River Sockeye Salmon *Oncorhynchus nerka* were declared endangered in 1991 after several years of decreasing abundance. Several factors, including poor marine survival, likely contributed to the decline of Snake River Sockeye Salmon. Little is known about their migration and ocean distribution and the factors influencing their production. We sampled (1) coastal waters from southern British Columbia (BC) to southeast Alaska during June–July, October–

November, and February–March 1998–2011; and (2) Oregon and Washington coastal waters during May–June and September 2007–2010. In total, 8,227 juvenile Sockeye Salmon were captured. Despite their extremely low abundance relative to other stocks, 15 coded-wire-tagged juveniles from Redfish Lake were recovered since 2007, primarily in spring and summer surveys off the BC coast. Genetic analyses revealed that an additional eight Redfish Lake juveniles were also present in this area during summer. Snake River smolts undertook a rapid northward migration that brought them well beyond the Columbia River estuary and plume, exposing them to ocean conditions prevailing off BC. Through a multimodel inference approach, we characterized associations between the number of returning adults and a suite of ocean and river variables. Seven ocean variables and five river variables were chosen for the model selection analysis (e.g., copepod biomass anomalies, coastal upwelling indices, date of the spring transition, river discharge, river temperature, and the proportion of smolts transported through the hydropower system). Although adult returns were highly correlated with smolt abundance, our analyses suggest that ocean conditions encountered during the first growing season (as indexed by copepod anomalies) contribute to the variability in total adult returns. There was also evidence for a negative effect of transporting smolts through the hydropower system, with the caveat that we used transportation data for steelhead *O. mykiss* as a proxy.

Van Doornik, D. M., Hess, M. A., Johnson, M. A., Teel, D. J., Friesen, T. A., & Myers, J. M. (2015). Genetic population structure of Willamette River Steelhead and the influence of introduced Stocks. *Transactions of the American Fisheries Society*, *144*(1), 150–162. http://doi.org/10.1080/00028487.2014.982178

Conservation genetics studies are frequently conducted on Pacific salmon *Oncorhynchus* spp. to delineate their population structure and to quantify their genetic diversity, especially for populations that have experienced declines in abundance and are subject to anthropogenic activities. One such group of salmonids is steelhead *O. mykiss* (anadromous Rainbow Trout) from the Willamette River, a tributary of the Columbia River. Within the Willamette River there are multiple steelhead life history and run-timing types, some of which originated from nonnative populations. Late winter-run steelhead and Rainbow Trout are native to the Willamette River, whereas early winter-run and summer-run steelhead have been introduced into the system via releases from artificial propagation efforts. We conducted genetic analyses of Willamette River steelhead to determine the effect that nonnative steelhead released into the Willamette River basin have had on the genetic population structure of native steelhead. We found genetic differentiation among the samples that separated steelhead into four population groups that corresponded to run type. Possibly due to local adaptation, the native run type has retained its genetic distinctiveness from the introduced types, despite there being opportunities for gene flow among all types. Introduced early winter-run steelhead appear to be the origin of steelhead inhabiting certain Willamette River tributaries where native steelhead did not historically spawn.

Williams, J. G., Smith, S. G., Fryer, J. K., Scheuerell, M. D., Muir, W. D., Flagg, T. A., Zabel, R. W., Ferguson, J. W. & Casillas, E. (2014). Influence of ocean and freshwater conditions on Columbia River sockeye salmon *Oncorhynchus nerka* adult return rates. *Fisheries Oceanography*, *23*(3), 210–224. http://doi.org/10.1111/fog.12056

In recent years, returns of adult sockeye salmon *Oncorhynchus nerka* to the Columbia River Basin have reached numbers not observed since the 1950s. To understand factors related to these increased returns, we first looked for changes in freshwater production and survival of juvenile migrants. We then evaluated productivity changes by estimating smolt-to-adult return rates (SAR) for juvenile migration years 1985–2010. We found SAR varied between 0.2 and 23.5%, with the highest values coinciding with recent large adult returns. However, the largest adult return, in 2012, resulted not from increased survival, but from increased smolt production. We evaluated 19 different variables that could influence SARs, representing different facets of freshwater and ocean conditions. We used model selection criteria based on small-sample corrected AIC to evaluate the relative performance of all two- and three-variable models. The model with April upwelling, Pacific Northwest Index (PNI) in the migration year, and PNI in the year before migration had 10 times the AICc weight as the second-best-supported model, and R2 = 0.82. The variables of April ocean upwelling and PNI in the migration year had high weights of 0.996 and 0.927, respectively, indicating they were by far the best of the candidate variables to explain variations in SAR. While our analyses were primarily correlative and limited by the type and amount of data currently available, changes in ocean conditions in the northern California Current system, as captured by April upwelling and PNI, appeared to play a large role in the variability of SAR.

Winship, A. J., O'Farrell, M. R., & Mohr, M. S. (2014). Fishery and hatchery effects on an endangered salmon population with low productivity. *Transactions of the American Fisheries Society*, *143*(4), 957–971. http://doi.org/10.1080/00028487.2014.892532

We estimated the natural spawner–fry stock–recruitment relationship and juvenile survival rates for Sacramento River winter Chinook Salmon *Oncorhynchus tshawytscha* in California and used these estimates to examine the expected numbers of spawners and fishing mortality under different fishing mortality rates and levels of hatchery supplementation. A stochastic, age-structured population dynamics model was fit to fry and female spawner abundance data for the years 1996–2010. Estimated survival rates of fry through the end of the first year in the ocean were generally <0.5%. Estimated survival rates of hatchery-origin fish from egg to the end of the first year in the ocean were on average about four times greater than the estimated maximum rate for natural-origin fish. The hatchery program was estimated to increase the number of spawners returning to natural spawning areas and thereby increase the fishing mortality rate that could be sustained. Assessing the past or future net effect of the hatchery on the size of the natural population would require quantifying any potential reduction in the productivity of the natural population as a result of reduced fitness of hatchery-origin fish spawning in natural spawning areas.

Winship, A. J., O'Farrell, M. R., Satterthwaite, W. H., Wells, B. K., & Mohr, M. S. (2015). Expected future performance of salmon abundance forecast models with varying complexity. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(4), 557–569. http://doi.org/10.1139/cjfas-2014-0247

We evaluated the scope for improving abundance forecasts for fishery management using Sacramento River fall Chinook salmon (*Oncorhynchus tshawytscha*) as a case study. A range of forecast models that related the Sacramento Index (SI; an index of adult ocean abundance) to jack (estimated age 2) spawning escapement the previous year were considered. Alternative models incorporated effects of density dependence, local environmental conditions, the abundance of the previous cohort, and trends or autocorrelation in the jack-to-SI relationship. Forecast performance was assessed in terms of bias, accuracy, ability to track trends in the SI, and management objectives. Several models achieved higher accuracy than the model used for

management, but no single model performed best across all criteria, and substantial forecast error remained across all approaches considered. Environmental models generally performed better than the management model, but there were differences in the relative importance of individual environmental variables over time and among model formulations. Accounting for model selection uncertainty in environmental models decreased their forecast performance. Simpler models often had similar or better performance than environmental models. In particular, the model incorporating temporally autocorrelated errors demonstrated potential for modest forecast improvement with relatively little additional model complexity.

Ye, H., Beamish, R. J., Glaser, S. M., Grant, S. C. H., Hsieh, C., Richards, L. J., Schnute, J. T. & Sugihara, G. (2015). Equation-free mechanistic ecosystem forecasting using empirical dynamic modeling. *Proceedings of the National Academy of Sciences*, *112*(13), E1569–E1576. http://doi.org/10.1073/pnas.1417063112
It is well known that current equilibrium-based models fall short as predictive descriptions of natural ecosystems, and particularly of fisheries systems that exhibit nonlinear dynamics. For example, model parameters assumed to be fixed constants may actually vary in time, models may fit well to existing data but lack out-of-sample predictive skill, and key driving variables may be misidentified due to transient (mirage) correlations that are common in nonlinear systems. With these frailties, it is somewhat surprising that static equilibrium models continue to be widely used. Here, we examine empirical dynamic modeling (EDM) as an alternative to imposed model equations and that accommodates both nonequilibrium dynamics and nonlinearity. Using time series from nine stocks of sockeye salmon (*Oncorhynchus nerka*) from the Fraser River system in British Columbia, Canada, we perform, for the the first time to our knowledge, real-data comparison of contemporary fisheries models with equivalent EDM formulations that explicitly use spawning stock and environmental variables to forecast recruitment. We find that EDM models produce more accurate and precise forecasts, and unlike extensions of the classic Ricker spawner–recruit equation, they show significant improvements when environmental factors are included. Our analysis demonstrates the strategic utility of EDM for incorporating environmental influences into fisheries forecasts and, more generally, for providing insight into how environmental factors can operate in forecast models, thus paving the way for equation-free mechanistic forecasting to be applied in management contexts.

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Subject: Pisces System Will Be OFFLINE for Maintenance, 6/23 @ 5pm PT - Please plan accordingly!

Importance: Normal

Good morning Pisces Users:

At 5pm today, we will be releasing a new version of Pisces desktop. We expect the system to be down for less than an hour during the release.

Please ensure you have completed your work and logged out prior to 5pm. If you don't hear anything further from us, you can assume it is up and running first thing on Wednesday 6/24.

We understand that this may be an inconvenience for some, so for those users who need support from your IT department each time you install a new version of Pisces – please send us a reply highlighting that for us. We're looking to implement targeted solutions in conjunction with your IT staff for those organizations that are affected.

As always, for system access or other issues – email support@cbfish.org.

Regards,

The PISCES Team

Bonneville Power Administration

This email was sent to all BPA and non-BPA users, the Pisces Team, and additional BPA staff as appropriate.

From: Pisces

Sent: Thu Aug 06 09:07:12 2015

To: Pisces

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Subject: Pisces System Will Be OFFLINE for Maintenance, 8/6 @ 5pm PT - Please plan accordingly!

Importance: Normal

Good morning Pisces Users:

At 5pm today, we will be releasing a new version of Pisces desktop. We expect the system to be down for less than an hour during the release.

Please ensure you have completed your work and logged out prior to 5pm. If you don't hear anything further from us, you can assume it is up and running first thing on Wednesday 6/24.

We understand that this may be an inconvenience for some. If you require support from your IT department each time you install a new version of Pisces – please send us a reply highlighting that for us. We're looking to implement targeted solutions in conjunction with your IT staff for those organizations that are affected.

As always, for system access or other issues – email support@cbfish.org.

Regards,

The PISCES Team

Bonneville Power Administration

This email was sent to all BPA and non-BPA users, the Pisces Team, and additional BPA staff as appropriate.

From: David Welch

Sent: Wed Aug 26 11:57:23 2015

To: Jason Sweet; Shields, Barbara A (bashields123@gmail.com); Josh Murauskas; John R. Skalski; Jim Anderson (jim@cbr.washington.edu)

Cc: Erin Rechisky; Aswea Porter; Sonia Batten

Subject: North Pacific blob & fisheries management...

Importance: Normal

Attachments: North Pacific ‘blob’ stirs up fisheries management _ Nature News & Comment.pdf

This just came out in this week’s issue of Nature, commenting on the potential impact of the N Pacific “blob” on fisheries management—I thought you would find it interesting reading.

(b)(5) [redacted]

[redacted]

Regards, David

David

kintamav_RGB

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

NATURE | NEWS

North Pacific 'blob' stirs up fisheries management

Unusually warm ocean strengthens calls to consider ecosystem variables in setting catch limits.

Virginia Gewin

20 August 2015

Ingo Arndt/Minden Pictures/FLPA

Interactions between predators and prey are integral to ecosystem-based fisheries management.

Unprecedented conditions in the Pacific Ocean have sent fisheries managers into uncharted waters. 'The blob', an unusually warm water mass that has been parked in the northern Pacific for 18 months, has quelled upwelling that typically delivers nutrients to coastal waters where migratory salmon, tuna and whales fatten themselves on 'forage species' such as anchovies, sardines and krill.

The nutrient shortage comes at a time when many of those forage species are already at historic lows. With a strengthening El Niño — warmth in the eastern equatorial Pacific that affects weather patterns worldwide — fisheries managers face a good deal more uncertainty than usual as they prepare to set catch limits for next year.

The situation lays bare the urgent need to improve how ecological processes are taken into account in fisheries decision-making, scientists said at the American Fisheries Society annual meeting in Portland, Oregon, this week. Managers tend to base catch limits on fish-stock assessments that focus on individual species and presume that population trends are stable. Ecosystem-based fisheries management aims for a more comprehensive, long-term approach that considers variables such as predator–prey relationships, climate conditions and economic factors.

"This year is an excellent case study showing that we need to do ecosystem-based fisheries management," said Jason Link, senior scientist for ecological research with the US National Oceanic and Atmospheric Administration (NOAA) in Woods Hole, Massachusetts.

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- Fisheries: Eyes on the ocean
- Pacific fisheries meet 'fails to end tuna overfishing'

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Up to now, the bodies that set fisheries catch limits have only sparingly used ecosystem-based approaches. But last November, the Pacific Fishery Management Council, which makes catch recommendations for the West Coast to the US National Marine Fisheries Service, reviewed and conditionally endorsed a comprehensive ecosystem-based computer model — the first step towards bringing such a tool into management decision-making. Isaac Kaplan, a research fisheries biologist at NOAA's Northwest Fisheries Science Center in Seattle, Washington, who led the model's development, says that it will next be used to predict how the northern Pacific ecosystem will respond to looming challenges such as depleted sardine populations and ocean acidification caused by global warming.

Slow uptake

Ecosystem-based fisheries management is a hardly a new idea. "There have been countless calls for fisheries management to adopt a broader approach, but uptake of these principles has been relatively slow," said Tim Essington, a fisheries scientist at the University of Washington in Seattle.

The biggest barrier may be the need to collect and analyse the relevant biological data, such as information on predator–prey relationships. "We realize that, to get buy-in, we need to offer busy managers efficient ways to simplify their work and avoid problems," Essington said. He is co-chair of a task force that is looking into how to implement ecosystem-based fisheries management; it aims to publish a blueprint next year.

To help with planning, supporters of ecosystem-based fisheries are creating tools such as the California Current Predator Diet Database, which is amassing information about the eating habits of 119 Pacific species. Such information is valuable for predicting how fluctuations in the population of a prey species will affect its predators. At the fisheries meeting, Amber Szoboszlai, a research analyst at the Farallon Institute for Advanced Ecosystem Research in Petaluma, California, showed how she had used the database to find that fish eat 75% of the anchovies consumed in the Pacific, whereas mammals eat only 16% and seabirds

7%.

Also at the meeting, Link presented a plan that will have the National Marine Fisheries Service implementing ecosystem-level tools within 3–5 years to assess the risk of overfishing and the vulnerability of the fishery to climate change. Meanwhile, the conservation community is concerned about the potential for a wide-scale fisheries collapse in the face of the blob and El Niño. If, as some fear, the blob signals a regime change in how the Pacific behaves, they argue that ecosystem-based management will be essential to preventing such a catastrophe. "The whole system seems to be changing radically," says Rebecca Goldburg, director of ocean science for the Pew Charitable Trusts in Washington DC, "making the case for ecosystem-based management more urgent."

Nature **524,** 396 (27 August 2015) doi:10.1038/nature.2015.18218

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Sent: Mon Feb 08 09:08:53 2016

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Cc: ADL_EW_ALL; ADL_ECF_ALL

Subject: Environmental Training Invitation

Importance: Normal

Attachments: 2016 Environmental Compliance Training Letter.pdf

Please respond to me, Michelle Bennett, with your expected attendance by at least a week before the session you plan to attend.

Also, please forward to other implementation partners that might be interested in attending. Respond to me, Michelle Bennett, with your expected attendance by at least a week before the session you plan to attend.

Michelle Bennett

Lead Secretary/Office Manager

SalientCRGT | Bonneville Power Administration EC-4
V: 503.230.3900 | F: 503.230.5699 | E: mlbennett@bpa.gov

Please consider the environment before printing this email.

BPA-2021-00513-F 0330

BONNEVILLE POWER ADMINISTRATION
Department of Energy
Bonneville Power Administration
P.O. Box 3621, ECF-4
Portland, OR 97208-3621

ENVIRONMENT, FISH & WILDLIFE

February 5, 2016

In reply refer to: ECF-4 2016 Environmental Compliance Training (Response Requested)

Dear Fish and Wildlife Contractor:

2015 was another great year of achievements for fish and wildlife project implementation. I appreciate all your efforts and our partnership continues to be a very successful one.

This past spring, our environmental compliance staff offered more than 11 training sessions throughout the Columbia River Basin to aid you and your staff in understanding the background and procedures for efficient completion of environmental permitting and compliance for your fish and wildlife projects. These training sessions were met with attendance and feedback beyond our expectations. We would like to follow up that success with more offerings for environmental compliance training in 2016.

This letter provides information on upcoming environmental compliance training that will be hosted by BPA's environmental compliance staff in 2016. This training will be similar to last year, but expanded to include updates as a result of changes during the past year. We will provide additional focus on the inclusion of environmental protection requirements in sub-contracts, writing complete work element descriptions, and considerations for other protection measures you should be aware of.

We are providing this training at four central locations. You only need to attend one session. I encourage you to invite sub-contractors you work with or other major partners in implementation of your projects to attend as well. Your RSVP is critical, because if not enough people express interest in a particular site, we will cancel the training for lack of interest. Therefore, it would greatly aid our planning to know expected attendance at each session, so please respond to Michelle Bennett at mlbennett@bpa.gov with the names and email addresses of attendees, and the date and location that you will attend. Each session will be a half day starting at 10:00 am and ending by 3:00 pm.

Along with your RSVP, please send Michelle Bennett specific questions you have or environmental processes you would like to learn more about so that we can be sure to address them in our discussions. Topics that will be covered include:

- A discussion on National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and National Historic Preservation Act (NHPA) requirements, with the focus on communication and processes to solve common issues that have arisen.
- Roles and responsibilities in federal environmental compliance.
- Writing project descriptions for more efficient environmental compliance.
- Use of BPA's programmatic ESA coverage, the Habitat Improvement Project biological opinion, and updated Restoration Review Team procedures and data requirements.
- Contract clauses and environmental compliance milestones – ensuring environmental protection measures are implemented.

- Field marking sensitive areas.
- Migratory Bird Treaty Act and Bald and Golden Eagle Act.
- What to do with Pacific Lamprey observation forms.
- Question and Answer time.

Locations and dates you can choose to attend:

Session	Location	Address	Date and Time
Session 1	The Dalles, OR	Discovery Center 5000 Discovery Drive	March 2, 2016 10:00 am – 3:00 pm
Session 2	Coeur D'Alene, ID	La Quinta Inn 333 W. Ironwood Dr.	March 3, 2016 10:00 am – 3:00 pm
Session 3	Boise, ID	IDFG HQ Trophy Room 600 S. Walnut St.	March 8, 2016 10:00 am – 3:00 pm
Session 4	Wenatchee, WA	Confluence Technology Ctr Methow Room 285 Technology Center Way	March 9, 2016 10:00 am – 3:00 pm

Please contact Don Rose at dlrose@bpa.gov or 503-230-3796 if you have any questions. You can also call toll free 800-622-4519 or contact the environmental compliance lead on your contract. Please respond to Michelle Bennett with your expected attendance by at least a week before the session you plan to attend.

Sincerely,

(b)(6) [redacted]

William C. Maslen
Manager, Fish and Wildlife

From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Tue Mar 01 15:38:27 2016

To: David Welch

Cc: Mendoza Flores,Luisa F (BPA) - EWB-4; Welch,Dorothy W (BPA) - EWM-4; Petersen,Christine H (BPA) - EWP-4; Barco III,John W (BPA) - EWP-4; Sweet,Jason C (BPA) - PGB-5

Subject: RE: (Very) High Level Proposal Outline…

Importance: Normal

David,

We would like to find some time to meet with you to discuss these options in more depth. Even though it is a long trip, we think it would be useful to have you come down and meet with us in person. It would be a good chance for you to meet my boss, John Barco and have another round of discussion with Lorri Bodi and other key BPA managers.

(b)(5) [redacted]

(b)(5) [redacted]

Finally, if you could start thinking about schedule and costs related to these options, we will need that information before we can make a decision on how to proceed.

Give me a holler if you have any questions. I'll have Luisa (cc'd) above reach out to you and to schedule the meeting.

Thanks,

Ben

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, January 22, 2016 1:16 PM
To: Zelinsky,Benjamin D (BPA) - EWP-4
Subject: (Very) High Level Proposal Outline…

Ben- As discussed, some points outlining what we could contribute.

1) (b)(5) [redacted]

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[redacted]

(b)(5)
[redacted]

(b)(5)
[redacted]

(b)(5)

[redacted]

(b)(5)

[redacted]

(b)(5) [redacted]

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

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Browse animations of the results from our

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

P Please consider the environment before printing this e-mail

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

Sent: Fri Mar 18 11:10:41 2016

To: 'david.welch@kintama.com'

Cc: Bettin,Scott W (BPA) - EWP-4; EW Admin

Subject: Bonneville Power Administration Visit and Form

Importance: Normal

Attachments: Foreign Nationals Form.doc

Hello Dave,

We spoke earlier this morning about visiting us at our Bonneville Power Administration office in Portland, OR with Ben Zelinsky, John Barco and others. As promised, attached is the form we need you to fill out so that we can submit it to Security prior to your visit. Please fill out blocks 1 – 7 and return to me by fax at (503) 230-4563 next Tuesday, March 22. Please call (503) 230-5888 prior to faxing the form so that one of the Fish and Wildlife Admins can pick it up (in case I am not at my desk)..

Your visit is scheduled for April 14th from 2:00 p.m. – 4:00 p.m. (Pacific Time) in room 421. Our address is:

905 NE 11th Ave,

Portland, OR 97232

Scott Bettin will be your host and I will be your escort, if you have any questions, please let us know!

Thank you and we look forward to your visit!

Luisa Mendoza Flores
Administrative Assistant, EWB / EWP

Environment, Fish & Wildlife

Bonneville Power Administration
905 NE 11th Ave. | Portland, OR 97232
(**503.230.5888** | 7 **503.230.4563**

* **lfmendoza@bpa.gov**

In accordance with Department of Energy Order 142.3, the BPA requires all foreign nationals (FN) to complete a foreign national (FN) registration form to document the purpose and dates of their intended visit/assignment. The BPA Host will assist the foreign national in completing the form. The BPA Host is responsible for completing blocks 8, 9 and 10 prior to submitting the form for processing. Hosts are responsible for ensuring all required fields are completed on the FN form. Completed forms should be sent electronically to the "Foreign National Visits and Assignments" e-mail in box. The Security Office will communicate to the host the status of the approval of the FN form. No FN will be allowed to begin work with BPA or be on BPA site until their FN request has been approved.

INSTRUCTIONS FOR COMPLETING THE FOREIGN NATIONAL REGISTRATION

BPA Host will ensure foreign national (FN) completes blocks 3, 4, 5, 6, and 7. The Host is responsible for completing blocks 8, 9, entirely. All required *fields must be completed prior to submitting the form to Foreign Visits and Assignments (FV&A) staff." All other fields, though not required, should be completed if the foreign national is able to do so.

BLOCK 1. *Name of Visitor/Assignee. Enter the complete First, Middle and last Name of the Foreign Visitor. If no middle name, enter the letters "NMI".

BLOCK 2. Form Determination Information

***Citizenship:** State the country of citizenship for the foreign national.

***Country of Employer:** State the country where the foreign national visitor's employer is located.

***Type of Request** If the foreign national is here for at least 30 consecutive days, FN request is considered an Assignment. If the FN is here for less than 30 consecutive days, FN request is considered a visit. If FN request is for a long term contract but FN is not expected to be onsite for the consecutive 30 day period, the FN request will be processed as a visit (30 day approval) and will need to be requested each time the FN physically visits the facility. If this is an Extension of an existing assignment, mark that box.

BLOCK 3. Biographical Information

***Gender: "Female" or "Male":** Check the appropriate box

***Country of Citizenship:** self explanatory

***Country of Birth:** self explanatory

Is the visitor currently in U.S.? Mark the appropriate box

***Date of Birth:** self explanatory

***City of Birth:** self explanatory

BLOCK 4. Employer Information *(Parent Organization Information and Address)*: All fields are Self explanatory

***Institution /Company Name**

Street Address, if more than one, put it on the form

City, State, Zip Code

Phone Number, Fax Number

Email Address

***Title or Position and Duties**

***Country of Employer**

◆

For BLOCKS 5 and 6, *at least one section must be completed to demonstrate FN is in US legally.

BLOCK 5. VISA Information: self explanatory - For VISA Type: Select one item from the list provided by clicking on the Visa Information link.

BLOCK 6. Passport Information: self explanatory.

BLOCK 7. Place of Work (only if different from employer): Self Explanatory.

BLOCK 8. Host Information *(Must be a badged BPA employee – federal or contractor allowed)* *All fields are self explanatory.
Does the Host have a clearance? Does the BPA Host have an "L" (SECRET level) or "Q" (TOP SECRET level) clearance? If so, mark the appropriate box.

BLOCK 9. *Visit Information:* *All *required fields must be completed, or form cannot be processed.*

- For "SUBJECTS": select all relevant subjects from the drop down lists provided.
- For *PURPOSE OF THE VISIT: Select one item from the drop down list provided.

SUBMITTING THE FOREIGN NATIONAL REGISTRATION FORM AND OTHER MISCELLANEOUS ITEMS:

- AFTER COMPLETION OF THIS FORM, THE HOST SHOULD REVIEW FOR ACCURACY.
- THE HOST WILL SUBMIT THE FORM TO VIA ONE OF THE APPROVED MEANS (See BPA connections page)
- THE FORM WILL THEN BE PROCESSED BY THE FV&A STAFF.
- THE BPA HOST WILL RECEIVE A NOTIFICATION FROM THE FV&A STAFF ONCE THE FN VISIT IS APPROVED.
- THE BPA HOST WILL NEED TO ENSURE THAT A VISITORS ACCESS FORM 5632.11E IS SUBMITTED.
- THE BPA HOST WILL NEED TO COMPLETE HOST TRAINING IF TRAINING HAS NOT ALREADY BEEN COMPLETED (ANNUAL TRAINING REQUIREMENT; WILL BE PROVIDED TO HOST BY FV&A STAFF).
- THE BPA HOST SHALL FOLLOW INSTRUCTIONS AS NOTED IN THE SECURITY PLAN FOR THE FN VISIT.
- LASTLY, THE BPA HOST WILL NEED TO OFFICIALLY CLOSE OUT THE FN VISIT or ASSIGNMENT WHEN THE VIST/ASSIGNMENT IS COMPLETE AND THE FN IS OFF SITE. CLOSE OUT INFORMATION SHALL INCLUDE THE FOLLOWING AND SHALL BE SENT ELECTRONICALLY TO THE FOREIGN NATIONAL VISITS AND ASSIGNMENTS E-MAIL INBOX.

1. Name of Visitor
2. Actual Start Date of Visit
3. Actual End Date of Visit
4. Status of Assignment *(State one of the following: Cancelled After Approved, No-Show, or Complete)*

OFFICIAL USE ONLY
May be exempt from public release under the Freedom of Information Act (5 U.S.C. 552), exemption number and category: ____________
BPA review required before public release
Name/Org: ______________________ Date: __________

1. Name of Visitor/Assignee

*First Name:	*Middle:	*Last:

2. Visit Determination Information

*Citizenship: *Country of Employer:

*Type of Request *(check one)*: [ ] Visit *(less than 30 days)* [ ] Assignment *(30 consecutive days or more)* [ ] Extension of an Assignment

3. Biographical Information

*Gender:	[ ] Female	[ ] Male	Is Visitor currently in U.S.?	[ ] Yes	[ ] No
*Country of Citizenship:			*Date of Birth *(mm/dd/yyyy)*:		
*Country of Birth:			*City of Birth:		

4. Employer Information

Affiliation or Company Info:

*Institution or Company Name:		Phone Number:	
Street (1):		Fax Number:	
Street (2):		Email Address:	
City:		State:	
Zip Code:		*Country of Employer:	

*Title or Position and Duties:

*** Visa or Passport information must be completed**

5. ♦Visa Information *(For Visa Type, click link below to copy/paste appropriate information.)* Visa Information		6. ♦Passport Information	
Visa Number:		Passport Number:	
Visa Type:		Country of Issue:	
Exp. Date *(mm/dd/yyyy)*:		Exp. Date *(mm/dd/yyyy)*:	

7. Place of Work *(if different from Employer)*

Company Name:		Phone Number:	
Street (1):		Fax Number:	
Street (2):		Email Address:	
City:		State:	
Zip Code:		Country of Employer:	

Title or Position and Duties:

Interpreter Needed? Yes No Business Type conducted by Employer:

Educational Background: Field of Research:

(If known, FN will complete this section completely)

Additional Biographical Information:

Current U.S. Address:		City:	
Street (1):		State:	
Street (2):		Zip Code:	
Permanent Address:		City:	
Street (1):		State:	
Street (2):		Zip Code:	

8. Host Information

*Host's First Name: Middle: *Last:

*Host's Citizenship: *Phone:

Does the host have a clearance? *(L or Q)* Yes No

9. Visit Information

*Desired Start Date *(mm/dd/yyyy)*: *Desired End Date *(mm/dd/yyyy)*:

*Subject(s): *(Choose from the drop-down menus)*

*Description of Visit/Assignment, including specific activities or involvement:

*Purpose of visit: *(Choose from the drop-down menu)*

Is the assignment for intermittent access periods? *(Example: 2 days one week, 3 days the next week, 1 day on 3rd week=6 days)* Yes No Number of Days On site:

Will there be interactions with individuals with Security Clearances? *(L/Secret or Q/Top Secret clearances)* Yes No

List individuals:

First Name: Middle: Last:

First Name: Middle: Last:

Is this Visit for Employment? Yes No

*List Buildings and Rooms to be accessed:

Building: Room: Type:

Building: Room: Type:

Building: Room: Type:

Cost to DOE/BPA:

*DOE/BPA Mission(s) that will be advanced by this Visit/Assignment:

*Will Visitor/Assignee be granted computer access? Yes No

If granted computer access, is the access on-site or off-site? On Off

List hardware and software to which access is granted:

Remarks/Comments *(or additional information that did not fit above)*

****Denotes Required Information***

Please submit this form by FAX, encrypted/password protected attachment or mail

(BPA must receive this completed form at least 14 days prior to the scheduled visit/assignment for FN's from non-sensitive countries & 45 days prior to visits/assignments for FN's from sensitive countries. FV&A Staff cannot guarantee approval of the visit/assignment start date if request is not submitted within identified time frame).

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

Sent: Tue Mar 22 09:37:34 2016

To: 'David Welch'

Subject: RE: Bonneville Power Administration Visit and Form

Importance: Normal

David,

All four pages made it through. I will have Scott do his part and proceed with Security.

Thank you David!

Luisa Mendoza Flores

Bonneville Power Administration

(503) 230-5888

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, March 22, 2016 9:14 AM
To: Mendoza Flores,Luisa F (BPA) - EWB-4
Subject: RE: Bonneville Power Administration Visit and Form

Hi Luisa-

The fax seems to have partially gone through—it says that page 2 has been successfully transmitted, but it seems to have hung on page 3.

Page 3 & page 4 are simply blank pages with very fine print that I was faxing back to you to fill out, so if you get just the first page of the form from me, that is all I have completed.

Do let me know what makes it through the wires!

Thanks, David

From: Mendoza Flores,Luisa F (BPA) - EWB-4 [mailto:lfmendoza@bpa.gov]
Sent: Tuesday, March 22, 2016 7:25 AM
To: David Welch
Subject: RE: Bonneville Power Administration Visit and Form

Good morning David,

It would be easier if you could send it back in Word of PDF, but because the form contains your personal identifiable information it is safer to send it via fax. That way your information won't get compromised.

Please call me before you fax it so that I can stand by the fax as it comes through.

Thank you,

Luisa Mendoza Flores
Administrative Assistant, EWB / EWP

Environment, Fish & Wildlife

Bonneville Power Administration
905 NE 11th Ave. | Portland, OR 97232
(**503.230.5888** | 7 **503.230.4563**

* lfmendoza@bpa.gov

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, March 18, 2016 11:44 AM
To: Mendoza Flores,Luisa F (BPA) - EWB-4
Subject: RE: Bonneville Power Administration Visit and Form

Hi Luisa—

Thanks for sending this. I am happy to send it back by FAX next Tuesday following your directions, but I wonder if it might not be easier for you if I fill it out and return it as either a Word document or as a PDF?

If so, let me know and I will do so; otherwise, I will fax it back next Tuesday.

Regards, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

10-1850 Northfield Road, Nanaimo, BC, Canada V9S 3B3

49.211908°N, -123.960753°W

Office Tel: (250) 729-2600 (x) 223 Fax: (250) 729-2622 Mobile: [redacted]

Skype: david.welch.kintama

david.welch@kintama.com

www.kintama.com

Browse animations of the results from our

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

P Please consider the environment before printing this e-mail

From: Mendoza Flores,Luisa F (BPA) - EWB-4 [mailto:lfmendoza@bpa.gov]
Sent: Friday, March 18, 2016 11:11 AM

To: David Welch
Cc: Bettin,Scott W (BPA) - EWP-4; EW Admin
Subject: Bonneville Power Administration Visit and Form

Hello Dave,

We spoke earlier this morning about visiting us at our Bonneville Power Administration office in Portland, OR with Ben Zelinsky, John Barco and others. As promised, attached is the form we need you to fill out so that we can submit it to Security prior to your visit. Please fill out blocks 1 – 7 and return to me by fax at (503) 230-4563 next Tuesday, March 22. Please call (503) 230-5888 prior to faxing the form so that one of the Fish and Wildlife Admins can pick it up (in case I am not at my desk)..

Your visit is scheduled for April 14th from 2:00 p.m. – 4:00 p.m. (Pacific Time) in room 421. Our address is:

905 NE 11th Ave,

Portland, OR 97232

Scott Bettin will be your host and I will be your escort, if you have any questions, please let us know!

Thank you and we look forward to your visit!

Luisa Mendoza Flores

Administrative Assistant, EWB / EWP

Environment, Fish & Wildlife

Bonneville Power Administration
905 NE 11th Ave. | Portland, OR 97232
(**503.230.5888** | 7 **503.230.4563**

* **lfmendoza@bpa.gov**

From: David Welch

Sent: Thu Apr 14 11:40:08 2016

To: Mendoza Flores,Luisa F (BPA) - EWB-4; Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Final ppt

Importance: Normal

Attachments: BPA Presentation (14 April 2016)-FINAL.pdf

Here is the revised ppt, with the changes requested by Ben; I am sending this as backup.

To get this to a size where it will go via email, I had to delete some slides, so if possible I would prefer to work off the original on my laptop.

Luisa, I can be there as early as you like—I am currently working in the coffee bar at the Double Tree across the road. If I don't hear otherwise, I will present myself at 12:30, as the security process tends to take a while for Canadians. Unless you need to escort me from that point, I can wait in the cafeteria area (I'm wearing a grey suit and dark blue tie… should be easy to identify me! J)

David

From: Mendoza Flores,Luisa F (BPA) - EWB-4 [mailto:lfmendoza@bpa.gov]
Sent: Thursday, April 14, 2016 11:11 AM
To: Zelinsky,Benjamin D (BPA) - EWP-4; David Welch
Subject: RE: Final ppt

Good morning,

If you bring your laptop in, we can connect you to the projector and it should be fine. I will make sure to say for the first 10 minutes of the presentation in case there are any technical difficulties. J

David - could you please arrive earlier so that we can get you connected and be ready to go before the meeting starts?

Thank you,

Luisa Mendoza Flores

Administrative Assistant | Business Operations Support EWB-4

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

Please consider the environment before printing this email.

-----Original Message-----
From: Zelinsky,Benjamin D (BPA) - EWP-4
Sent: Thursday, April 14, 2016 11:08 AM
To: 'David.Welch@kintama.com'
Cc: Mendoza Flores,Luisa F (BPA) - EWB-4
Subject: Re: Final ppt

Working off your laptop should be fine. We just can't connect you to the internet.

----- Original Message -----

From: David Welch [mailto:David.Welch@kintama.com]

Sent: Thursday, April 14, 2016 10:46 AM

To: Zelinsky,Benjamin D (BPA) - EWP-4

Cc: Mendoza Flores,Luisa F (BPA) - EWB-4

Subject: Re: Final ppt

Just on the TriMet

The ppt is probably too big to email, but I will try once I get to a coffee shop

I understand the problem with USBs, but assumed I could just work off my laptop. Not feasible?

Sent from my iPhonethe

> On Apr 14, 2016, at 10:36 AM, Zelinsky,Benjamin D (BPA) - EWP-4 <bdzelinsky@bpa.gov> wrote:

>

> I left you a vm - please leave off budget numbers if it isn't too late and then please email Luisa and me the final ppt. Our security rules make it hard for us to use a flash drive so emailing the final ppt is preferable.

>

> Thanks and see you in a bit

>

> Looking forward to our discussion

>

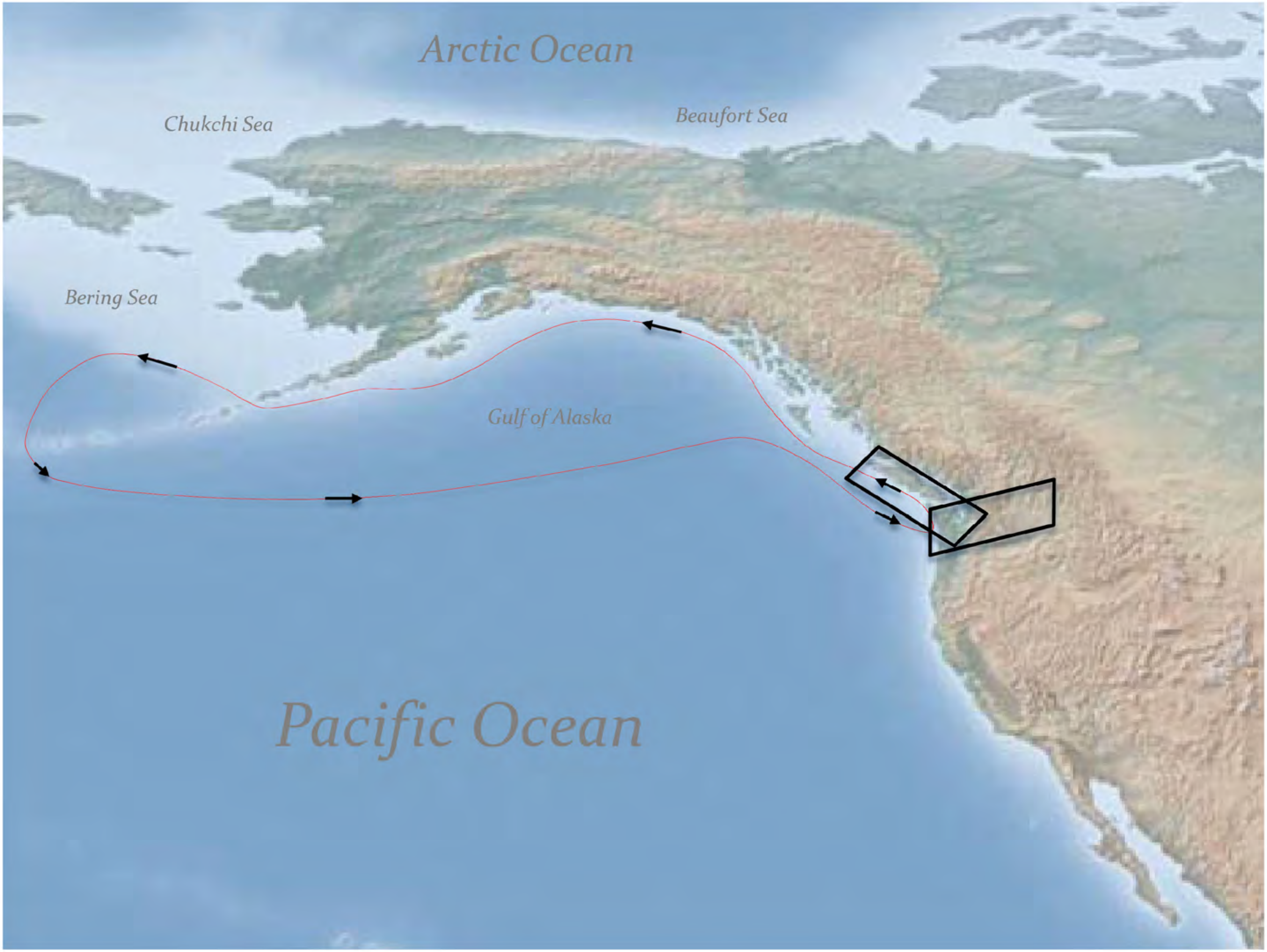
> Ben

Outline

(b)(5)

[redacted]

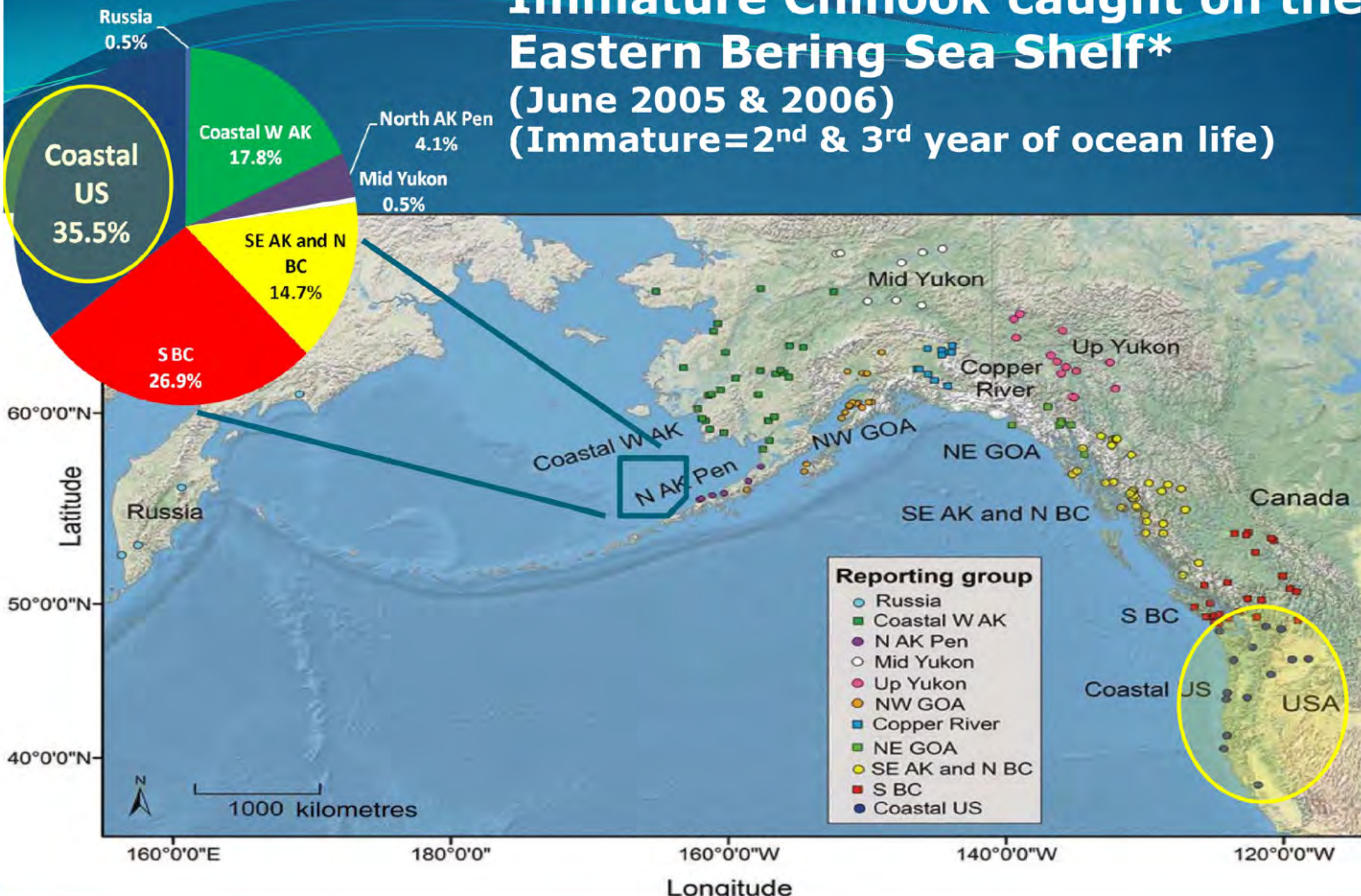
David Welch
david.welch@kintama.com
(250) 739-9044
KINTAMA


Arctic Ocean
Chukchi Sea
Beaufort Sea
Bering Sea
Gulf of Alaska
Pacific Ocean

Immature Chinook caught on the Eastern Bering Sea Shelf*

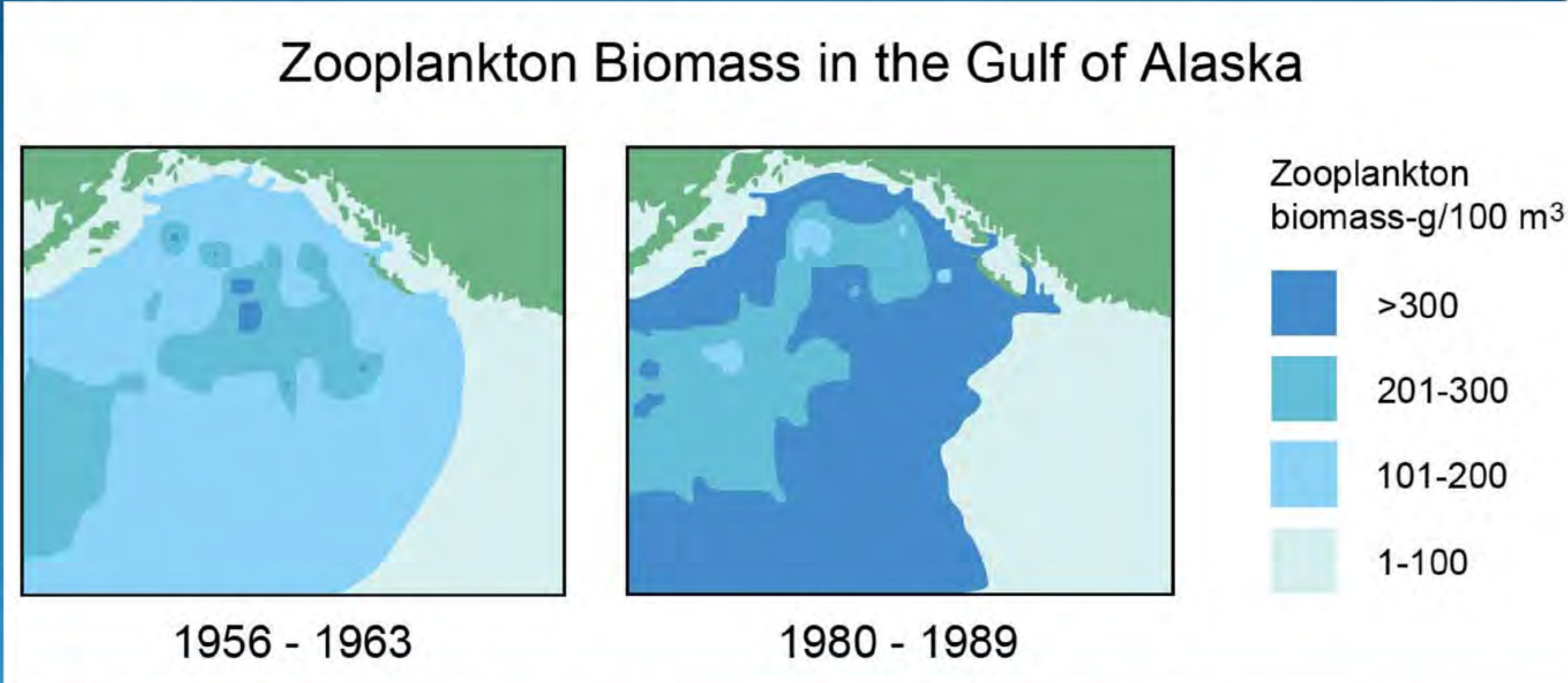
(June 2005 & 2006)

(Immature=2nd & 3rd year of ocean life)



* Larson et al. (2013). Can. J. Fish. Aquat. Sci. 70:1-14.

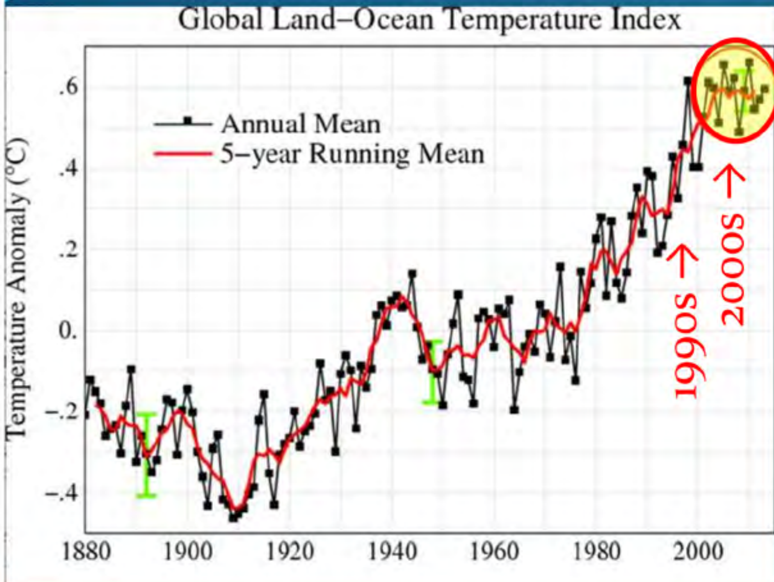
Big, Long-Term Changes Are Occurring in the Ocean

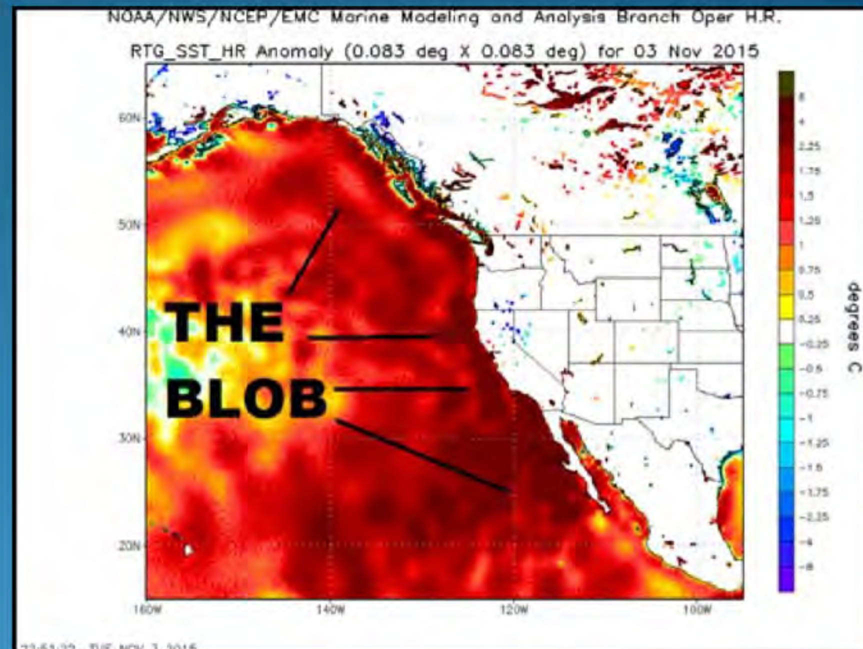


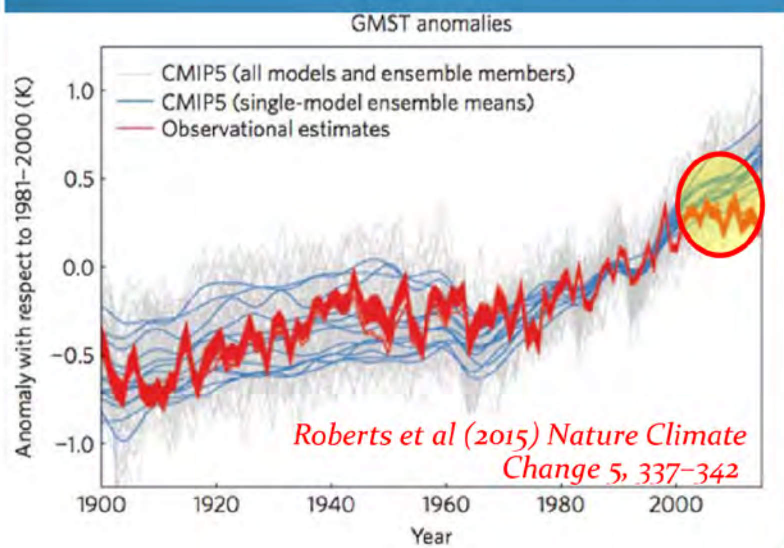
- Plankton far more abundant in the 80s than the 1950s & 60s
- 1980s corresponds to a period when salmon stocks from many (not all) regions increased

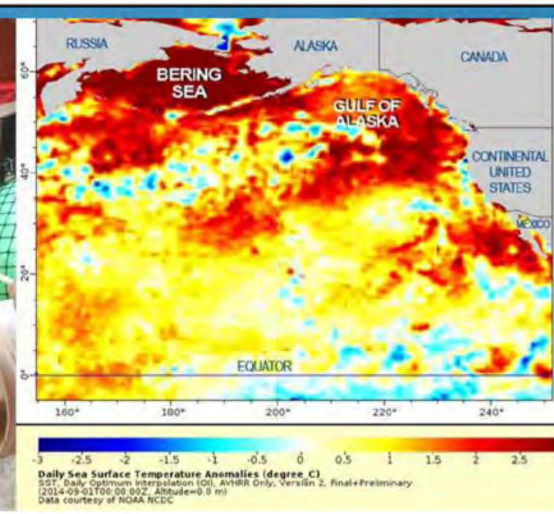
Brodeur, R. D., & Ware, D. M. (1992). *Fisheries Oceanography, 1(1), 32-38.*

The Future of Salmon is Hot & Sunny









Chinook Resource Problems are Not Limited to the Pacific North-West

ALASKA Journal of Commerce

HOME OIL & GAS FISHERIES CONSTRUCTION TRANSPORTATION TECH & TELECOM POLITICS A

Book of Lists Top Forty Under 40 Money Mining Health Opinion Movers & Shakers Special Se

Alaska Journal / November-Issue-1 2013 / Kings in cycle: Salmon follow boom and bust patt...

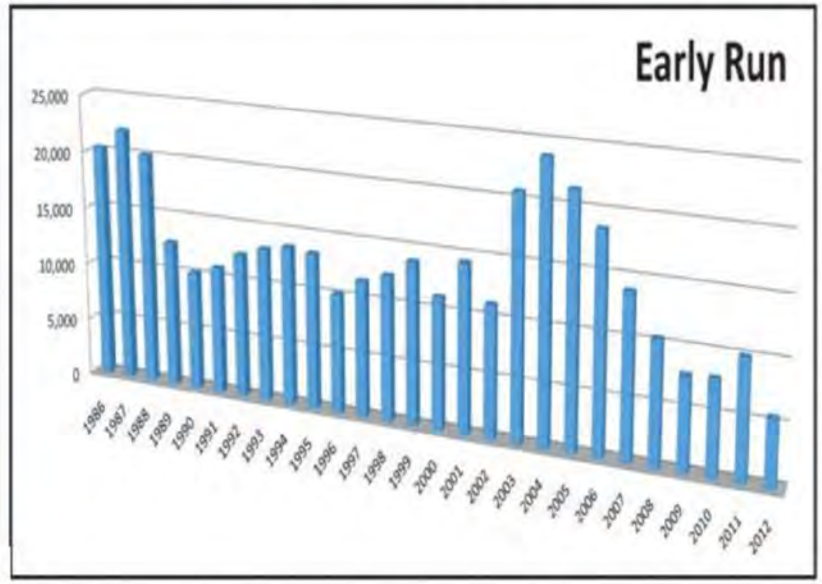
Kings in cycle: Salmon follow boom and bust pattern

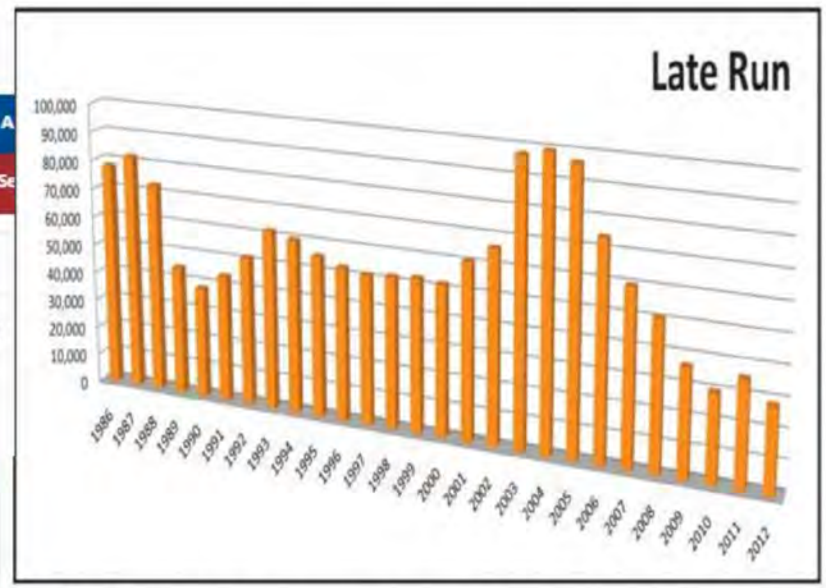
By: Rashah McChesney and Molly Dischner, Morris News Service-Alaska

Posted: Thu, 10/31/2013 - 7:04am

Source: http://www.alaskajournal.com/Alaska-Journal-of-Commerce/November-Issue-1-2013/Kings-in-cycle-Salmon-follow-boom-and-bust-pattern/

Kenai River King Salmon returns 1986-2012

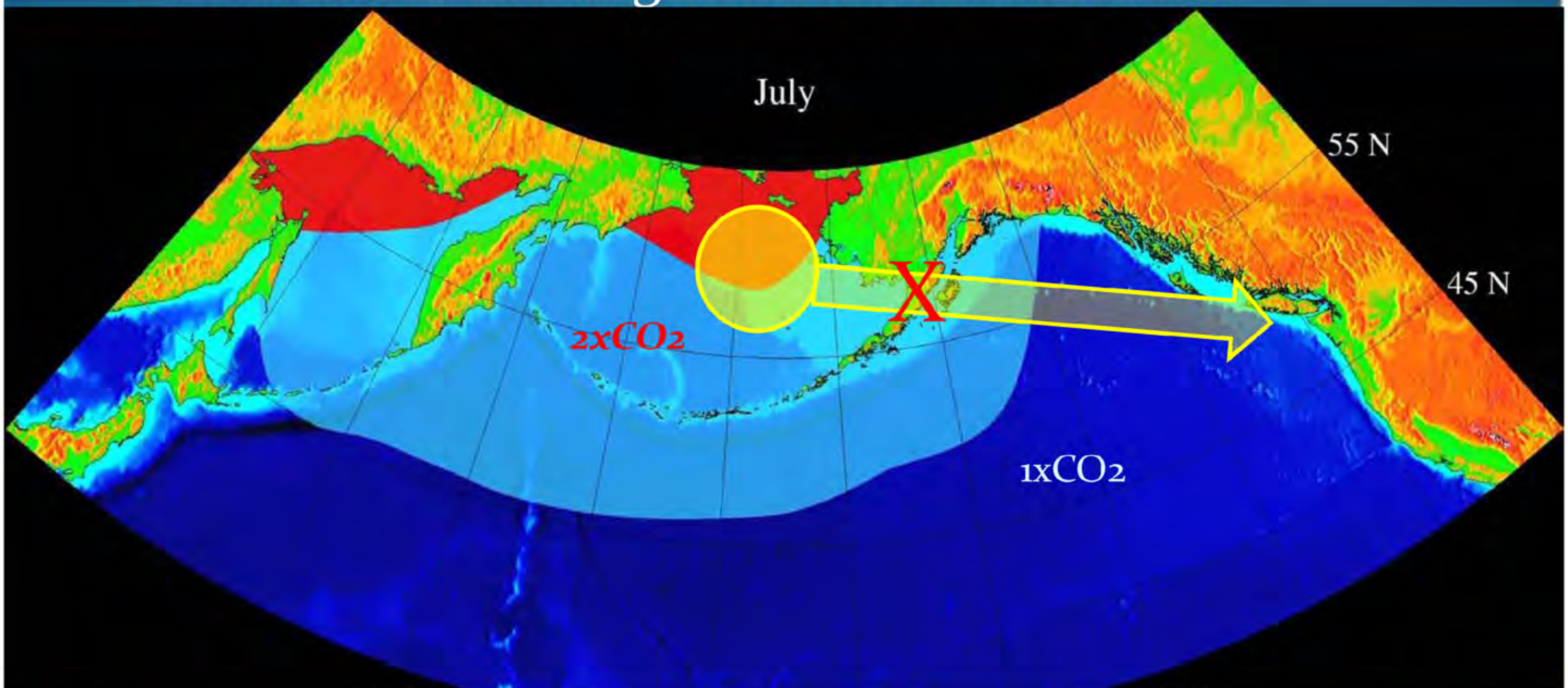




Source: Alaska Department of Fish and Game 2013 interim escapement goal report, run estimates using a state-space model

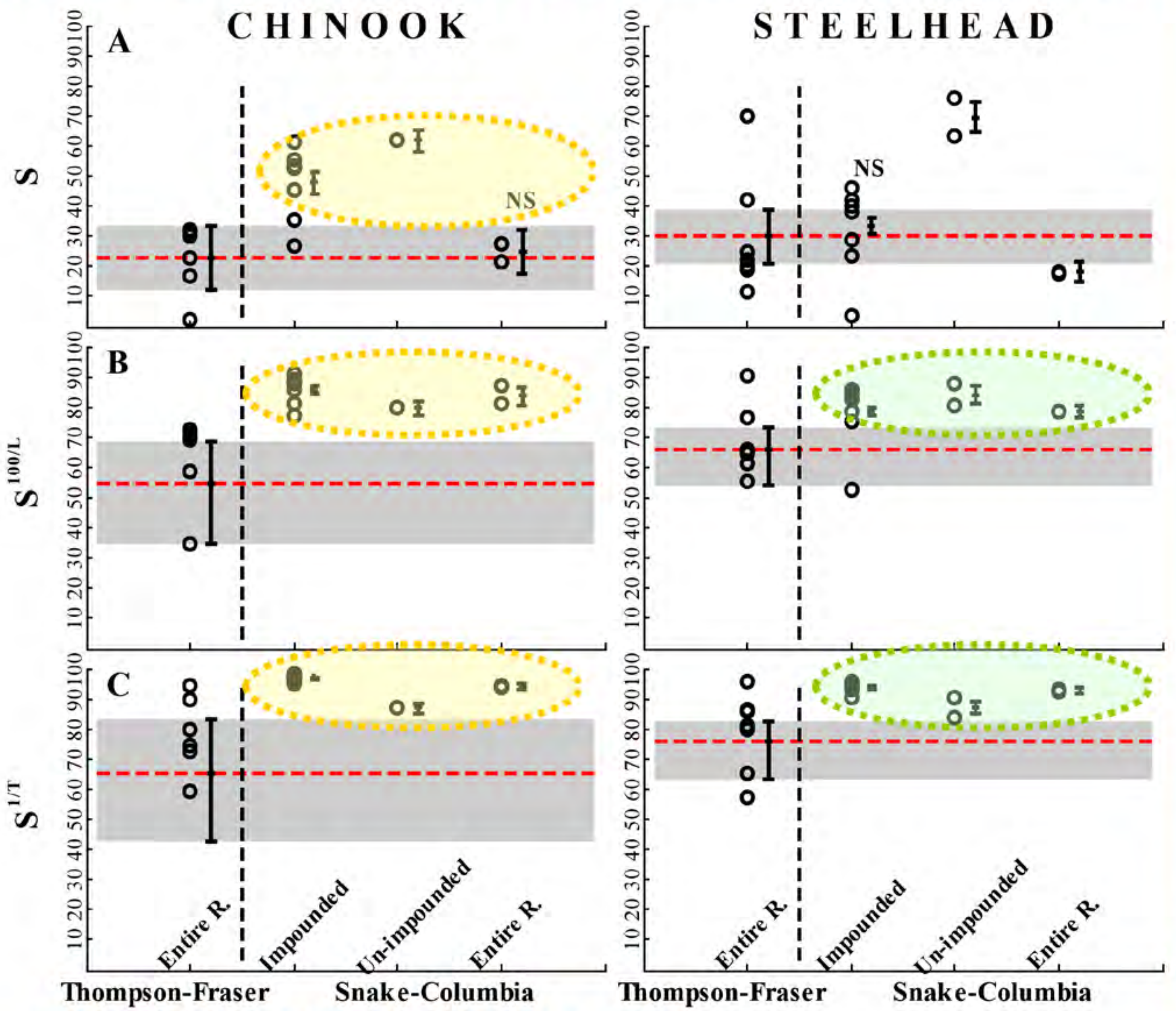
Global Warming-The Long Term View

- The details of how juvenile salmon migrate to the Bering Sea and then back to freshwater as adults may be critical to whether or not migration can be successful.



Welch, *et al* (1998). Thermal limits and ocean migrations of sockeye salmon : *Long-term consequences of global warming. Can. J. Fish. Aquatic Sci. 55:937-948.*

2008 "Large-Rivers" Paper: Thompson-Fraser v. Snake-Columbia Smolt Survivals



Welch et al (2008) PLoS Biology 6(10):e265

Survival To River Mouth

Survival per 100 Km

Survival per Day

In most comparisons, survival in the impounded section of the Snake-Columbia R was higher than in the lower river or the un-dammed Fraser

2008 "Large-Rivers" Paper: Thompson-Fraser v. Snake-Columbia Smolt Survivals

An Update Needed.

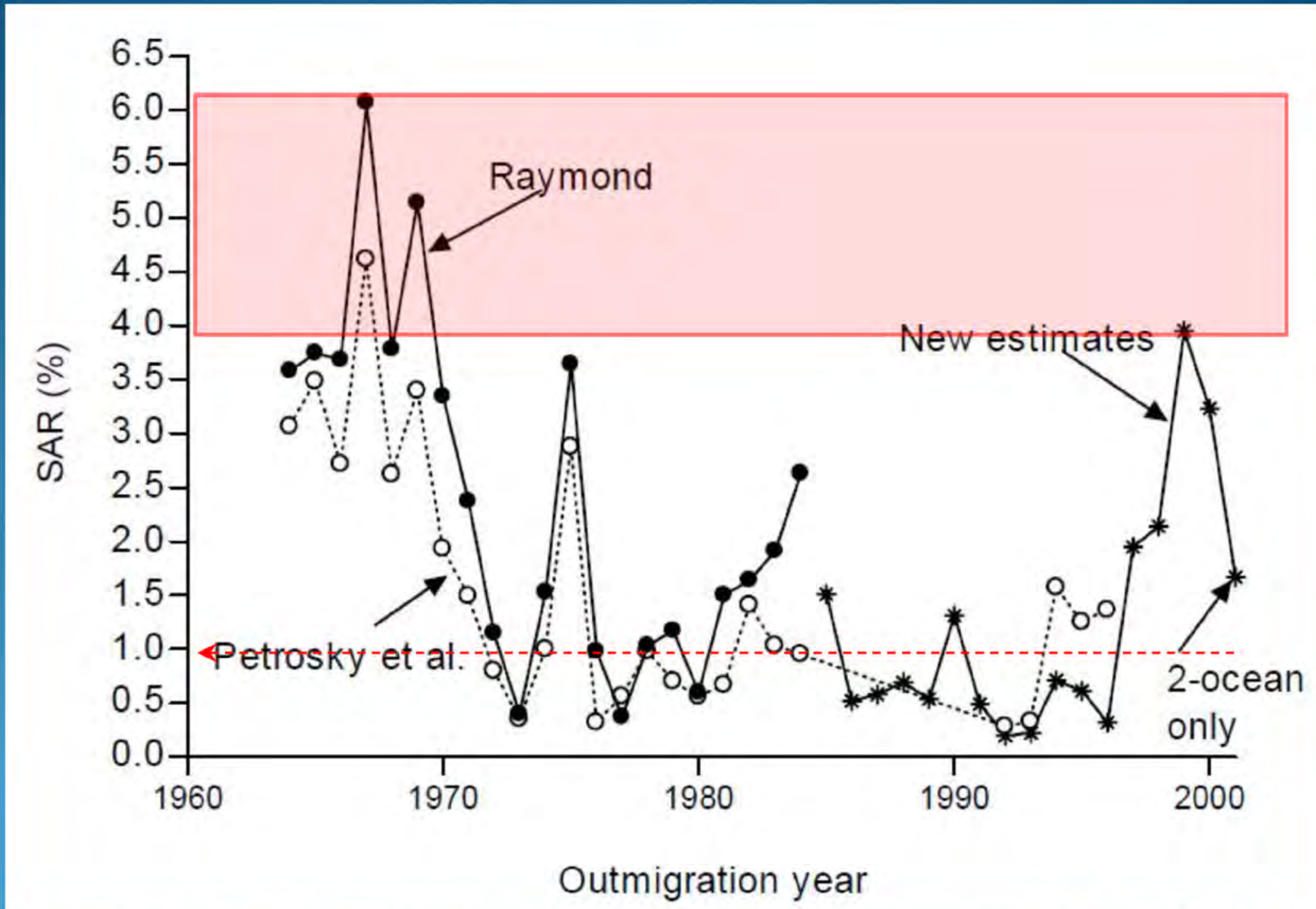
We now have tributary survival data for 3 Fraser River Populations showing that much of the survival loss is confined to the tributary, not the Mainstem

- Cultus Lake sockeye (2004-07)
- Chilko Lake sockeye (2009-16)[a,b]
- Chilko Lake Chinook (2016 only)

[a] Joint work with Scott Hinch/UBC
[b] Trib/mainstem data for 2011+12 only

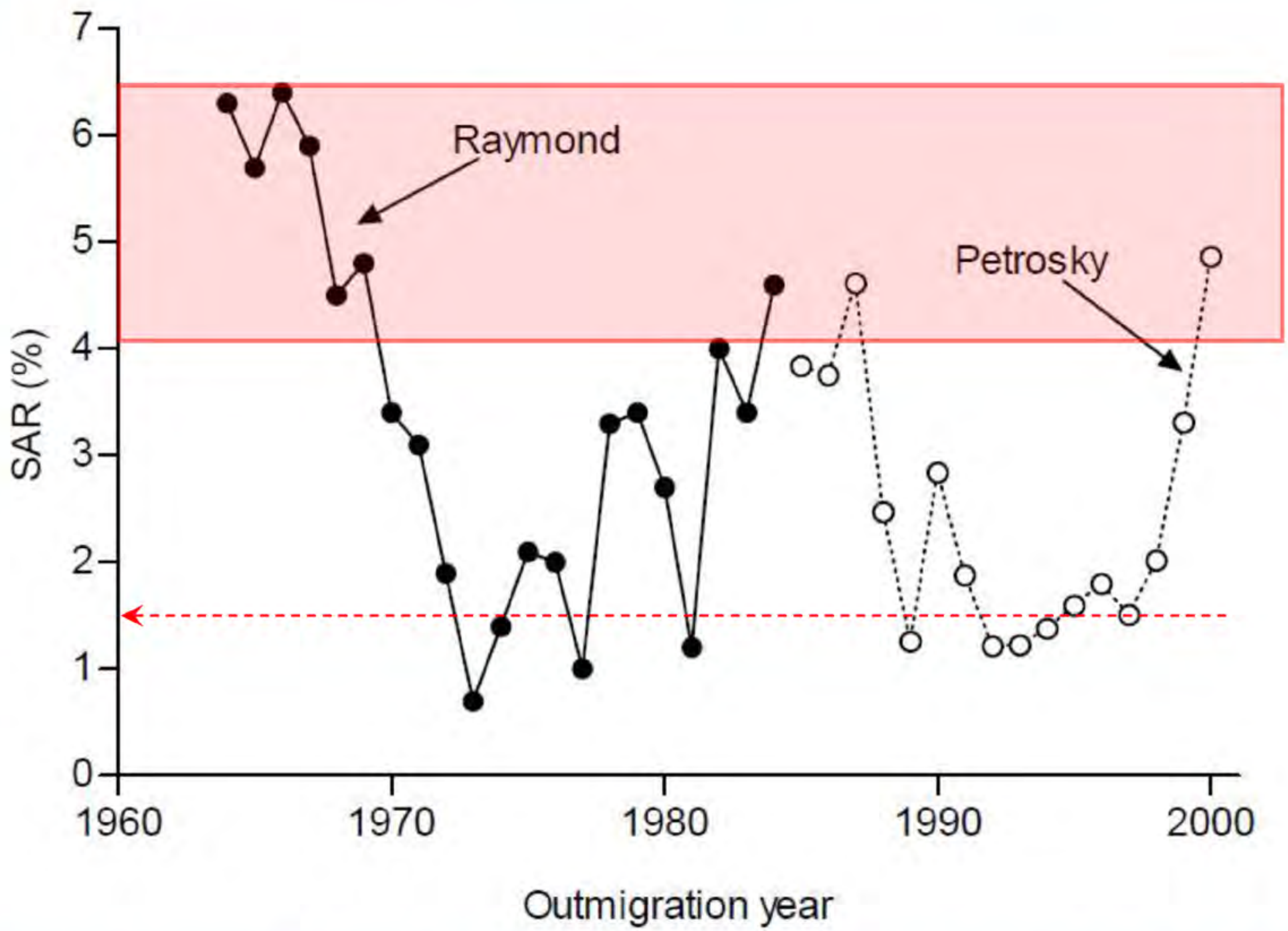
Columbia R SARS

Wild Snake River Spring Chinook SARS



Source: Williams et al (2005) NOAA Technical Memorandum NMFS-NWFSC-63 **Effects of the Federal Columbia River Power System on Salmonid Populations** (Fig. 2, p. 10)

Wild Snake River Steelhead SARS



Source: Williams et al (2005) NOAA Technical Memorandum NMFS-NWFSC-63 **Effects of the Federal Columbia River Power System on Salmonid Populations** (Fig. 4, p. 12)

Survival to Adult Return(SAR)

The product of survival through multiple habitats:

$$SAR = S1 \cdot S2 \cdot S3 \cdot \ldots \cdot S_{\text{Late Marine}}$$

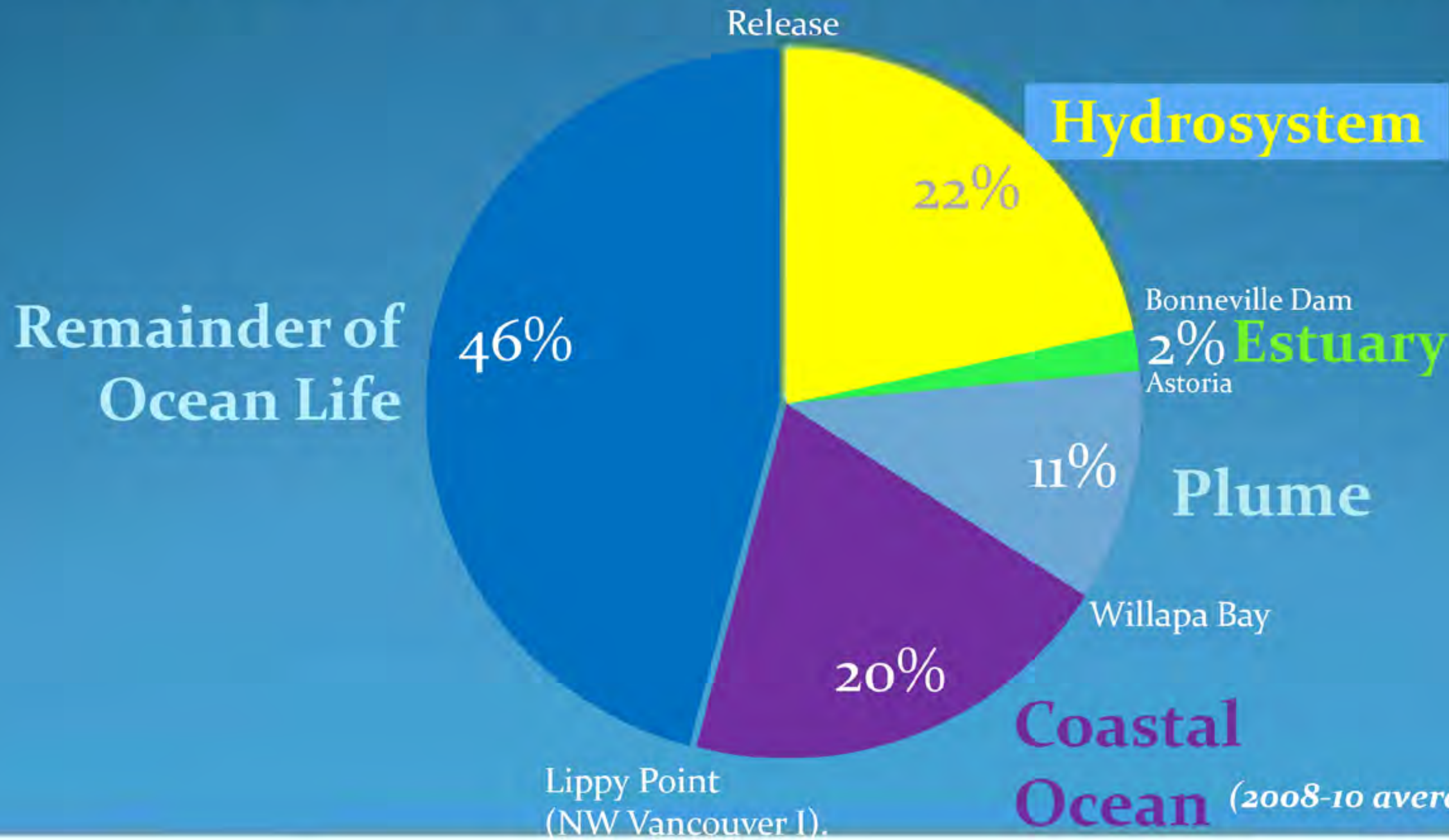
- It seems reasonable that many life history segments are key drivers of adult numbers, since:

$$\text{ADULT RETURN} = \#\ \text{Smolts Out} \cdot SAR$$

$$= \#\text{Smolts} \cdot S1 \cdot S2 \cdot S3 \cdot \ldots \cdot S_{\text{Late Marine}}$$

Where is Columbia River Survival Determined?

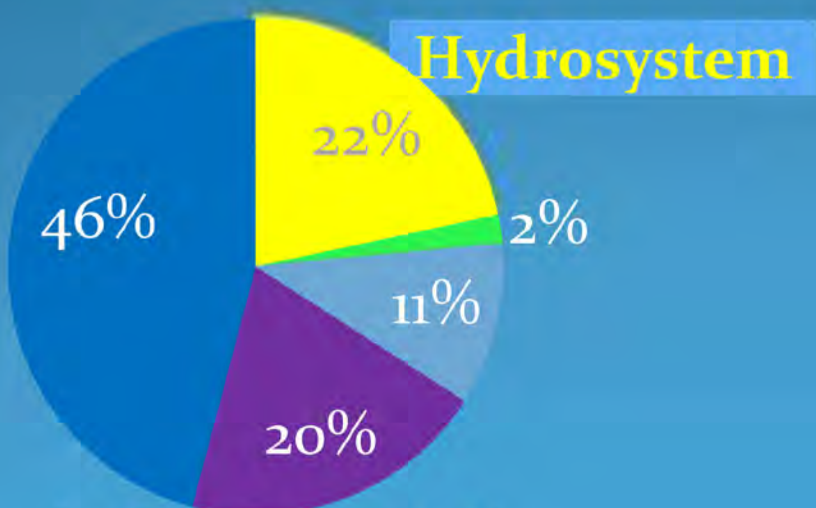
- Acoustic tag-based survival estimates indicate that majority of Chinook survival is determined at sea; hydrosystem & estuary have smaller roles compared to the ocean (Plume, Coastal Ocean, & "Remainder of Ocean").



(2008-10 average survivals)

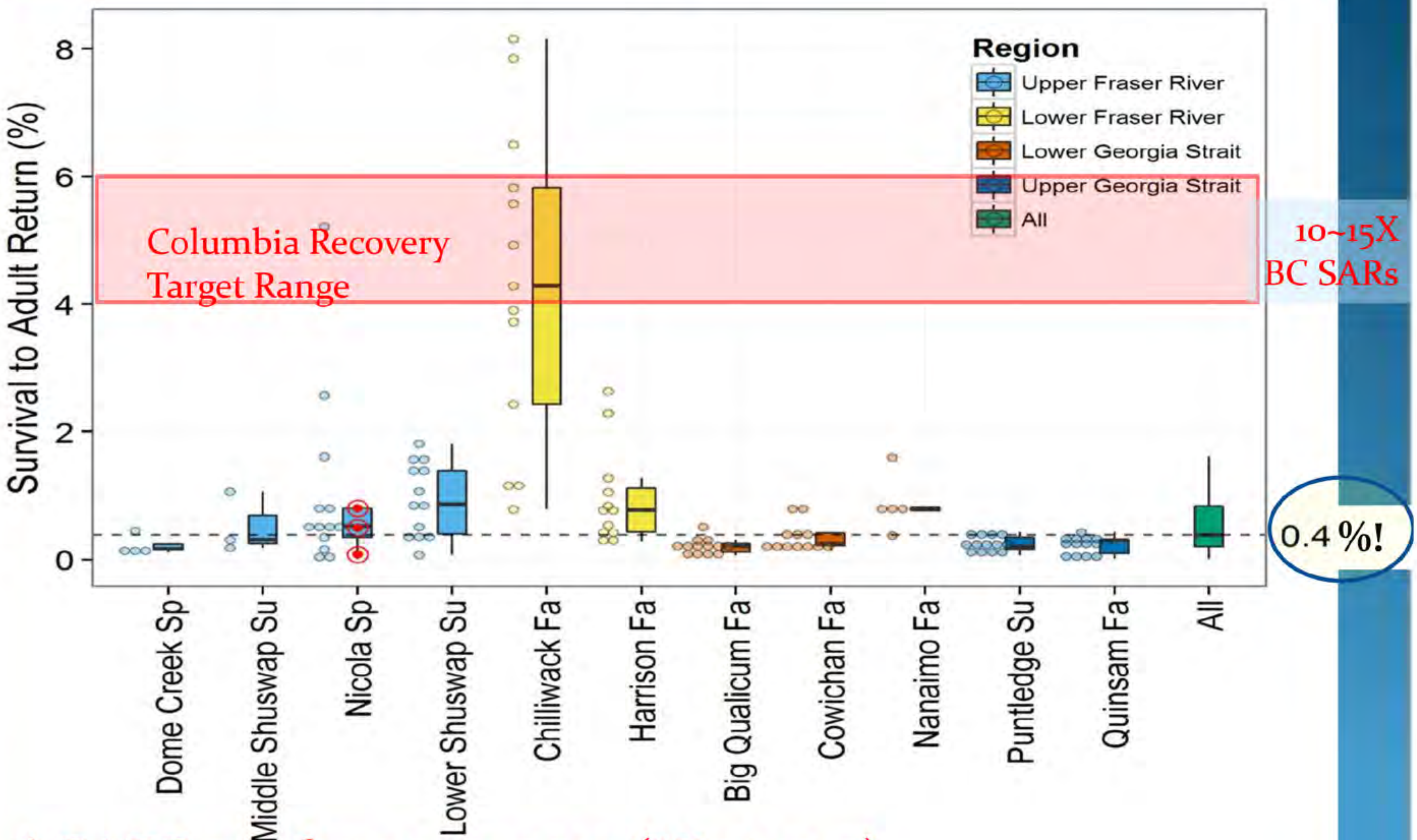
Where Are Columbia River Survivals Determined?

- We Can Now Quantify Relative Importance of Events Happening in the Ocean to SARs
- A Major Implication is that Studies Based on Statistical Correlation of SARS with Various Environmental Conditions have almost No Statistical Power… Thus Negligible Credibility



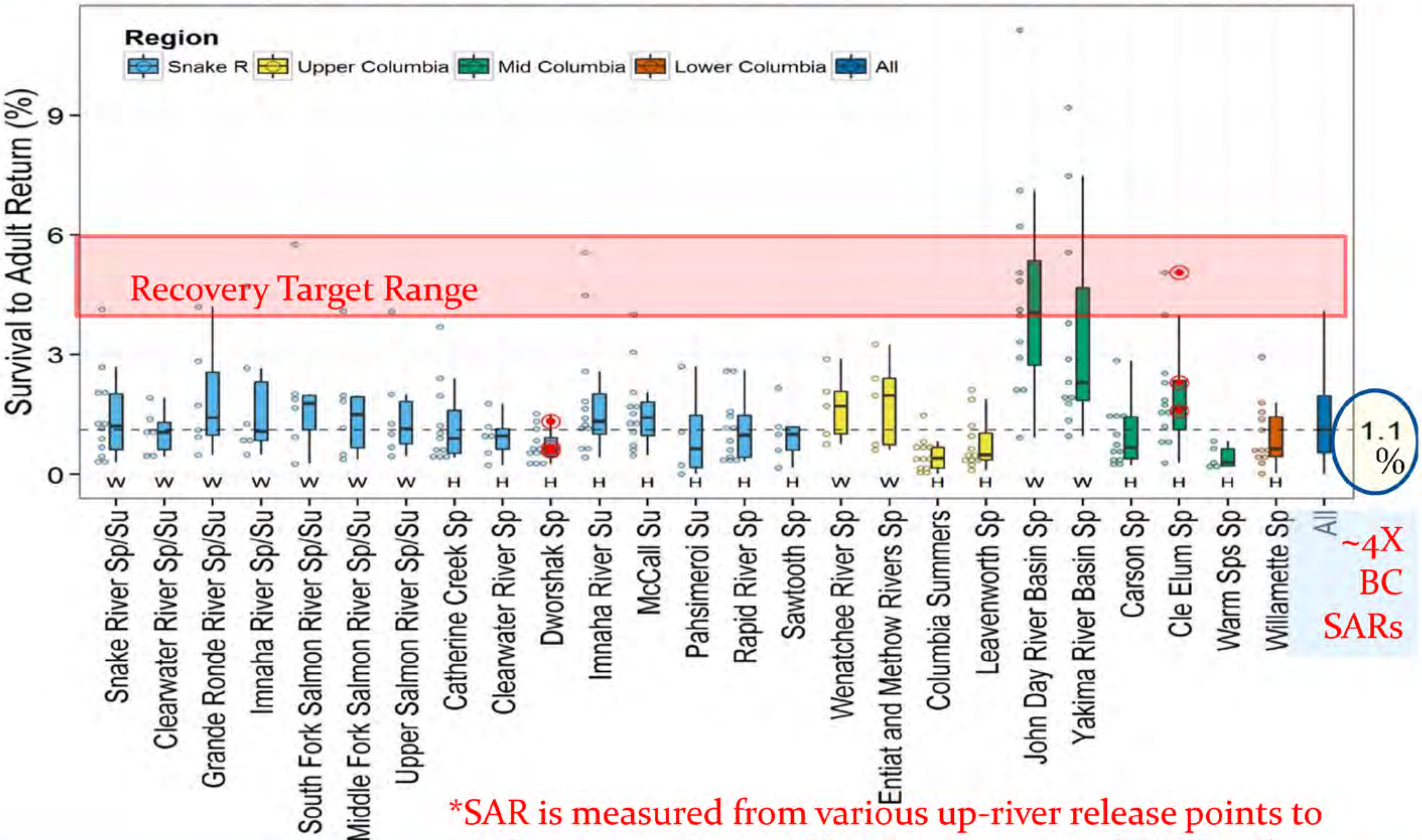
(2008-10 average survivals)

BC Chinook SARs



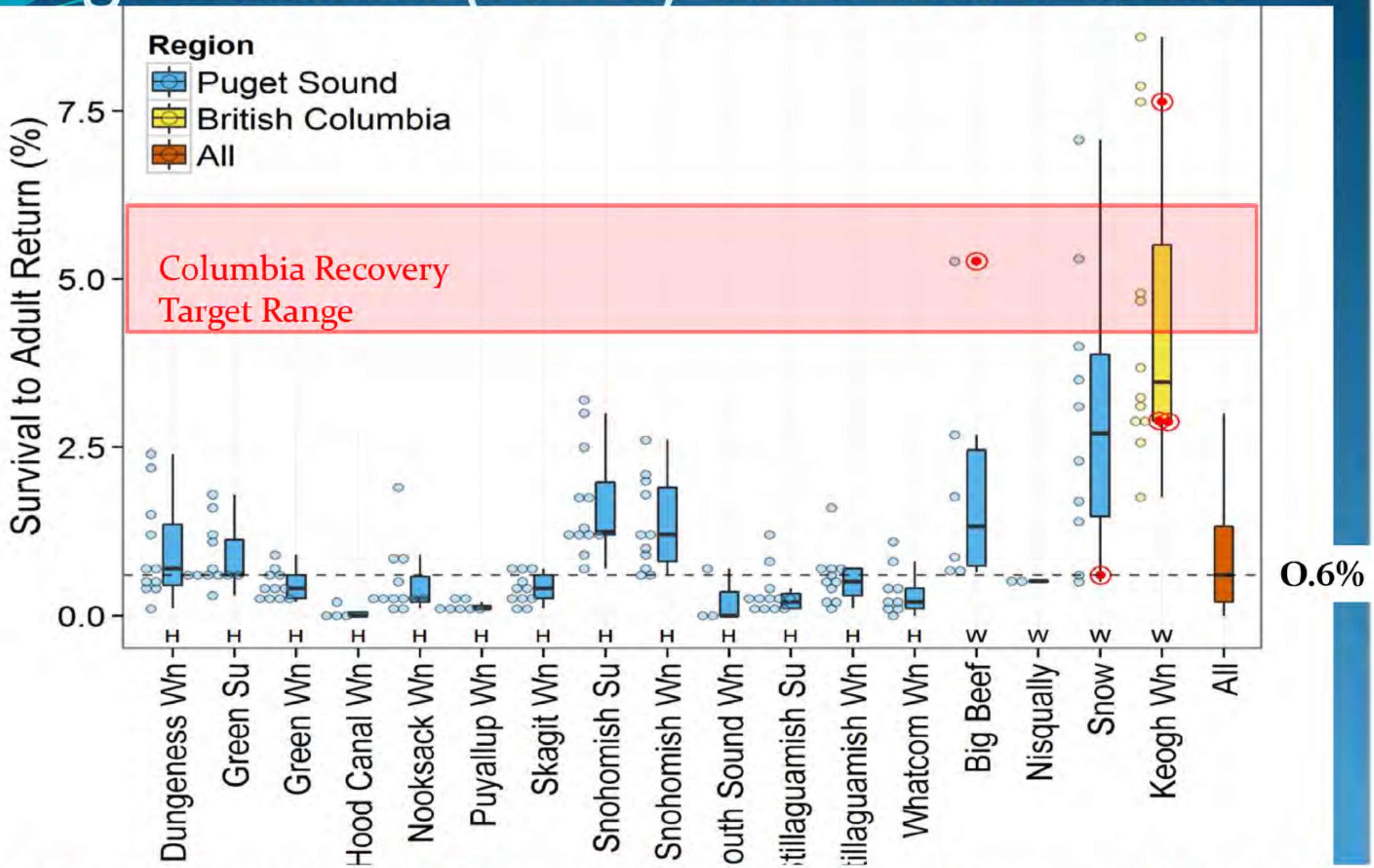
* SARS are for 2000-2012 (Kintama).

Columbia River Chinook SARs



*SAR is measured from various up-river release points to adult return at Bonneville Dam, 2000-2011 (FPC Data)

Puget Sound (& BC) Steelhead SARS



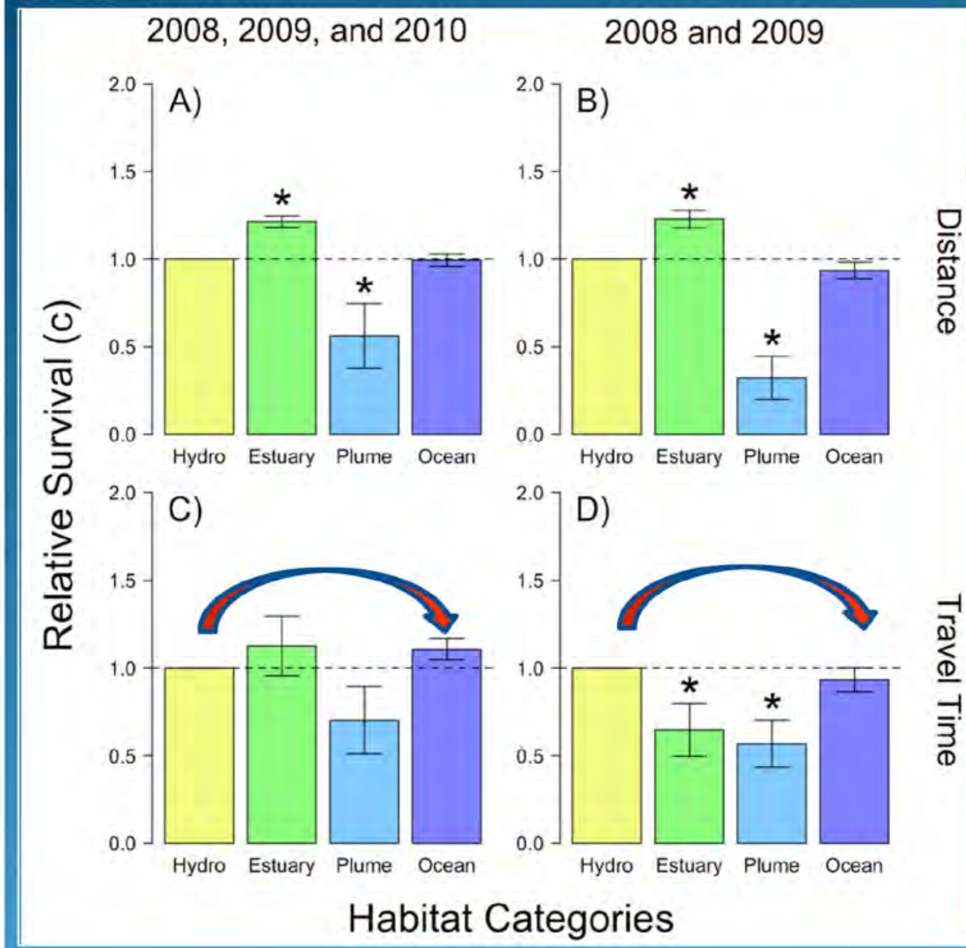
* Puget Sounds SARS are for various years, 2000 & later

Implications

- For BC Chinook stocks to "rebuild" to the Columbia level, SARS will have to increase 300-400%.
- To achieve the Columbia's Rebuilding Goals, BC Chinook SARs would have to increase 1,000~1,500%.
- Strongly suggests that the Columbia has the wrong perspective: It will not be possible to rebuild to current SAR targets (the 1960s) if other regions can't.
- Suggests (again) that the major issue is a common problem in the ocean.

Ocean vs Freshwater Survival

Ocean vs Freshwater Survival

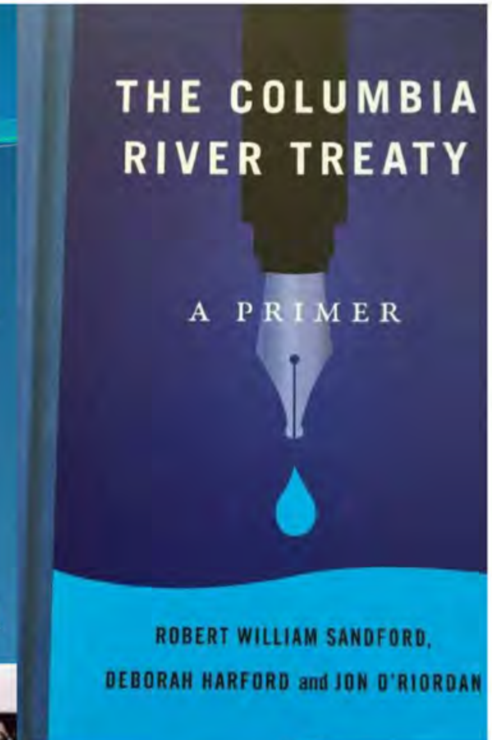


- Measured hydrosystem and coastal ocean survival rates are similar; $S_{FW} \approx S_{Ocean}$
- (b)(5) [redacted]
- (b)(5) [redacted]

Perspective

- Manipulating the hydrosystem for salmon (spill, drawdown, breach) is in essence a trade-off:
  - Smolts spend less time in the river…
  - … & more time in the ocean
  - Whether this improves conservation depends entirely on the implicit assumption that the ocean is the better environment

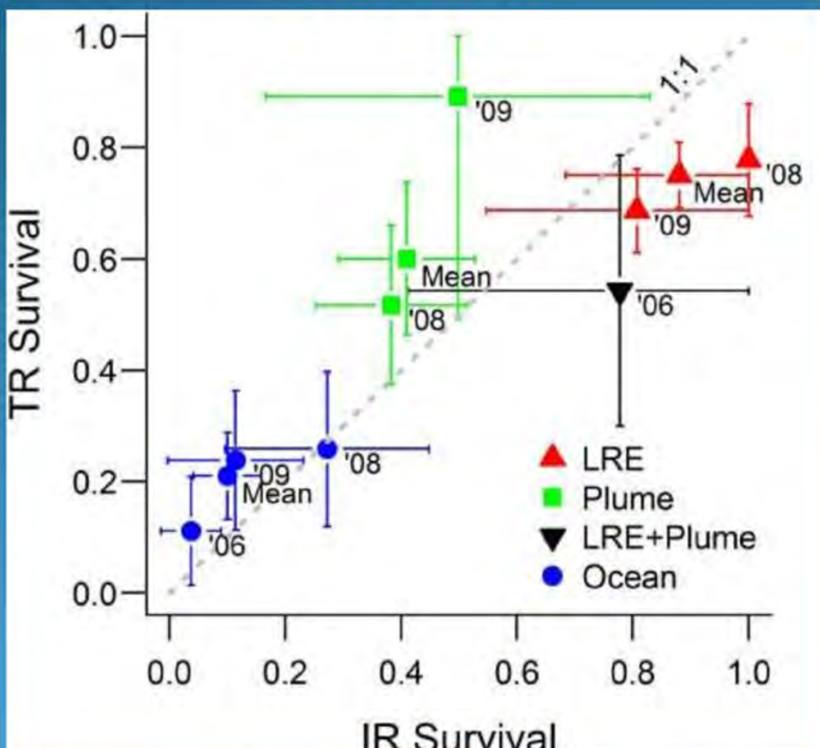
Out of the frying pan and into the fire



"Delayed Mortality" & "Differential-Delayed (Transport) Mortality" Show Role of Ocean

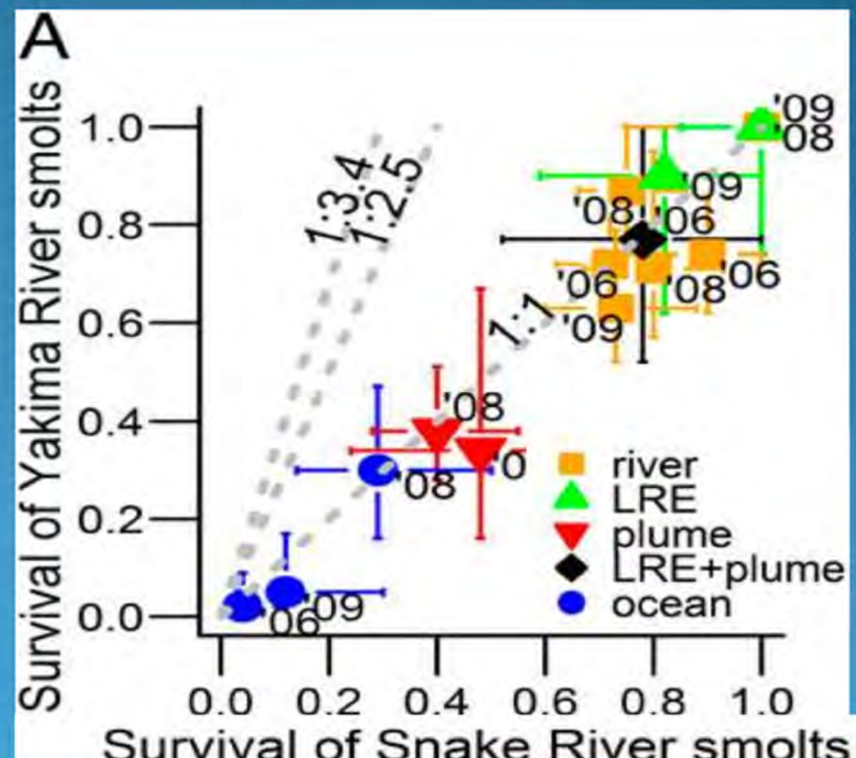
- *Transport findings can only occur if $S_{ocean} \approx S_{Hydrosystem}$*

Transport vs In-River Survival



Rechisky *et al* (2012). *Nature Sci. Reports*
doi:10.1038/srep00448

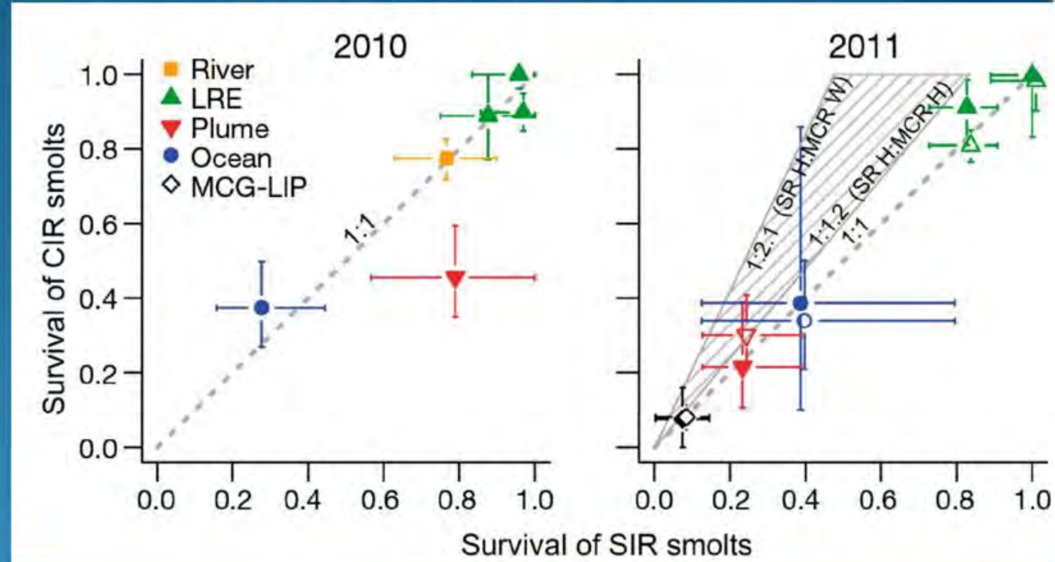
4 vs 8 Dam Survival

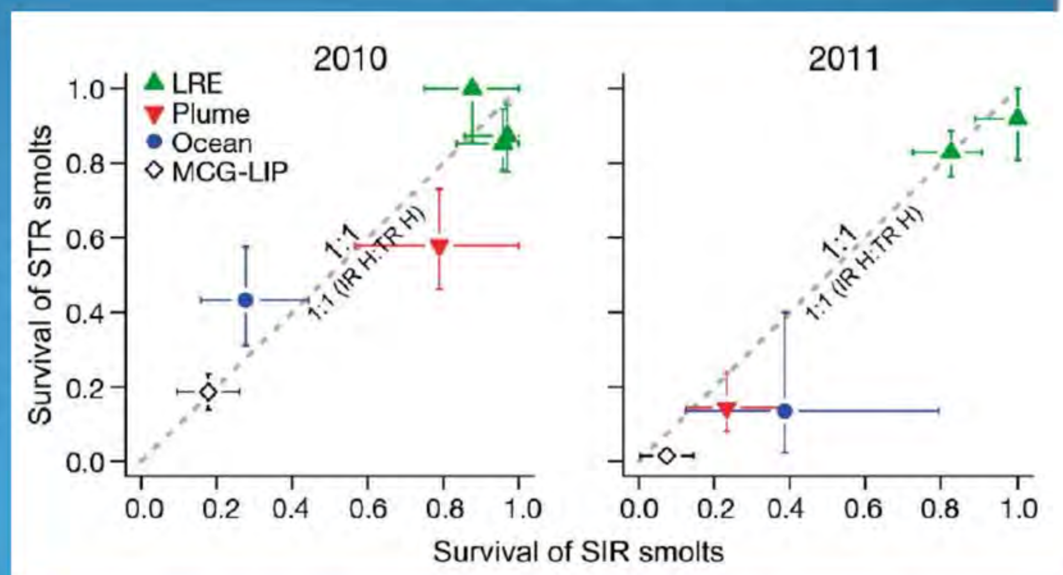


Rechisky *et al* (2013). *Proc. Nat. Acad. Sci. USA*
doi:10.1073/pnas.1219910110

Follow-Up DM & DDM Studies

- In 2010 & 2011 extended studies to smolts randomly selected at John Day & Bonneville Dams
- Stock ID done afterwards from DNA
- No survival differences found
- Study extends delayed mortality results to include upper Columbia stocks
- New studies covered "most" of the size range of migrating smolts





Rechisky et al (2014). *Mar. Ecol. Prog. Series, 496, 159–180 doi:10.3354/meps10692*

From: David Welch

Sent: Thu Apr 14 11:58:33 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Cc: Mendoza Flores,Luisa F (BPA) - EWB-4

Subject: Re: Final ppt

Importance: Normal

I'll try not to create a ruckus at Security, to try and get expedite the process

;-)

Sent from my iPhone

On Apr 14, 2016, at 11:56 AM, Zelinsky,Benjamin D (BPA) - EWP-4 <bdzelinsky@bpa.gov> wrote:

David,

If you show up at 1:30 that should give us plenty of time still even with your Canadianess. Just call Luisa's extension at x5888 after checking with the guards and she'll escort you. I'll come join you soon after.

Ben

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, April 14, 2016 11:40 AM

To: Mendoza Flores,Luisa F (BPA) - EWB-4; Zelinsky,Benjamin D (BPA) - EWP-4
Subject: RE: Final ppt

Here is the revised ppt, with the changes requested by Ben; I am sending this as backup.

To get this to a size where it will go via email, I had to delete some slides, so if possible I would prefer to work off the original on my laptop.

Luisa, I can be there as early as you like—I am currently working in the coffee bar at the Double Tree across the road. If I don't hear otherwise, I will present myself at 12:30, as the security process tends to take a while for Canadians. Unless you need to escort me from that point, I can wait in the cafeteria area (I'm wearing a grey suit and dark blue tie… should be easy to identify me! J)

David

From: Mendoza Flores,Luisa F (BPA) - EWB-4 [mailto:lfmendoza@bpa.gov]
Sent: Thursday, April 14, 2016 11:11 AM
To: Zelinsky,Benjamin D (BPA) - EWP-4; David Welch
Subject: RE: Final ppt

Good morning,

If you bring your laptop in, we can connect you to the projector and it should be fine. I will make sure to say for the first 10 minutes of the presentation in case there are any technical difficulties. J

David - could you please arrive earlier so that we can get you connected and be ready to go before the meeting starts?

Thank you,

Luisa Mendoza Flores

Administrative Assistant | Business Operations Support EWB-4

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

Please consider the environment before printing this email.

-----Original Message-----
From: Zelinsky,Benjamin D (BPA) - EWP-4
Sent: Thursday, April 14, 2016 11:08 AM

To: 'David.Welch@kintama.com'
Cc: Mendoza Flores,Luisa F (BPA) - EWB-4
Subject: Re: Final ppt

Working off your laptop should be fine. We just can't connect you to the internet.

----- Original Message -----

From: David Welch [mailto:David.Welch@kintama.com]

Sent: Thursday, April 14, 2016 10:46 AM

To: Zelinsky,Benjamin D (BPA) - EWP-4

Cc: Mendoza Flores,Luisa F (BPA) - EWB-4

Subject: Re: Final ppt

Just on the TriMet

The ppt is probably too big to email, but I will try once I get to a coffee shop

I understand the problem with USBs, but assumed I could just work off my laptop. Not feasible?

Sent from my iPhonethe

> On Apr 14, 2016, at 10:36 AM, Zelinsky,Benjamin D (BPA) - EWP-4 <bdzelinsky@bpa.gov> wrote:

>

> I left you a vm - please leave off budget numbers if it isn't too late and then please email Luisa and me the final ppt. Our security rules make it hard for us to use a flash drive so emailing the final ppt is preferable.

>

> Thanks and see you in a bit

>

> Looking forward to our discussion

>

> Ben

From: David Welch

Sent: Wed Aug 17 12:39:12 2016

To: Creason,Anne M (BPA) - EWL-4; Erin Rechisky; Zelinsky,Benjamin D (BPA) - A-7

Subject: RE: BPA Contracting info-- email #1

Importance: Normal

Attachments: CR299513-SoleSourceJustification Kintama-DRAFT (17 Aug 2016).docx

Hi Anne—

Attached is the Sole Source Justification for your review and use. I hope to get the final SOW to you later today or possibly tomorrow—(b)(6) [redacted] so I am even slower than normal with getting [redacted] week!

Feel free to give me a call on my cell if you want to discuss the attached.

Best, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

10-1850 Northfield Road, Nanaimo, BC, Canada V9S 3B3

Office Tel: (250) 729-2600 (x) 223 Fax: (250) 729-2622 Mobile: [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: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: Tuesday, August 16, 2016 8:24 AM
To: Erin Rechisky; Zelinsky,Benjamin D (BPA) - EWP-4
Cc: David Welch
Subject: RE: BPA Contracting info-- email #1

Just checking in with you all on the status of this.....Ben, we still have not received Work Order info. Erin, when do you expect to have a statement of work and justification to me? No rush—I just want to make sure I'm staying on top of this one.

Thanks—

Anne

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Thursday, August 04, 2016 11:44 AM
To: Zelinsky,Benjamin D (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4
Cc: David Welch
Subject: RE: BPA Contracting info-- email #1

Thanks Ben.

Erin

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: August 4, 2016 11:41 AM
To: Creason,Anne M (BPA) - EWL-4; Erin Rechisky
Subject: RE: BPA Contracting info-- email #1

Yes – communication and discussion of the results will be a critical element. Travel to support that should be included. Thanks for checking.

From: Creason,Anne M (BPA) - EWL-4
Sent: Thursday, August 04, 2016 11:33 AM
To: 'Erin Rechisky'; Zelinsky,Benjamin D (BPA) - EWP-4
Subject: RE: BPA Contracting info-- email #1

Hi Erin—

I'm not sure what was contemplated as part of the scope of this study. Ben—can you please confirm that you and others were anticipating having Kintama folks travel as part of the study, in order to present their findings?

Thanks—

Anne

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Thursday, August 04, 2016 11:30 AM
To: Creason,Anne M (BPA) - EWL-4
Subject: RE: BPA Contracting info-- email #1

It there a possibility that David and/or I will be travelling to Portland to present our findings? Can I include travel to scientific meetings where we present the results, i.e., AFS meetings, Salmon Ocean Ecology?

Erin

From: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: August 4, 2016 11:01 AM
To: Erin Rechisky
Subject: RE: BPA Contracting info-- email #1

Thanks Erin. Just use the Sections in the Budget that are relevant. I imagine it's personnel (staff) time and overhead. Maybe travel (if you do use travel make sure that the rates are within the USA GSA travel per diem rates: http://www.gsa.gov/portal/content/104877)? You can delete the other non-applicable sections. Thanks!

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Thursday, August 04, 2016 10:58 AM
To: Creason,Anne M (BPA) - EWL-4
Subject: RE: BPA Contracting info-- email #1

Hi Anne,

Regarding the budget, I am to list items in section 5 and section 6 as well as the overhead in section 7? I am not sure what capitol equipment is (David is out of the office so I can't check with him). Do I need to fill this in if we are not doing a field study?

Thanks,

Erin

From: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: July 26, 2016 2:07 PM
To: David Welch; Erin Rechisky
Subject: BPA Contracting info-- email #1

Hi Erin & David—

Here's something to get you started. We'll need a Line Item Budget in this format: https://www.bpa.gov/efw/FishWildlife/InformationforContractors/IFCDocuments/LineItemBudgetTemplate.xls

I've asked a colleague for examples of a technical statement of work (SOW) and sole-source justification. In the meantime, have a look at the BPA contracting site regarding SOWs to get an idea of what we'd need to include if this turns out to be a Pisces-type contract. https://www.bpa.gov/efw/FishWildlife/InformationforContractors/Pages/Statements-of-Work.aspx

Hopefully I'll get something back by the end of the day that I can send your way.

Cheers—

Anne

Complete a non-competitive justification for procurements with an anticipated value of over $10,000 following this format as it applies. A non competitive transaction justification is not required for procurements under $10,000, procured from Federal Prison Industries, other federal agencies, AbilityOne Nonprofit Agencies for the Blind or other Severely Handicapped, Government Printing and Binding or for utility services. (BPI 11.7.1.1)

1. **Description of Materials or Services:**
Provide a complete description of the requirement, what program or project it supports and how it supports the mission of BPA. Quantities and detailed descriptions are not required unless as a part of the justification contained in section 3 of this justification. If requesting materials, include the Manufacturer, Manufacturer's part number, and indicate whether or not a time critical outage schedule for use of these items applies.

(b)(5) [redacted]

2. **Non Competitive Authority:** *From the list below check the applicable BPI authority permitting the proposed non-competitive transaction. Contact your Contracting Officer or Team Lead if you need assistance.*

- ☐ Repair parts, accessories, supplemental equipment or services required for supplies or services previously furnished or contracted for which are available from only one contractor. (BPI 11.7.1.2(a));
- ☐ Required by law or Executive Order (BPI 11.7.1.2(b));
- ☐ The entity has the responsibility to manage the property or resource to be affected by the services performed. (BPI 11.7.1.2 (c));
- ☐ BPA standard items, when a Business Line Vice President or equivalent level manager has determined in writing that BPA must standardize the use of the item, and that determination is available for review by the HCA. (BPI 11.7.1.2 (e));

☐ Agreements with nonprofit research organizations such as the Electric Power Research Institute (EPRI) for the purposes identified in this section (BPI 11.7.1.2 (f) (1-6));

☐ Establish or maintain an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or a federally funded research and development center. (BPI 11.7.1.3 (a));

☐ When other parties have offered BPA an opportunity to participate in specific projects on a cost-sharing basis, and the sponsor has arranged for a substantial portion of the required funding for the entire project. (BPI 11.7.1.3(b));

☒ This is the only feasible source which can meet BPA's requirement and no other supplies or services will satisfy agency requirements (BPI 11.7.2);

3. **Justification:**
Provide sufficient information to support the proposed non competitive transaction based on the authority cited above and instructions of this section. Keep in mind that this document is reviewed and that your explanations may be formally questioned and protested if your justification is insufficient or not valid. For the BPI authorities 11.7.1.2 (f), 11.7.1.3(a) and 11.7.1.3(b), be sure to address the specific information required by those sections. For the BPI authority 11.7.2, unique source, all of the following elements must be provided: (1) The minimum mandatory requirements for the procurement (may be addressed in Section 1, Description of Materials or Services); (2) Identify what other sources were considered during market research (may be addressed in Section 6, Market Survey, below) and why those sources do not meet the minimum mandatory requirements and are not feasible due to form, fit, function, capabilities, capacity, experience, price, or delivery timeframe; (3) Demonstrate that the proposed contractor is the only feasible source based on unique capabilities, unique experiences, or unique attributes.

Kintama Research Services

Kintama Research Services is a world leader in the design and use of large-scale underwater acoustic telemetry arrays, with particular experience in applying these technologies to provide novel scientific information relevant to salmon management. Bonneville Power Administration contracted with Kintama Research Services, Ltd. under project #2003-114-00 from 2003-2012 for in-river, estuary and early marine survival estimates as they relate to delayed mortality due to migration through the FCRPS or transportation around the FCRPS.

(b)(5) [redacted]

(b)(5)

[redacted]

Welch, the president and founder of Kintama has received multiple awards for his scientific research, including the American Fisheries Society's award for Best Published Paper (2014), the American Fisheries Society's Award of Excellence-Fisheries Management (2012), the Canadian Society for Meteorology & Oceanography's J. P. Tully Medal in Oceanography (2012), and the Prix d'Excellence (2008) and Prix de Distinction (2007) from Fisheries & Oceans Canada for *"Exceptional Scientific Contributions to the Government of Canada"* and *"Outstanding Scientific Contributions Related To National And International Climate Change Research*, respectively. Dr Rechisky has over 20 years of work on acoustic telemetry of marine fish, and completed her PhD at the University of British Columbia analyzing the Columbia River data to look at the credence of the delayed mortality and differential-delayed mortality theories. She is also the current Secretary of the American Fisheries Society's B.C.-Washington Chapter. Aswea Porter, M.Sc., has worked for Kintama since 2006, and is senior data analyst and has primary responsibility for managing Kintama's acoustic telemetry database and much of the underlying preparatory analysis needed for production of scientific reports and published papers, as well as extensive involvement in the writing phase.

Why BPA is doing Estuary and Ocean Research:

(b)(5)

[redacted]

(b)(5) [redacted]

History of Sole Source to Kintama:
Kintama has no history of sole source contracting.

Why we still need Kintama's services:

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5)

[redacted]

(b)(5)

[redacted]

----

4. **Actions to Promote Competition:** At the onset of each procurement, all unique source justifications are scrutinized and screened for the possibility of further competition by Supply Chain. Further, competition barriers are discussed with the customer and options explored when available. *This section is prefilled and needs no editing.*

5. **Project Estimated Amount:** The anticipated price to the Government is $ *Requester must fill in the estimated or actual amount here (attach any and all quotes received). At time of award the Contracting Officer will determine if price is fair and reasonable.*

6. **Market Survey:** *Describe the market research that was performed that led you to your conclusion that there was need to waive competition. If no market research was performed, such as in instances of Urgent and Compelling, explain in detail here.*

7. **Requirements Certification:** I certify that the requirement outlined in this justification is a bonafide need of the Bonneville Power Administration and that the supporting data under my cognizance, which are included in the justification, are accurate and complete to the best of my knowledge and belief.
(Signature of the responsible manager)

Name & Title Date

8. Approval *This part is filled out by Contracting Staff as part of the Justification*

a. **Contracting Officer's Certification: (required)** I certify that the foregoing justification is accurate and complete to the best of my knowledge and belief.

Contracting Officer Signature Date

From: David Welch

Sent: Thu Aug 18 13:46:47 2016

To: Lut,Agnes (BPA) - KEWR-4; Ben Zelinsky; amcreason@bpa.gov (amcreason@bpa.gov)

Subject: FW: Journal of Aquatic Animal Health - Decision on Manuscript ID UAAH-2015-0059.R2

Importance: Normal

Agnes, Ben, & Anne—

Just keeping you in the loop. Our paper analyzing the potential impacts of high TDG (total dissolved gas) levels on smolt survival below Bonneville has been accepted for publication in the Journal of Aquatic Animal Health. This paper has had a rather checkered history with some reviewers arguing strongly against publication because the study was observational in nature and we could not prove cause and effect. (An interesting argument, considering that the arguments for improved smolt survival at higher flows are based on correlations and thus also have solely an observational basis!).

Nevertheless, Ian Brosnan has kept with this and I am pleased to say that the reviewers and editors now agree to the paper's publication and that the limitations inherent to the nature of the study are reasonably spelled out. I don't have a problem providing you with a pre-publication copy if it would be of use now, but otherwise suggest waiting till it appears in the journal in a few months' time.

Regards, David

P.S. [redacted], he is currently Associate Chief for Strategic Planning, NASA Ames Research Center. Not bad for a fall back career when Kintama didn't work out! J

kintamav_RGB

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

From: BROSNAN, IAN G. (ARC-SG) [mailto:ian.g.brosnan@nasa.gov]
Sent: Thursday, August 18, 2016 5:49 AM
To: David Welch
Subject: Fwd: Journal of Aquatic Animal Health - Decision on Manuscript ID UAAH-2015-0059.R2

VICTORY!

(I'm very pleased)

Begin forwarded message:

From: Journal of Aquatic Animal Health <onbehalfof+jwolf+epl-inc.com@manuscriptcentral.com>
Date: August 18, 2016 at 06:39:48 MDT
To: <ian.g.brosnan@nasa.gov>
Subject: Journal of Aquatic Animal Health - Decision on Manuscript ID UAAH-2015-0059.R2
Reply-To: <jwolf@epl-inc.com>

18-Aug-2016

Dear Dr. Brosnan:

Ref: Survival rates of out-migrating yearling Chinook salmon in the lower Columbia River and plume following exposure to gas supersaturated water

Our reviewers have now considered your paper and have recommended publication in Journal of Aquatic Animal Health. We are pleased to accept your paper in its current form which will now be forwarded to the publisher for copy editing and typesetting. The reviewer comments are included at the bottom of this letter, along with those of the editor who coordinated the review of your paper.

You will receive proofs for checking, and instructions for transfer of copyright in due course.

The publisher also requests that proofs are checked through the publisher's tracking system and returned within 48 hours of receipt.

Thank you for your contribution to Journal of Aquatic Animal Health and we look forward to receiving further submissions from you.

Sincerely,
Jeffrey Wolf
Editor, Journal of Aquatic Animal Health

jwolf@epl-inc.com

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author
I am still not convinced that it is valid to make inferences to the daily survival rate in this study, but I believe that the revised Discussion adequately entertains the alternatives, considering that this is an observational study and your recommendations for future study.

Associate Editor
Comments to the Author:
The modifications highlighting the caveats associated with assumptions about time-based survival estimates are an improvement to the manuscript, giving the readers a better sense for how the observations can be viewed. Nonetheless, this manuscript is likely to provoke disparate opinions among readers, as it did among reviewers.

Field analyses always have confounding variables (e.g., higher TDG correlates with faster flows), making it hard to achieve clean study designs. And often, effects that are strong in a lab setting are diminished by environmental variability, so it is important to examine effects in field settings when possible. Hopefully, this manuscript will stimulate the fish health community to think more closely about how to plan & implement field studies.

From: David Welch

Sent: Fri Aug 19 11:14:24 2016

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

Cc: Aswea Porter; Erin Rechisky

Subject: Draft SOW & Sole Source. Justification..

Importance: Normal

Attachments: CR299513-SoleSourceJustification Kintama-DRAFT (19 Aug 2016).docx; SOW Kintama-DRAFT (19 Aug 2016).docx

Hi Anne-

Please see attached. As mentioned, if we can keep the specific reporting/check-in requirements as simple as possible, this will be helpful from the perspective of getting the papers published in high quality reputable journals where the authors need to certify that *"…the funders played no role in the design or execution of the study"*. Ideally, the requirements here will simply state that Kintama will provide a white paper to BPA, and BPA will make a decision to support additional funding for the peer-reviewed publication at that time. Your contracting folks may want more details than this of course, to satisfy their own requirements.

I have also used **red font** for the summary of deliverables section, as you may want to look at this closely from BPA's scheduling perspective. There is a ***lot*** of work to do to meet these timelines, but I think it is just feasible if we start soon.

Finally, we will be glad to investigate the possibility of including Willamette R SARS in the SAR report, so please provide a contact if you have one for this data. However, to ensure that we scrupulously maintain a balanced perspective here, can you also advise on any other substantial sources of below Bonneville SAR data for the Columbia River that we should also try to incorporate?

I look forwards to your response. FYI, I have not CCed Ben Zelinski on this, as I leave it up to you to forward for comments as appropriate.

Thanks, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

10-1850 Northfield Road, Nanaimo, BC, Canada V9S 3B3

Office Tel: (250) 729-2600 (x) 223 Fax: (250) 729-2622 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

Complete a non-competitive justification for procurements with an anticipated value of over $10,000 following this format as it applies. A non competitive transaction justification is not required for procurements under $10,000, procured from Federal Prison Industries, other federal agencies, AbilityOne Nonprofit Agencies for the Blind or other Severely Handicapped, Government Printing and Binding or for utility services. (BPI 11.7.1.1)

1. **Description of Materials or Services:**
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(b)(5) [redacted]

(b)(5) [redacted]

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- ☐ Required by law or Executive Order (BPI 11.7.1.2(b));
- ☐ The entity has the responsibility to manage the property or resource to be affected by the services performed. (BPI 11.7.1.2 (c));
- ☐ BPA standard items, when a Business Line Vice President or equivalent level manager has determined in writing that BPA must standardize the use of the item, and that determination is available for review by the HCA. (BPI 11.7.1.2 (e));

☐ Agreements with nonprofit research organizations such as the Electric Power Research Institute (EPRI) for the purposes identified in this section (BPI 11.7.1.2 (f) (1-6));

☐ Establish or maintain an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or a federally funded research and development center. (BPI 11.7.1.3 (a));

☐ When other parties have offered BPA an opportunity to participate in specific projects on a cost-sharing basis, and the sponsor has arranged for a substantial portion of the required funding for the entire project. (BPI 11.7.1.3(b));

☒ This is the only feasible source which can meet BPA's requirement and no other supplies or services will satisfy agency requirements (BPI 11.7.2);

3. **Justification:**
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(b)(5)

[redacted]

(b)(5)

[redacted]

(b)(5)

[redacted]

Welch, the president and founder of Kintama has received multiple awards for his scientific research, including the American Fisheries Society's award for Best Published Paper (2014), the American Fisheries Society's Award of Excellence-Fisheries Management (2012), the Canadian Society for Meteorology & Oceanography's J. P. Tully Medal in Oceanography (2012), and the Prix d'Excellence (2008) and Prix de Distinction (2007) from Fisheries & Oceans Canada for *"Exceptional Scientific Contributions to the Government of Canada"* and *"Outstanding Scientific Contributions Related To National And International Climate Change Research*, respectively. Dr Rechisky has over 20 years of work on acoustic telemetry of marine fish, and completed her PhD at the University of British Columbia analyzing the Columbia River data to look at the credence of the delayed mortality and differential-delayed mortality theories. She is also the current Secretary of the American Fisheries Society's B.C.-Washington Chapter. Aswea Porter, M.Sc., has worked for Kintama since 2006, and is senior data analyst and has primary responsibility for managing Kintama's acoustic telemetry database and much of the underlying preparatory analysis needed for production of scientific reports and published papers, as well as extensive involvement in the writing phase.

Why BPA is doing Estuary and Ocean Research:

(b)(5)

[redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

History of Sole Source to Kintama:
Kintama has no history of sole source contracting.

Why we still need Kintama's services:

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

1) (b)(5) [redacted]

(b)(5) [redacted]

2) (b)(5) [redacted]

3) (b)(5) [redacted]

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4. **Actions to Promote Competition:** At the onset of each procurement, all unique source justifications are scrutinized and screened for the possibility of further competition by Supply Chain. Further, competition barriers are discussed with the customer and options explored when available. *This section is prefilled and needs no editing.*

5. **Project Estimated Amount:** The anticipated price to the Government is $411,600 ($343,000 to take the three reports to White Paper stage, and additional $68,600 to complete reports if appropriate for publication in the peer-reviewed scientific literature).

6. **Market Survey:** *Describe the market research that was performed that led you to your conclusion that there was need to waive competition. If no market research was performed, such as in instances of Urgent and Compelling, explain in detail here.*

7. **Requirements Certification:** I certify that the requirement outlined in this justification is a bonafide need of the Bonneville Power Administration and that the supporting data under my

cognizance, which are included in the justification, are accurate and complete to the best of my knowledge and belief.
(Signature of the responsible manager)

Name & Title Date

8. **Approval** *This part is filled out by Contracting Staff as part of the Justification*

   a. **Contracting Officer's Certification: (required)** I certify that the foregoing justification is accurate and complete to the best of my knowledge and belief.

Contracting Officer Signature Date

Statement of Work Template

A statement of work should address each of the following topics in the sequence presented below. In the event that a topic is not relevant to a specific acquisition action, it need not be covered.

Part A General

A.1 Objective

(b)(5) [redacted]

A.2 Background

(b)(5) [redacted]

(b)(5) [redacted]

[redacted]

A.3 Location of Project

This project will be performed at the Kintama Research Services office in Nanaimo, BC Canada.

A.4 BPA-Furnished Property or Services

Description	Point of Delivery	Date to be Delivered
NONE		

A.5 Contractor-Furnished Property or Service

The Contractor shall provide all property and services to perform the work of this contract.

A.6 Definitions

SARs-Smolt to Adult Survival

A.7 Documentation

Specifications and standards (either Federal or industry-wide) which are to be used in the performance of work are listed here, for incorporation by reference into the contract.

Part B Technical Approach/Tasks

B.1 General Requirements

Kintama will collate available data and produce three reports, initially for internal BPA use; if these reports are deemed useful, additional work will then be completed to bring them to a sufficient standard that they are appropriate for submission to peer-reviewed scientific journals for publication. These three reports will:

1) [redacted]

2) (b)(5) [redacted]

3) (b)(5) [redacted]

B.2 Methods to be Used

This is a completion contract. Three reports will be completed and submitted to BPA for internal use and review. If the results warrant publication, further funding may be negotiated to support refinement to a level where it can be submitted for peer review and publication in a scientific journal.

B.3 Specific Requirements

Christine—Let's keep this as simple and clean as possible. Any boilerplate you can provide?

The specific steps or activities to be accomplished by the contractor will be described in sufficient detail for the prospective contractor to prepare thorough proposals. If BPA approval or review is required at specific points, they should be defined in this Subpart. In general, this section should include the following elements in chronological order.

Phases *(may contain go, no go, decision points). For each phase, include the following:*

> Tasks *(may contain go, no go decision points) and detailed activities. Include sub tasks as needed. For each Task, include a due date expressed in elapsed days after award, not in specific calendar dates, as well as the following:*
>
> > *Deliverables. Deliverables could be specific products such as computer disks or printouts, copies of a publication or a report, presentation of workshops or briefings, test plans, specifications, drawings, test data, or other types of measurable results.*

Quality Assurance. This section should clearly state the manner in which BPA will determine whether the contractor has met the requirements of each Task or Deliverable. If BPA reserves the right to reject a report as incomplete or inaccurate, the criteria by which that decision will be made should be outlined. Indicate the minimum quality level, and the range of deviation acceptable. Also describe how rejection or variances outside the acceptable range of deviation may reduce or nullify payments and will require the contractor to rework or submit a plan for remedy.

Payment. A description of how pricing, as shown in the Schedule of Prices of the contract Terms, correlates with each Task or Deliverable. Also include any instructions about the payment process that are unique to this task. For example, "Upon completion of this Task, BPA will pay the contractor the fixed price indicated in the Schedule of Prices. Contractor shall not invoice BPA for this Task prior to BPA acceptance of the work."

Phase 1

Tasks: Collect & analyze the available data on Chinook and steelhead SARS for west coast salmon stocks and compare to Columbia Basin.

Deliverables: report and presentation?

QA:

Payment:

Phase 2

Tasks

Deliverables

QA

Payment

Phase 3

Tasks

Deliverables

QA

Payment

B.4 Summary of Deliverables.

Description	Format	Due Date	Days for BPA Review
(b)(5) [redacted]	White paper report for internal BPA use	31 July 2017	1 month
(b)(5) [redacted]	White paper report for internal BPA use	1 March 2017	1 month
(b)(5) [redacted]	White paper report for internal BPA use	1 March 2017	1 month

Part C Inspection and Acceptance (Quality Assurance)

This section should provide a summary of the methods that the COTR and Field Inspectors will use to perform quality assurance. At a minimum, BPA should describe its intent to conduct periodic surveillance. Other methods may include Trend Analysis, Third-Party Audits, and Contractor Reported Data.

Part D Technical Exhibits

In some instances, voluminous and detailed data is required to provide the contractor with sufficient information to develop a proposal. Such detail should be appended as exhibits to the work statement.

From: Creason,Anne M (BPA) - EWL-4

Sent: Fri Aug 19 12:04:25 2016

To: David Welch

Cc: Zelinsky,Benjamin D (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4

Subject: RE: Draft SOW & Sole Source. Justification..

Importance: Normal

Thanks David. Yes, Christine and I spoke regarding the "appearance of bias" issue and I complete agree that you should do what is necessary to make sure your study is viewed as unbiased as possible.

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, August 19, 2016 11:48 AM
To: Creason,Anne M (BPA) - EWL-4
Cc: Zelinsky,Benjamin D (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4
Subject: RE: Draft SOW & Sole Source. Justification..

Thanks so much—I apologize for the confusion.

Erin did much of the leg work on putting these two files together during my two week's absence on holidays, and then left for two weeks vacation just before I got back. I guess I must have somehow incorrectly assumed that Christine assumed the lead.

[redacted]

David

kintamav_RGB

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

From: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: Friday, August 19, 2016 11:41 AM
To: David Welch
Cc: Zelinsky,Benjamin D (BPA) - EWP-4
Subject: FW: Draft SOW & Sole Source. Justification..

Importance: High

Hi David—

Just wanted to make sure you have my correct email address. You had sent this email and information to Christine Peterson, who is more of a technical contact, and won't be the COTR on this.

I'll have a look and get back to you. I'm still waiting for Ben to get back to me on the funding part of this before I dive too much further into getting this submitted.

Thanks—

Anne

From: Petersen,Christine H (BPA) - EWP-4
Sent: Friday, August 19, 2016 11:37 AM
To: Creason,Anne M (BPA) - EWL-4
Subject: FW: Draft SOW & Sole Source. Justification..

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, August 19, 2016 11:14 AM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Aswea Porter; Erin Rechisky
Subject: Draft SOW & Sole Source. Justification..

Hi Anne-

Please see attached. As mentioned, if we can keep the specific reporting/check-in requirements as simple as possible, this will be helpful from the perspective of getting the papers published in high quality reputable journals where the authors need to certify that *"...the funders played no role in the design or execution of the study"*. Ideally, the requirements here will simply state that Kintama will provide a white paper to BPA, and BPA will make a decision to support additional funding for the peer-reviewed publication at that time. Your contracting folks may want more details than this of course, to satisfy their own requirements.

I have also used **red font** for the summary of deliverables section, as you may want to look at this closely from BPA's scheduling perspective. There is a ***lot*** of work to do to meet these timelines, but I think it is just feasible if we start soon.

Finally, we will be glad to investigate the possibility of including Willamette R SARS in the SAR report, so please provide a contact if you have one for this data. However, to ensure that we scrupulously maintain a balanced perspective here, can you also advise on any other substantial sources of below Bonneville SAR data for the Columbia River that we should also try to incorporate?

I look forwards to your response. FYI, I have not CCed Ben Zelinski on this, as I leave it up to you to forward for comments as appropriate.

Thanks, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

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Office Tel: (250) 729-2600 (x) 223   Fax: (250) 729-2622 Mobile: (b)(6) [redacted]

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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 Aug 23 15:38:15 2016

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

Cc: BROSNAN, IAN G. (ARC-SG)

Subject: RE: Elder et al 2016

Importance: Normal

Attachments: JAAH TDG Paper Revision 2 Submission Proof (1 June 2016).pdf

Thanks, Christine-- I appreciate the perspective-- the Columbia River "juggernaut" has gotten so massive that sometimes it is hard to sort out why people say and do some of the things that they do. I think that the answer is "Groupthink" and it is not something unique to the region or the Columbia River biologists... there is a great book called "Criminal Investigative Failures" (Rossmo, D. K. (2008). Criminal investigative failures: CRC Press.) that takes apart a number of very high profile wrongful criminal convictions to see what went wrong. (I went to this literature because here the pressure on public officials to come up with an answer is even greater and the sometimes "unprofessional" behavior of the individuals that results has an even greater impact than what occurs in operating the dams).

One of the key points from that book is that groupthink tends to come to dominate a group of detectives when they feel beleaguered, all sit around the same table, and develop tunnel vision... they become convinced they have the correct culprit far too early/quickly and narrow the investigation process down and exclude potential offenders... and then they become motivated to defend those initial decisions because they all sat around the table and collectively made them and they now feel the need to defend the integrity of their colleagues and "the process", rather than push the "restart button". I see strong analogies to the lack of willingness of salmon biologists coast-wide to admit that a lot of the salmon problems are out at sea, and that they need to address them head on rather than continue to fight for continued efforts to do things in freshwater.

I copy Ian Brosnan for his knowledge that I have given you the accepted copy of the manuscript. Please keep this within tight bounds at BPA until it is published... No sense in giving the FPC any extra time to prepare one of their memos trashing a result that they don't like...

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Tuesday, August 23, 2016 3:21 PM
To: David Welch

Subject: RE: Elder et al 2016

Hi David,
No problem at all - at many places with various organizational structures, it is perfectly fine to talk with anyone on the 'team' about a contract matter. Our own organizational structure can be a bit hard to discern - the set of folks at your presentation were from both 'power generation' and our F&W program.

It would be nice to see your current TDG paper, and I would not disperse it widely. I saw a version from two years ago. Tomorrow, a couple of us are going to the Corps temperature modeling presentation. Water quality will play a big role in this EIS, and there are a number of small debates that we have not chosen to engage in recently.

Yes, when we were talking about how the Columbia River area came to have the arrangement of agency roles, with FPC serving as an unofficial biometry experts/policy voices. In a sense, I think the 'action agencies' (Corps, BPA, Bureau) don't effectively do their PR job. We have staff who put together presentations showing our side of the story, and I think they get presented internally and don't reach outside news agencies. Our rarely visited youtube channel has some great pieces on projects we've funded, done by John Tyler. There is a weekly meeting called FPAC which is attended by the state agencies, tribes, and one NOAA rep, where FPC play the role of presenting environmental conditions and fish numbers every week, and they also tend to push the agenda that is reflected in the memos that they write up. I rarely paid attention, but I noticed that Jason Sweet sometimes listens to their online recordings in order to see what the hot issues are. There have been examples where there is suddenly a set of news articles which claim the same thing (that dams are heating the river, or lack of spill is killing fish yet a little bit more could double returns) and this can be traced back to FPAC and press releases that are sent out. We are not able to really write a rebuttal to a memo because it isn't exactly our place as a government agency. (b)(5) [redacted]
(b)(5) [redacted]

http://blogs.idahostatesman.com/a-primer-on-the-salmon-science-debate-underlying-spill-test-proposal/
http://www.oregonlive.com/opinion/index.ssf/2015/05/planned_cormorant_slaughter_is.html

-----Original Message-----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, August 19, 2016 2:12 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Elder et al 2016

Right-- it was-- I just falsely assumed that since I had been talking with you about issues this week that you had taken over as COTR sometime after I had left on holidays.

It would be good to talk about the TDG paper and get your take on it, but can I send you the accepted draft copy without having it too broadly distributed at this point (discreet discussion at BPA is fine)? I just don't want to be seen as lobbying over the results-- the study has limitations, but it also is the first paper I know of that documents the possibility that sub-lethal TDG exposure can potentially be causing elevated mortality later in the plume, and multiple days after exposure. This is presumably because of stroke-like symptoms from TDG making the affected smolts more susceptible to predation but of course we can't get at the mechanism from this sort of observationa; study.

You can see the reviewer's & editor's final comments on it accepting the version I will send you, noting the likely key points of contention, and if you want I can provide the earlier criticisms and our detailed rebuttals. As for actually publication, when it can be freely cited, I'm not sure-- it may well be months before the journal actually puts it on their website.

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, August 19, 2016 1:36 PM
To: David Welch
Subject: Re: Elder et al 2016

Hi,
Sorry, here is where I think the misunderstanding started this morning. I thought you might be wanting to generally talk about what you are doing, or sources of data, or the TDG topic.

Christine

----- Original Message -----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, August 18, 2016 04:21 PM Pacific Standard Time
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Elder et al 2016

Hi Christine--

Are you available to take a brief phone call now? Or should I call you in the morning on Friday?

David

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, August 18, 2016 3:35 PM
To: David Welch
Subject: FW: Elder et al 2016

Hi David,

Agnes just mentioned the status of your paper with Ian Brosnan. I thought I would forward this paper that just went into print. Several thought that Tim Elder's statistical methods were hard to understand, and also didn't understand the inference of a elevated effect from going through multiple dams when his tables seem to show lower mortality with multiple dams (more of a culling effect?).
Scott and I saw a draft of this when it looked a bit different, and I gave it extra points for selecting this technique which would not require them to presume the shape of the curve of the relationship (like a linear regression) and for considering TDG and barometric pressure as variables. I realized I have to look more into the importance of barometric pressure differential because I havent' considered it before.

Along other lines, was your group able to identify sources of Willamette SARs data? This might be a challenging location due to the history of hatcheries and their various release locations but there are a few people with OSU and the Corps who could probably find wild or reliable hatchery data.

Christine Petersen

-----Original Message-----
From: Bettin,Scott W (BPA) - EWP-4
Sent: Thursday, August 18, 2016 2:51 PM
To: Grimm,Lydia T (BPA) - A-7; Bodi,Lorri (BPA) - E-4; Francis,Rose (BPA) - LN-7; Barco III,John W (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

http://www.fpc.org/documents/memos/47-16.pdf

It appears Michele is catching up on her reading. A 12 page review of the document was kicked off with this sentence. "The subject analysis is so extensively flawed that the conclusions reached are not credible or applicable to any fish passage management questions." - s

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4
Sent: Friday, August 12, 2016 12:54 PM
To: Bettin,Scott W (BPA) - EWP-4; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

Charlie spotted that this paper you got from Mark Weiland a couple years ago got into print. I think they get a bonus point for considering TDG and even having this as a major risk around dams. I'm not sure how the rest of the world will perceive it. They aren't dwelling on the routes the fish went through.

-----Original Message-----
From: Charlie Paulsen [mailto:cpaulsen@paulsenenvironmentalresearch.com]
Sent: Friday, August 12, 2016 10:23 AM

To: Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5
Subject: Elder et al 2016

Christine & Julie:

I saw this discussed in CBB this morning, and I'm not quite sure what to make of it. If you get a chance to look at it I'd appreciate hearing your views.

Charlie

Survival rates of out-migrating yearling Chinook salmon in the lower Columbia River and plume following exposure to gas supersaturated water

Journal:	*Journal of Aquatic Animal Health*
Manuscript ID	UAAH-2015-0059.R2
Manuscript Type:	Article
Keywords:	Disease and Parasites, Early Life History, Marine Nearshore, Physiology, Tags and Tagging, Water Quality

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<A> Abstract

In 2011, unusually high flows raised total dissolved gas (TDG) levels in the Columbia River (USA) well above the 120% regulatory limit imposed to prevent harmful impacts to aquatic organisms. After observing gas bubble trauma (GBT) in dead juvenile yearling Chinook salmon *Oncorhynchus tshawytscha* (smolts) held in tanks, we compared estimated survival rates of acoustic-tagged in-river (IR) and transported (T) smolts released below Bonneville Dam prior to and during the period of elevated TDG (>120%). The log odds of estimated daily survival in the lower river and plume were significantly lower for IR smolts released during the period of elevated TDG (maximum possible exposure = 134%) than smolts released when TDG < 120%. Transported smolts released 10-13 km below Bonneville Dam during the same period of elevated TDG had lower maximum possible exposure levels, 126% TDG, and there were no significant differences in log odds of estimated daily survival in the lower river and plume relative to smolts released when TDG < 120%. Direct mortality due to GBT is probably reduced in natural settings relative to laboratory experiments because smolts can move to deeper water, where pressure keeps gasses in solution, and migrate downstream of the spillway where TDG levels decrease as the river returns to equilibrium with the atmosphere. However, initially non-lethal GBT may reduce survival rates by increasing smolt susceptibility to predation and infection. Although our findings are limited by the observational nature of the study, our analysis is the first direct assessment of the potential influence of gas supersaturation on free-ranging smolt survival in the river and coastal ocean below a large dam. Experiments using simultaneous releases of control and gas-exposed groups

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are warranted and should consider the possibility that the chronic effects of TDG exposure on survival are important and persist into the early marine period.

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<A> Introduction

The practice of spilling water over dams can induce gas bubble trauma (GBT, also termed gas bubble disease) in aquatic species, including salmon smolts, by increasing total dissolved gas levels (TDG) in the river below the spillways. Globally, as the number of hydropower projects grows, there is increasing concern about the effects of TDG on fish health (Wang et al. 2015). There is a rich body of literature evaluating the physical, biological, and ecological effects of dissolved gas and gas bubble trauma (GBT) on salmon smolts (reviews in Weitkamp and Katz 1980, McGrath et al. 2006, and Maynard 2008). Most direct mortality effects at exposures up to 125% TDG may be avoided when fish are at liberty to compensate by migrating (Weitkamp and Katz 1980). However, even non-lethal GBT experiences may affect survival by increasing juvenile salmon's susceptibility to predation (Mesa and Warren 1997), bacterial infections (Huchzermeyer 2003), and fungal infections (Weitkamp 1976; Lutz 1995). Existing infections and multiple exposures may also reduce resistance to GBT, thereby rendering otherwise non-lethal exposures to supersaturated water deadly (Weiland et al. 1999, Cramer 1996)

Juvenile salmon that pass through spillways avoid the physical effects of powerhouse passage, and this may contribute to improved salmon survival, an issue of particular concern for salmon listed as 'Threatened' or 'Endangered' under the U.S.A. Endangered Species Act (Budy et al. 2002, Schaller et al. 2010, USOFR 2012). The states of Oregon and Washington balance the impact of spill against its potential benefits with modified water quality standards that permit elevated TDG levels in dam forebays (115%) and

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tailraces (120%) during smolt outmigration (USEPA 1986, OCR 2003, OSA 2003, ODEQ EQC 2009). These regulatory measures are intended to prevent juvenile salmon from experiencing TDG levels above 120%, with exceptions for high flow events when powerhouse capacities are exceeded and spill is involuntary. TDG levels often exceed regulatory limits for several days each year and for a variety of reasons, such as flood, flow and temperature control, equipment maintenance or malfunctions, or communication failures. 2011 was unusual for having sustained, systemic exceedances in the Columbia River basin resulting from high flow that triggered exemptions to the TDG limits (USACOE 2011).

Previous research into the effects of TDG exposure has focused on symptoms and effects of GBT induced by exposure to gas supersaturated water in laboratory and cage studies, or field surveys of GBT symptoms. No previous work has measured survival effects in the lower river and plume, in part due to the fact that the technology for conducting such studies, e.g., acoustic telemetry, was not available at the time that the majority of studies were conducted. However, in 2011, high flows in the Columbia River, USA resulted in TDG reaching 134% below Bonneville Dam, fortuitously coincident with the release of both barge-transported and in-river migrating acoustic tagged juvenile yearling Chinook salmon *Oncorhynchus tshawytscha* (henceforth, 'smolts') during a long-term study (Rechisky et al. 2012, Rechisky et al. 2013, Brosnan et al. 2014, Rechisky et al. 2014). During this period of high TDG, we observed mortality due to GBT in 17 of 59 smolts held for tagging in tanks supplied with water taken from the upper face of Bonneville

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Dam. This was the first time GBT was observed among fish used during the long-term study.

Because the timing of the tagged smolt releases covered the period before and after dissolved gas levels climbed above state TDG limits, we were provided a unique opportunity to compare the potential effect of exposure to gas supersaturation on subsequent survival of free-ranging smolts in the lower river and estuary (Bonneville to Astoria, henceforth 'lower river') and the plume (Astoria to Willapa Bay; Figure 1). Our objective with this retrospective cohort study is to compare survival of transported and in-river smolts released to gas supersaturated waters below the 120% state water quality limits, classified as low exposure, with that of their counterparts, released when levels were above the limits, classified as high exposure (Figure 2). Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT do not appear to play an important role in survival over the study period (see Discussion).

We evaluated the transported and in-river smolts separately because of their handling differences, and pooled smolts released several days apart (Figure 3, Table 1). Low exposure transported smolts were released at average TDG of 116% and high exposure transported smolts at 125% TDG. Because direct mortality effects may be avoided at up to 125% TDG (Weitkamp and Katz 1980), we hypothesized lower survival among the high exposure smolts due to chronic GBT effects, but not acute effects. Low exposure in-river smolts were released at average TDG of 118% and high exposure in-river smolts at

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132% TDG, thus we hypothesized acute, chronic or a combination of acute and chronic survival effects in the high exposure smolts (Cramer et al. 1996).

We developed our hypotheses regarding survival effects on these transported and in-river smolts from existing research. In laboratory settings, chronic effects on fish health, such as increased susceptibility to bacterial infections (Huchzermeyer 2003) and fungal infections (Weitkamp 1976; Lutz 1995), appear in chronic exposures up to 120% TDG, with acute mortality from gas bubble trauma occurring at higher levels (Mesa et al. 2000). However, TDG exposure decreases with depth and distance downstream of the dams and in field settings where smolts are at liberty to migrate mortality effects may be absent below 125% TDG (Weitkamp and Katz 1980). Multiple sub-lethal exposures may also result in chronic effects on salmonids (White 1991), and while horizontal and vertical migrations in field settings may not mimic the continuous exposures studied in the laboratory, multiple exposures are possible and may affect survival. For example, Cramer (1996) concluded that multiple exposures affected survival of smolts exposed to 130% TDG below Ice Harbor Dam when TDG levels at upstream dams exceeded 110-115% TDG.

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<A> Methods

Seven hundred eighty hatchery and wild origin smolts collected at Lower Granite Dam and Bonneville Dam were surgically implanted with Vemco V7-2L acoustic transmitters (7x20mm, 1.6g in air) and PIT tags (tagging methods are described in detail in Rechisky et al. 2014). To analyze the impact of exposure to dissolved gas above 120% TDG (the Oregon and Washington tailrace water quality standard) on transported (T) and in-river (IR) migrating smolts, we assigned each smolt to one of four groups, Transport Low Exposure, Transport High Exposure, In-River Low Exposure, or In-River High Exposure (Table 1). In-river smolts were assigned to the high exposure group if they were released after May 13th, when daily TDG levels exceeded 120% TDG at the Cascade Island TDG monitoring site and to the low exposure group otherwise (Figures 1 and 2). Transported smolts were assigned to the high exposure group if they were released after May 17th, when daily total dissolved gas levels exceeded 120% at the Warrendale TDG monitoring site, and to the low exposure group otherwise (Figures 1 and 2). We compared within, but not across transport and in-river groups because they were not similarly handled (Figure 3). The Transport Low Exposure group serves as a control for the Transport High Exposure group, and the In-River Low Exposure group as the control for the In-River High Exposure group.

In-river migrants (n=580) were collected at Bonneville Dam and held in 1 meter deep, flow-through tanks flushed with river water drawn from the upper dam face. IR smolts were tagged on the day of capture, or the next day, and released on the fourth day at the smolt monitoring facility below the dam (Columbia rkm 234; Figures 2 and 3). Three

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hundred IR smolts were released in late-April/early-May, and 280 in late-May (Table 1). Transport smolts (n=200) were collected at Lower Granite Dam (Snake R.), tagged the day after collection, transported downstream in barges operating gas-stripping equipment 3d after capture, and released 10-13km below Bonneville Dam on day 4 (Columbia rkm 222-225; Figures 2 and 3). Half of the transported smolts were released in early-May, and half in late-May (Table 1). We pooled smolts assigned to the same group but released on different days because TDG levels were similar and we did not expect the small differences in release dates to affect survival (Table 1).

The In-River High Exposure smolts were released at 132% average TDG, and low exposure smolts at 118% average TDG. The river water above Bonneville Dam was also supersaturated: total dissolved gas averaged across the five USGS monitoring sites above Bonneville Dam from April 1st to May 25th (the start of the fish migration season and voluntary spill at the Columbia River dams, through the last capture date) was 113% (Tanner et al. 2011, USGS 2013). Based on laboratory studies (e.g., Mesa et al. 2000) and field studies (Cramer 1996), we hypothesized that potential exposure prior to tagging followed by release at TDG >130% would result in chronic, acute, or a combination of effects that would be evident in reduced survival of the In-River High Exposure group relative to the In-River Low Exposure group.

The Transport High Exposure smolts were released at 125% average TDG, and the low exposure group at 116% average TDG. The river above Lower Granite Dam was also supersaturated: TDG averaged from April 1st through May 25th at the two monitoring

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sites above Lower Granite Dam was 107%. Since the Transport High Exposure group experienced average TDG of 125%, we did not expect that their survival would be reduced relative to the Transport Low Exposure group by acute mortality (Weitkamp and Katz 1980, Cramer 1996), but hypothesized that chronic effects would be evident.

Tagged smolts were tracked downriver and then north in the coastal ocean to Lippy Point, British Columbia, with listening lines ("sub-arrays") of acoustic receivers (Figure 1). We assume that smolts swam north shortly after entering the ocean, and that the cross-shelf extent of the ocean sub-arrays was sufficient to bound the early marine migratory path of similar proportions of the groups that are compared. These assumptions are well-supported by decades of trawl and telemetry observations that have consistently demonstrated shelf-confined, rapid northward migration of juvenile yearling Chinook salmon beyond the near vicinity of the river mouth and its strong tidal currents (Miller et al. 1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010, Rechisky et al. 2014).

Although acoustic tagged smolts have been detected on the southwest and western terminus of receiver arrays placed within approximately 15 km of the Columbia River mouth (McMichael et al. 2013), these detections occurred during outgoing tides and reflect the influence of the tidal plume, whose currents can exceed smolt swimming speeds (Horner-Devine et al. 2009). We do not believe these reflect coastal ocean migration patterns reported in previous trawl and telemetry studies, e.g., Miller et al.

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1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010, and do not suggest a violation of our assumptions.

The median difference in time of detection between sub-arrays at Astoria and Sand Island sub-arrays was only 2.8 hours (SE=0.25); due to the limited information and statistical penalty for estimating four additional parameters for survival of high and low exposure, in-river and transported smolts in this small region, the detections at Sand Island were combined with the Astoria sub-array detections to estimate survival in the lower river and estuary region (Figure 1). Six In-River Low Exposure smolts were detected on a sub-array of receivers at Cascade Head, Oregon (Figure 1), and one of these smolts was subsequently detected migrating north rapidly across the Willapa Bay and Lippy Point (British Columbia) sub-arrays. We only used the detections of the five remaining smolts at Sand Island/Astoria in the survival model, thus apportioning their mortality to the plume region.

Survival estimates in each migration segment for high and low exposure IR and T fish, φ, and the detection probability at each sub-array, p, was estimated using the Cormack-Jolly-Seber (CJS) live-recapture modeling framework, implemented with the RMark package in R (Lebreton et al. 1992; White and Burnham 1999; R Development Core Team 2011; Laake 2012). We used QAICc to select from three hypothesized models of the detection parameter p, including, (1) a model with a single common p at each sub-array, (2) a model with a unique p for each group at each sub-array, and (3) a model with

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a unique p for each group at Astoria (freshwater) and a common p at each ocean array (Rechisky et al. 2014).

We considered a ΔAIC > 2 to be significant for selecting the top-ranked model, model (1), which was used for all subsequent analysis. ΔAIC between model (1) and model (2) was 9.30, and 4.86 between model (1) and model (3). Survival parameters, φ, were estimated for all four groups in the lower river (release to Astoria) and plume (Astoria to Willapa Bay). Lippy Point was the final array along the migratory path, and estimated survival is thus confounded with detection probability on that array.

We used the median *c-hat* method to evaluate the model for overdispersion, a condition where the sampling variance exceeds the expected theoretical variance due to lack of model fit or violations of CJS assumptions, and adjusted the parameter variances of the selected model to avoid overestimating the precision of the parameters (White and Burnham 1999; Burnham and Anderson 2002). We used data from an ancillary tag life study in 2011 (details in online supplement) and program ATLAS methods to correct φ estimates for possible tag failure during migration to Lippy Point (Lady et al. 2012); tag life corrected survival estimates are denoted S.

High river flows that elevate TDG also shorten the time interval (or residence time) over which survival is observed and it is important to scale the measured survival values by the observational period as $S^{\frac{1}{T}}$, where S are corrected φ estimates and T are travel times. Calculating daily survival rates (henceforth, survival rates) in the lower river (S'_{DR}) and

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plume (S'_{DP}) required the group travel times in the lower river (T_R) and plume (T_P). We define T_R as the median of individual lower river travel times, in days, which were calculated by subtracting the release date from the time of entry into the plume, where entry time is taken as the final detection time of an individual at Astoria or Sand Island. T_P is the median of individual plume travel times, which were calculated by subtracting the time of plume entry from the time of plume departure (the final detection of an individual on the Willapa Bay).

In making this calculation, we assume that survival rates per unit time are constant and that any effect on the measured travel times from differential survival of slower- or faster-moving smolts is sufficiently small and affects the groups that are compared similarly so that the results are not affected. An alternative measure, survival per kilometer travelled, $S^{\frac{1}{km}}$, could also be used if individual travel distances between detection sites were known. However, the average distances between sub-arrays, particularly between Astoria and Willapa Bay, are likely not representative of distances traveled because the smolts' migration path between receivers is unknown.

We examined the effect of exposure within groups using the log odds ratio, $ln\left(\frac{\frac{S_{LE}}{1-S_{LE}}}{\frac{S_{HE}}{1-S_{HE}}}\right)$, and z-scores for estimated survival and daily survival. S_{LE} and S_{HE} denote survival or daily survival estimates for the low exposure and high exposure groups, respectively. Standard error of the log odds was estimated using the Delta Method, and z-scores were evaluated at the 0.05 level. A log odds ratio >0 indicates that odds of survival are greater

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for the low exposure group. Travel times were not normally distributed, so the variability of each group's travel time was evaluated using median absolute deviation (MAD). The variances of the estimated survival rates were determined by bootstrap resampling each groups' capture histories and travel times, estimating survival (φ), tag-life corrected survival (S), and daily survival rates (S'_D) for the resampled groups, and then calculating the variance of the results. The incorporation of bootstrap resampling of travel times captures the variability in $S^{\frac{1}{T}}$ resulting from variability in travel times.

In estimating survival, we made the standard CJS assumptions that (1) every tagged individual has equal probability of survival and detection following release, (2) sampling periods are instantaneous, (3) emigration is permanent, (4) that tags are not lost, and (5) that the fish that are detected have the same probability of future detection as tagged fish that are alive but undetected. Results from tag effects and tag retention studies supporting these assumptions are reported in the online supplement.

At high levels of gas supersaturation (TDG > 130%), acute mortality due to GBT may occur within hours (Mesa et al. 2000). We cannot determine whether acute mortality occurred in the In-River High Exposure group because we cannot count the surviving smolts until they reach Astoria several days after exposure. If acute mortality occurs quickly and close to the point of release, and the subsequent mortality rate is constant, then the following formula can be used to estimate the acute mortality at release that would result in the estimated survival to Astoria of the high exposure group, assuming

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that the estimated daily survival rate of the low exposure group in the lower river represents a base rate that is common to both high and low exposure groups:

$$M_a = 1 - \left[\frac{S_{R(e)}}{{S'_{d(u)}}^{T_{R(e)}}}\right]$$

Here M_a is acute mortality, $S_{R(e)}$ is the estimated net lower river survival of the high exposure group, $S'_{d(u)}$ is the estimated daily survival rate (denoted by a prime) of the low exposure group, and $T_{R(e)}$ is the lower river residence time of the high exposure group. LT_{20}, or time to 20% mortality, is 3-6 hours at 130% TDG in the laboratory (Mesa et al. 2000). Standard error of M_a was obtained using the bootstrap routine described above. If these smolts experienced acute mortality due to GBT within a few hours of exposure to supersaturated water, we would expect a comparable acute mortality estimate, with differences potentially attributable to chronic mortality. This estimate should be received with care, however. Exposure in field and laboratory may be very different, and mortality in groups of smolts exposed in the laboratory to 130% TDG and greater is variable; mortality at 3 hours ranges from approximately 0% to 20%, and approximately 20% to 65% at 6 hours (Mesa et al. 2000).

Hourly total dissolved gas levels recorded by automated water quality monitoring stations at (1) Cascade Island, located immediately below Bonneville dam and 1 km from the IR release site, (2) Warrendale, OR, located 9 km downstream of the dam at rkm 225 and 0-3 km from the T release sites, and (3) Camas/Washougal, located 40 km downstream (Figure 1), as well as at five upriver sites were provided by the U.S. Geological Survey

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(USGS 2013). Monitoring site locations and quality-assurance measures for these data are described in Tanner et al. (2011). TDG at the Lower Granite Dam forebay and Dworshak Dam tailrace were obtained from the U.S. Army Corp of Engineers via the Columbia Basin Research portal (CBR 2013). Total dissolved gas levels declined, on average, 0.5% per km between Cascade Island and Warrendale, so TDG recorded at these monitoring sites are expected to be comparable to TDG at the release sites.

High discharge through the Bonneville Dam spillway destroyed the Cascade Island monitoring site on May 18, 2011, just prior to the release of 280 acoustic tagged fish at the Bonneville Dam smolt monitoring facility (Table 1; Tanner et al. 2011). In lieu of field observations, we obtained estimated hourly TDG at Cascade Island from SYSTDG, a sophisticated model used by the U.S. Army Corp of Engineers to predict TDG levels and support spill management decisions in the Columbia River basin (Schneider et al. 1999; L. Hamilton, U.S. Army Corp of Engineers, personal communication). SYSTDG output compared well with observed TDG at Cascade Island when the monitoring station was intact (Figure 1), which indicates that the use of mixed source TDG data is unlikely to affect our grouping and analysis of survival of in-river smolts.

<A> Results

Five hundred and twenty-three smolts were detected on the Astoria sub-array, 480 on the Sand Island sub-array, 105 on the Willapa sub-array, 31 on the Lippy Point sub-array, and 6 on the Cascade Head sub-array. A total of 608 smolts were detected on the

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combined Sand Island and Astoria sub-array, with an estimated detection efficiency of 0.96 (SE=0.02). One hundred and ten smolts were detected on the Willapa Bay sub-array, with an estimated detection efficiency of 0.71 (SE=0.10; Table 2).

Seventy-two IR fish assigned to the low exposure group and detected at the river mouth remained somewhere upriver of the Astoria and Sand Island sub-arrays after May 14, when TDG reached 120% in the Bonneville Dam tailrace. Sixty-eight of these 72 subsequently crossed the river mouth by May 23, three crossed by May 28, and the single remaining fish crossed on June 13. The final two Transport Low Exposure fish to be detected at the river mouth crossed on May 15. Applying a back-calculation of their individual average travel speeds and the rate of decline in TDG from Bonneville Dam to the Camas/Washougal TDG monitoring station (Figure 2), we estimate that only the single in-river fish that crossed on June 13 was potentially exposed to TDG above 120% and we made no adjustments to the group assignments. We believe the use of average travel speeds, and therefore constant rates of travel, is reasonable; Carter et al. (2010) found that acoustic tagged smolts were detected on their acoustic arrays in the lower Columbia River nearly equally during all hours of the day, which suggests constant travel.

The median *c-hat* of the survival model was 1.45 (SE=0.32). Lebreton et al. (1992) and Burnham and Anderson (2002) suggest that values of *c-hat* should not exceed 3 or 4. A value of 1.45 is thus very weak evidence for overdispersion and indicates limited violations of our assumptions and good structural fit of the model. Estimated survival,

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tag-life adjusted survival, travel times, survival rates, and log odds ratios are shown in Table 2, along with the probability of detection on each array.

In the lower river, tag life corrected estimated survival of In-River High Exposure group was 0.82 (SE=0.03) and estimated survival of In-River Low Exposure group was 0.84 (SE=0.03). The log odds ratio was 0.14 (SE=0.25), which means the odds of surviving to the plume were 1.15 times greater for the low exposure group, calculated as $e^{0.14}$ and provided only for significant results henceforth. The log odds ratio was not significant at the 0.05 level (z=0.57, p=0.57). Median travel times were 2.7d (MAD=0.05) and 15.4d (MAD=1.23), respectively. Estimated daily lower river survival of the In-River High exposure group was 0.93 (SE=0.01) and 0.99 (SE=0.002) for the Low Exposure Group. The log odds ratio of daily survival estimates was 1.90 (SE=0.27) and was significant at the 0.05 level (z=7.12, p=1.06×10^{-12}). This means the odds of surviving to the plume were 6.69 times greater for the low exposure group.

Tag life corrected estimated survival of Transport High Exposure smolts in the lower river was 0.88 (SE=0.04) and estimated survival of Transport Low Exposure group was 0.80 (SE=0.05). The log odds ratio was -0.63 (SE=0.45) and was not significant at the 0.05 level (z=-1.39, p=0.16). Median travel times were 3.3d (MAD=0.11) and 4.6d (MAD=0.04), respectively. Estimated daily lower river survival of the Transport High Exposure smolts was 0.96 (SE=0.01) and 0.95 (SE=0.01) for Transport Low Exposure group. The log odds ratio of estimated daily survival was -0.25 (SE=0.47), and was not significant at the 0.05 level (z=-0.54, p=0.59).

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In the plume, tag life corrected estimated survival of the In-River High Exposure group was 0.28 (SE=0.05) and estimated survival of the Low Exposure Group was 0.26 (SE=0.04). The log odds ratio was -0.10 (SE=0.25) and not significant at the 0.05 level (z=-0.04, p=0.69). Median travel times were 4.2d (MAD=0.94) and 9.4d (MAD=1.26), respectively. Daily rates of plume survival of the In-River High Exposure group were 0.74 (SE=0.05) and 0.87 (SE=0.02) for the In-River Low Exposure group. The log odds ratio of estimated daily survival was 0.85 (SE=0.26) and was significant at the 0.05 level (z=3.26, p=0.001). This means the odds of surviving through the plume were 2.34 times greater for the low exposure group.

Tag life corrected estimated survival of Transport High Exposure group in the plume was 0.19 (SE=0.06) and estimated survival of Transport Low Exposure was 0.07 (SE=0.04). The log odds ratio was -1.08 (SE=0.60) and was not significant at the 0.05 level (z=-1.8, p=0.07). Median travel times were 4.0d (MAD=3.25) and 14.9d (MAD=0.14), respectively. Estimated daily plume survival of the Transport High Exposure groups was 0.66 (SE=0.20) and 0.84 (SE=0.13) for the Transport Low Exposure group. The log odds ratio of estimated daily survival was 0.98 (SE=1.04) and was not significant at the 0.05 level (z=0.95, p=0.34).

Acute mortality, M_a, was 0.16 (SE=0.03), meaning that 0.16 of the IR high exposure group would have to succumb shortly after release to realize the observed $S_{R(e)}$ of 82% (SE = 0.03). This compares reasonably well with an LT_{20} (time to 20% mortality) of 3-6

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hours for fish held at 130% TDG (Mesa et al. 2000). M_a of 20% would require $S_{R(e)}$ = 79%, which is within one standard error of the observed $S_{R(e)}$. The acute mortality estimate suggests that direct mortality effects of high TDG are possible in this group, but does not eliminate the possibility of chronic effects.

<A> Discussion

There is substantial prior evidence that exposure to elevated TDG levels can be harmful to aquatic organisms. Similar to divers suffering decompression sickness (Todnem 1991), smolt mortality following TDG exposure may occur in: (1) an acute phase of gas bubble trauma that can produce blockages of the vascular system (emboli) and internal and external soft tissue damage, where mortality is relatively quick and is directly caused by embolism or emphysema blocking blood flow to critical organs, or (2) a chronic phase where mortality may occur later and over much longer time periods and may indirectly result from predators targeting smolts with reduced fitness, e.g., reduced resistance to bacterial and fungal infections or impaired motor skills, brain function, or lateral line function that may increase susceptibility to predation (Bouck et al. 1976; Schiewe and Weber 1976; Bouck et al. 1980; Mesa and Warren 1997; Weiland et al. 1999; Mesa et al. 2000; Huchzermeyer 2003). By definition, chronic effects on survival are much more difficult to quantify in laboratory settings. Our results are consistent with the known effects of TDG exposure, but they rest on assumptions, discussed in detail below, that are uncertain.

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It is clear that elevated dissolved gas levels affected the In-River High Exposure group held at the Bonneville Dam smolt monitoring facility. Daily maximum TDG levels in the Bonneville Dam forebay reached 123% on May 27th and 122% on May 28th (USGS 2013). Exposure to the forebay-sourced water in the 1-m deep tanks resulted in gas bubble trauma in 17 smolts found dead in a holding tank on May 28 and examined by the Lower Columbia River Fish Health Center (the 59 remaining smolts did not appear to be affected). This was the only large mortality event that occurred during the tagging at Bonneville Dam and occurred as TDG levels peaked (Figure 2), demonstrating lethality.

Three smolts, of 75 held pre-release, also perished on May 27, presumably due to GBT, but they were not examined. No additional mortalities attributable to elevated TDG were observed during tagging at Bonneville Dam, or at Lower Granite Dam where TDG levels in the forebay peaked at 107% (CBR 2013). There were no reported incidences of gas bubble trauma in transported smolts and the barges used for transporting smolts from Lower Granite Dam for release below Bonneville operate gas-stripping equipment to prevent GBT during transit. Thus, there is compelling evidence for the lethality of river water reaching the upstream face of Bonneville Dam despite some opportunity for off-gassing as it flowed downstream from John Day Dam, i.e., just prior to spill further increasing TDG levels below Bonneville Dam.

Although we cannot demonstrate causality, the differences in estimated survival rates between high and low exposure groups are consistent with the effects of GBT. The In-River High Exposure group experienced multiple exposures to elevated TDG, potentially in the river upstream of the dam, and certainly in the holding tank, and then again when they were released into the river below Bonneville Dam when TDG levels were further elevated (130-134% TDG; Table 1). Their estimated lower river and plume survival was reduced relative to the In-River Low Exposure group, but not significantly. However, when the residence time between successive acoustic sub-arrays is considered, they experienced significantly reduced odds of survival in the lower river and the plume that are potentially explained by direct and indirect survival effects of GBT. Unfortunately, we cannot distinguish whether acute, chronic, or both survival effects are at play and we present both for completeness. Although our acute mortality estimate is strikingly consistent with expectation, this laboratory-to-field comparison should be interpreted with care because laboratory LT_{20} times are variable at high levels of TDG and exposures in a field setting will be more variable than in the laboratory, and may include additional factors.

The Transport High Exposure group did not experience the same repeated exposure to supersaturated water. Although they were potentially exposed while migrating to Little Granite Dam, they subsequently travelled in barges with gas-stripping equipment and were released at a location with lower levels of gas supersaturation (maximum TDG = 126%). Their limited exposure and rapid movement downstream (median 3.3 days) may explain the insignificant effect on estimated survival rates in the lower river – there was too little dissolved gas, or insufficient observation time, to detect any effect. However, the point estimate of the effect on plume survival for transported smolts is similar to that of the IR smolts, and could indicate chronic impacts on fitness from otherwise non-lethal

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exposure. Unfortunately, with fewer than 100 smolts reaching the Willapa Bay sub-array, it is not possible to draw any statistically robust inference. Any GBT effect manifest in the plume is probably not caused by stress related to salt water acclimation (Nebeker et al. 1979).

Although the differences are not statistically significant, it is interesting that the high exposure transported smolts had higher estimated survival in the lower river and plume, and a higher estimated daily survival rate in the lower river than the low exposure transported smolts. Scaling by time nearly removes the effect in the lower river, but these results are contrary to the commonly held belief that smolt mortality increases through the migratory season; we have no clear explanation for this finding.

Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT may also affect smolt survival in the Columbia River and plume and cannot be separated from potential TDG effects in this study. However, it is unclear whether these factors would have affected survival during the study period. Water temperature, measured at the Warrendale monitoring station (Figure 1), was between 8° and 13°C when IR and T smolts were released, well below both lethal levels, 22°-25°C, and levels affecting growth in juvenile Chinook salmon, ca. 15°C (Richter and Kolmes 2005).

Turbidity increased between the release times of the low and high exposure groups, reducing visibility from approximately 3 Secchi-feet to 2 in the Bonneville Dam forebay (CBR 2013), and increasing measured turbidity from approximately 6 NTU to 12 NTU at rkm 85 (CMOP 2016). Increasing turbidity is generally expected to improve, not reduce, smolt survival. For example, Gregory and Levings (1998) found that predation on juvenile salmonids by piscivorous fish was significantly reduced in the turbid Fraser River relative to the clear Harrison River and Nicomen Slough, although they examined a wider range of turbidity (<6 NTU in the Harrison River and Nicomen Slough against 26-106 NTU in the Fraser River).

Other diseases also do not seem likely to have played a role. Differences in the proportion of smolts exhibiting signs of disease other than GBT on dates when high and low exposure IR smolts were collected for tagging were not significant at the .05 level (z-tests; Fish Passage Center 2013b). The proportion of diseased smolts recorded at Bonneville Dam when Low Exposure IR smolts were collected was 0.011 ($n=145$ fish examined on April 20, and 100 each day on April 21, 30, and May 2) and .015 ($n=100$ examined each day on May 16 and 24) when IR High Exposure smolts were collected ($z=-0.39$, $p=0.69$). No disease data were recorded on May 19 and 25. The proportion of diseased smolts recorded at Lower Granite Dam when T Low Exposure smolts were collected was 0.02 ($n=100$ smolts examined each day on April 30 and May 2) and 0.00 ($n=84$ smolts examined on May 18, and $n=80$ on May 19) when T High Exposure smolts were collected ($z=1.82$, $p=0.069$).

The effect of emigration timing on plume survival is unclear. The timing of ocean entry has been linked to smolt-to-adult survival rates; Scheuerell et al. (2009) found that smolt-to-adult (SAR) return rates improved among fish entering the ocean in early- to mid-May

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relative to mid-June, but not the April to May period used here. However, their approach measured the effect of the entire marine life cycle on SARs, including a survival period encompassing the smolts' first winter at sea, not just the brief period of plume occupancy (Beamish and Mahnken 2001). Because survival was measured at adult return, 2-3 years after ocean entry, it is unclear whether the timing of plume entry would result in reduced odds of daily survival. Brosnan et al. (2014) found that daily plume survival rates, measured using acoustic telemetry, varied little from 2008-2011.

The effect of emigration timing on river survival has been better studied, although results differ. In the Columbia River basin, Smith et al. (2002) examined the effect of release date on juvenile Chinook salmon survival in the lower Snake River (280 km upstream of Bonneville Dam) and found no significant correlation with survival. Schreck et al. (2006) found in two of six years that mortality of both the transported and the combined (pooled) transported and in-river smolts increased in the lower Columbia River during the fish migration season. In contrast, however, McMichael et al. (2011) found that lower river survival of yearling Chinook smolts increased significantly from early-May to late-May, similar to our finding of improved (although non-significant) lower river survival in the later-arriving, Transport High Exposure group.

Columbia River basin smolts are observed to have symptoms of GBT when in-river TDG levels are elevated (Fish Passage Center 2013a), and exposure to supersaturated water leading to sub-lethal GBT experiences may have secondary effects that impact survival rates (Weitkamp 1976; Lutz 1995; Cramer 1996, Mesa and Warren 1997; Huchzermeyer

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2003). Although horizontal and vertical avoidance of supersaturated waters is potentially possible, this is clearly insufficient to completely protect smolts from the effects of GBT because they are routinely found with evidence of GBT when TDG levels reach 125%. The question of whether TDG limits can be raised above their current limits to 125% to allow increased spill in the FCRPS without affecting smolt survival (e.g., ISAB 2014) is challenging to answer due to the complexity of exposure histories that are not easily replicated in the laboratory and, consequently, the poor characterization of the effect of such exposures in the field. Results from the transported smolts examined here can be interpreted as indicating that exposure at approximately 125% TDG, when previous exposure is limited, has little direct impact on smolt survival, but may possibly lead to chronic effects expressed later in the life history. However, with the in-river smolts studied here, and similar to Cramer (1996), we find that exposure to approximately 130% TDG that is accompanied by previous, sub-lethal exposures to gas-supersaturated water may have acute, chronic, or a combination of effects that reduce survival.

Retrospective cohort studies are useful in evaluating survival effects when exposure to the causative agent is rare and difficult to replicate, as is the case here. However, it is the nature of such studies that the results are potentially confounded with other unidentified differences, which in our study would involve other uncontrolled mortality factors (such as predator abundance in the plume) that may co-vary with the differing arrival times of the high and low exposure groups. Although mortality due to GBT is a parsimonious explanation for the observed differences in survival estimates, it is not possible to exclude other potential causes for the differences in survival rates we measured.

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Our conclusions also rest on several assumptions, including (i) that survival is a time-based process (and not strictly distance-based), (ii) that the survival rate is constant, and (iii) that any effect on the measured travel times from differential survival of slower- or faster-moving smolts in the measured travel times affects the different groups under comparison similarly so that the results are not affected.

We have measured statistically significant differences in daily survival rates, and in our view, the drivers of smolt mortality in this region are predominantly time-based; if smolts did not migrate, they would still be subject to predation and disease over time while physically remaining in a particular location and (likely) at a consistent rate. In this time-based case, the insignificant differences in estimated aggregate plume survival measured between the Astoria and Willapa Bay arrays might be a result of an insufficient duration of the observation period (approximately one week).

The question of whether survival estimates measured between different geographic sub-arrays should be normalized by the time required for the different groups of smolts to reach the sub-arrays may be contentious. Because smolts exposed to high TDG levels also migrated between sub-arrays more quickly, likely due to the higher flow rates that occurred under high-flow conditions, their survival is measured over a shorter time period than for smolts exposed to lower TDG levels. It can be argued that measured survival may simply be related to the distance travelled rather than the time, so scaling for observation time may be inappropriate. We do not have sufficient information to rule

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out purely distance-based mortality processes operating in the lower river, estuary, and coastal plume, such as strong spatial variability in predation pressure.

Although our results are consistent with the known effects of TDG, the uncertainty in the underlying assumptions call for a controlled experiment to clarify how survival in the lower freshwater reaches of the Columbia River and the coastal ocean are affected by TDG exposure. A formal experiment using simultaneous paired releases of smolts exposed to different levels of TDG along with control groups of unexposed smolts could easily be performed using the same techniques described here and in Rechisky et al. (2012, 2013). Fixed-time sampling would address assumptions about survival rates and the difficulty presented by different observation periods. In the absence of fixed-time sampling, which presents a significant technical challenge, greater spatial sampling (i.e., more densely spaced arrays over a larger area) would improve inference about survival rates. Extending the period of observation beyond one month would also help elucidate survival differences that are not clearly distinguishable by the time smolts reach Willapa Bay. Such an experiment seems especially warranted within the Columbia River basin given the potentially significant conservation and economic costs of moving to higher spill levels (National Marine Fisheries Service 2013), and could inform new lines of inquiry globally where increasing numbers of hydropower projects are raising concerns about fish health (Huang and Yan 2009; Finer and Jenkins 2012; Wang et al. 2015).

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Tagging Site (Release Site)	Group	Treatment	Release Dates	Number Released	TDG (%) at Release (TDG Monitoring Site)
Lower Granite Dam (Columbia River Rkm 111-115)	Transport	Low Exposure	May 3	47	115.1 (WRNO)
			May 5	53	116.1 (WRNO)
		High Exposure	May 21	50	125.8 (WRNO)
			May 22	50	124.8 (WRNO)
Bonneville Dam (Bonneville Dam)	In-river	Low Exposure	April 23	100	118.8 (CCIW)
			April 24	100	118.5 (CCIW)
			May 3	50	118.0 (CCIW)
			May 5	50	118.5 (CCIW)
		High Exposure	May 19	48	131.0 (SYSTDG)
			May 22	101	131.3 (SYSTDG)
			May 27	72	133.8 (SYSTDG)
			May 28	59	133.3 (SYSTDG)

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Lower River	***p***	**φ (SE)**	**S (SE)**	**log odds (SE)**	**T (MAD)**	**S'$_D$ (SE)**	**log Odds (SE)**
IR,HE	0.96(.02)	0.80(.03)	0.82(.03)	0.14(.25)	2.7(0.05)	0.93(.01)	**1.90(.27)**
IR, LE		0.82(.03)	0.84(.03)		15.4(1.23)	0.99(.002)	
T, HE		0.86(.04)	0.88(.04)	-0.63(.45)	3.3(0.11)	0.96(.01)	-0.25(.0.47)
T, LE		0.78(.05)	0.80(.05)		4.6(0.04)	0.95(.01)	
Plume							
IR, HE	0.71(.10)	0.28(.05)	0.28(.05)	-0.10(.25)	4.2(0.94)	0.74(.05)	**0.85(.26)**
IR, LE		0.26(.04)	0.26(.04)		9.4(1.26)	0.87(.02)	
T, HE		0.19(.05)	0.19(.06)	-1.08(.60)	4.0(3.25)	0.66(.20)	0.98(1.04)
T, LE		0.07(.04)	0.07(.04)		14.9(0.14)	0.84(.13)	

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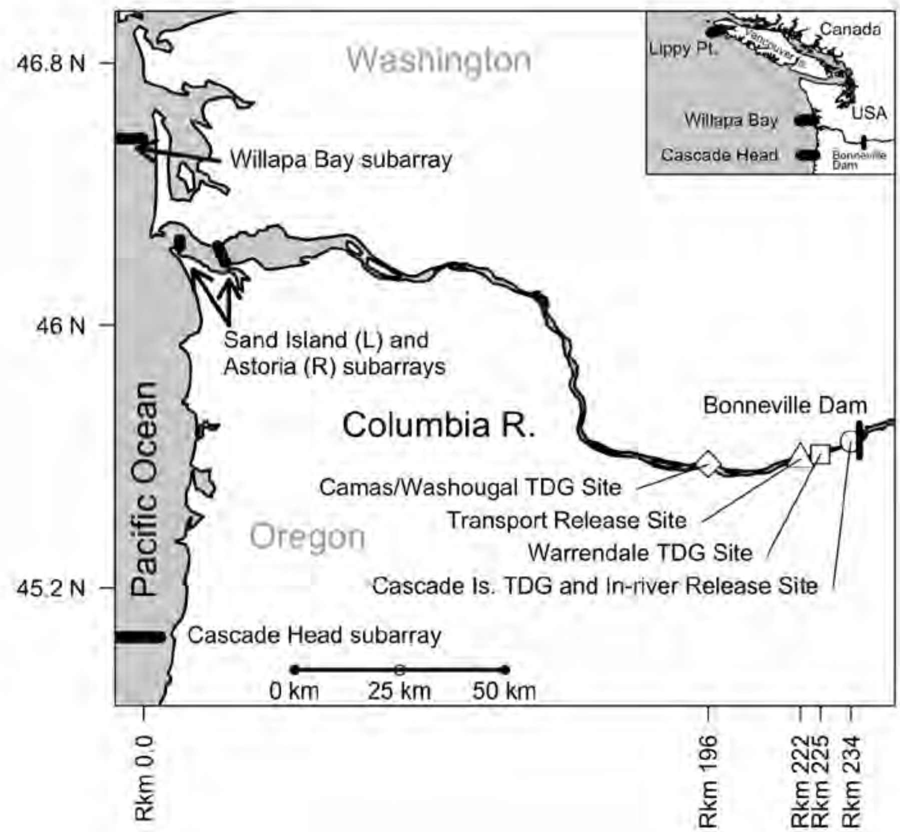

Figure 1. The Columbia River total dissolved gas monitoring sites below Bonneville Dam, tagged fish release sites, and the sub-arrays of acoustic receivers. In-river smolts were released at the Bonneville Dam smolt monitoring facility located approximately 1km downstream of the TDG monitoring site at Cascade Island. Transported smolts were released between Columbia rkm 222 and 225; the Warrendale TDG monitoring site is located at Columbia rkm 225. The plume region encompasses the region between the Astoria and Willapa Bay sub-arrays.
722x722mm (72 x 72 DPI)

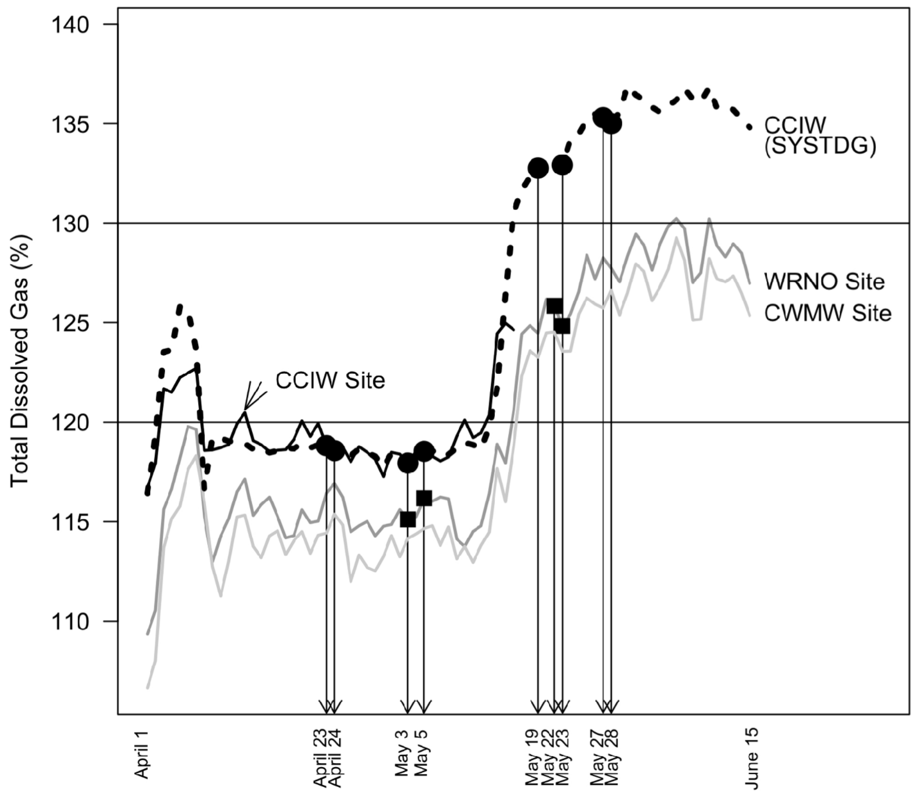

Figure 2. Average daily total dissolved gas (%) below Bonneville Dam, calculated using the Oregon methodology from data recorded at three downstream monitoring stations from April 1 through June 15, 2011. CCIW = Cascade Island site, WRNO = Warrendale site, and CWMW = Camas/Washougal site. Solid lines denote measured values at each station. The dotted line is the prediction for Cascade Island from the U.S. Army Corp of Engineers' SYSTDG model. Horizontal lines mark the Oregon and Washington 120% TDG limit for dam tailraces and the 130% TDG level referenced in the discussion; arrows mark the release dates for in-river and transport groups, denoted by circles overlaid on the CCIW data and squares overlaid on the WRNO data, respectively.
722x722mm (72 x 72 DPI)

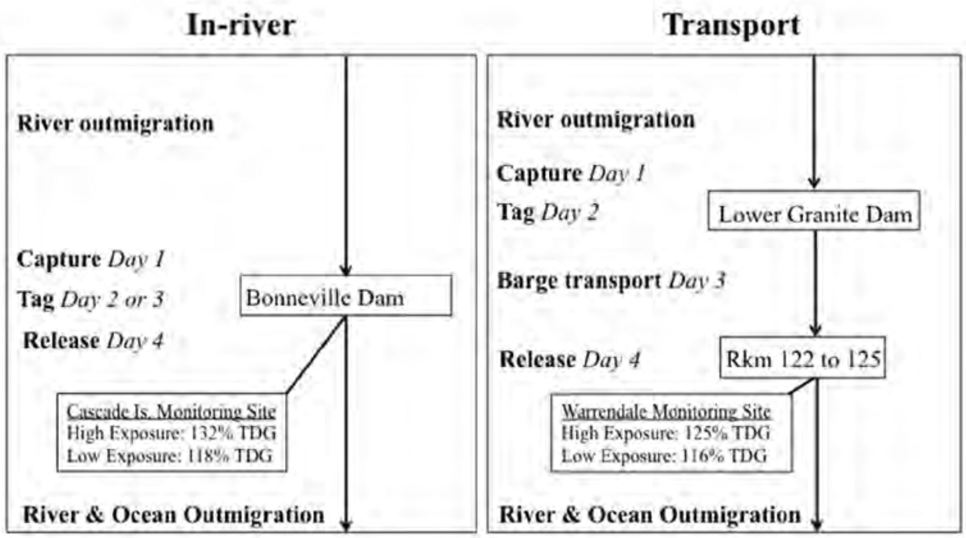

Figure 3. Treatment of the In-river and Transport groups (not to scale) showing location and timing of tagging events. Total dissolved gas (TDG) levels for the high and low exposure groups are average TDG over the release dates shown in Table 1.
254x190mm (72 x 72 DPI)

Supplement

Tag effects, tag retention, and tag life studies are fully described in Porter et al. (2012) and briefly reviewed here.

Tag effects and retention study. In 2011, the ancillary captive tagging study was concluded after 35 days. At that time, survival, mean fork length, and mean weights of smolts implanted with V7-2L dummy acoustic tags (n=101) and pit-tagged controls (n=99) were not significantly different. Only one dummy acoustic tag was shed. Growth rates of the DAT-tagged smolts in 2011 were slower than pit-tagged controls, but previous, long-term captive studies conducted under the same research program suggest this effect is short-term (Rechisky et al. 2010). Survival, tag retention, and growth effects evaluated in 2008, 2009, and 2010 studies yielded similar results.

Tag Lifespan Study. Forty-four V7-2L tags were randomly drawn for the tag life study from the tags available for the 2011 field study. They were exposed to the same handling conditions during the tagging period and subsequently stored and monitored in water between 18 and 22° C. The manufacturer's estimated tag lifespan was 51 days. Two tags failed prior to the rated lifespan, one on day 1, and a second on day 28. All tags expired by day 182. We used the program ATLAS methods to correct our survival estimates (Lady et al. 2012). ATLAS can apply corrections directly to CJS survival models, but not to the modified CJS survival model used in this analysis (note also that the model used in this analysis differs from the model in Porter et al. (2012)). We used Equations B.14,

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B.15, and B.16 from Lady et al. (2012) to implement the Kaplan-Meier method of estimating a tag survivorship curve and we used Equations B.23 through B.27 to correct each survival estimate

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Editor's Comments to Author:

Associate Editor
Comments to the Author:

We appreciate the Associate Editors' consideration of the value of the manuscript. At the request of the reviewers and Associate Editor, we have added several paragraphs in the Discussion (beginning line 545) to better describe the assumptions and limitations of our analysis, as well as improvements to future studies to address these issues.

The authors are commended for incorporating the critiques and suggestions of the reviewers into the manuscript. The revised manuscript satisfactorily addressed the concerns of one reviewer, had no effect on the second reviewer, and seemed to raise additional concerns for the third reviewer. The last 2 reviewers are most disturbed about the assumptions and application of the daily survival rate, a fundamental metric for the paper. There are certainly many assumptions required to calculate the daily survival rate, and as one reviewer pointed out, the overall survival did not differ among the groups. These divergent opinions by experts indicates there is value in getting the manuscript before a fish health audience, but there are big caveats that should accompany it.

Given the misgivings about underlying assumptions and survival calculations, the authors would need to re-frame the manuscript to explicitly reveal the vulnerabilities of conclusions derived from analyzing this type of data.

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Reviewer: 3
Comments to the Author

Lines 92-93: "we hypothesized both acute and chronic survival effects" for which of the treatment groups do you hypothesize these effects?
High exposure; this has been added to line 95.

Line 101: "river" should be capitalized.
This has been corrected here, and where it appeared elsewhere in the manuscript.

Lines 126-149: The third paragraph in the methods (lines 126-149) describes the hypotheses and the relevant background for the hypotheses. I would suggest that this information belongs in the introduction, not the methods.
We have made the change.

Lines 318-321: I understand why you use telemetry data to support your use of constant rates of travel in your calculations, but it is unclear to me why you mention seine net sampling. Is the comparison between acoustic tracking and seine net sampling necessary here?
Probably not; we have removed this sentence.

Lines 389-391: In the introduction (lines 70-72) you state that 17 out of 300 smolts were affected by GBT in the holding tanks but in lines 389-391 it reads as though 17 out of 59 smolts died in the holding tanks. Which is correct? If only 17 out of 300 smolts died I would not call this a "large" mortality event, as you do on line 391.
17 out of 59 is the most appropriate ratio and we have made this correction.

Lines 467-468: "The timing of ocean entry has been linked to smolt-to-adult survival rates." This statement should be supported by a citation before the authors use the data from Brosnan et al. (2014) to challenge it, or the order of the sentences should be changed.
We have moved the challenging sentence to the end of the paragraph.

Line 494-495: the word "potentially" is redundant in this sentence when it is used before the word "possible".
We have deleted 'potentially.'

Reviewer: 2
Comments to the Author

After careful consideration my initial review stands. Thank you for the opportunity. We have nothing to add.

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Reviewer: 1
Comments to the Author

We appreciate the reviewer's request in the following 'Comments to the Author' for greater discussion of the assumptions and drawbacks of using S^1/T prior to publication. We are very happy to provide it. It has been our stated position from the initial draft that our results are drawn from an opportunistic, observational study, and should be interpreted as such. However, we also believe the results are worth disseminating. The topic is timely and important, and we believe the consistency between previous laboratory studies and our observational results from the field makes a compelling case for an explicit experimental test in the field using matched treatment and control groups. Indeed, an explicit experimental test under field conditions is the best way to address comments from all the reviewers, and we believe that the substantial cost of such a test will be more easily justified if the observational results are published first.

To address the reviewer's request we have added several paragraphs at the end of the discussion (beginning line 545) to specifically highlight our assumptions and study limitations, including assumptions that (i) survival is a time-based process (and not strictly distance-based), (ii) that the survival rate is constant, and (iii) that any effect on the measured travel times from differential survival of slower-moving smolts in the measured travel times affects the different groups under comparison similarly so that the results are not affected. We also address the need for fixed temporal sampling, or at least a much greater density of spatial arrays, in any future experiment.

Responses to specific comments are detailed below.

The revised manuscript is much improved, and I appreciate the care that the authors gave to the revisions and responses to reviewer comments. The methods description, discussion, figures, and tables are all improved. However, I remain concerned that the authors base their conclusions on differences in estimates of daily survival rate. I believe it may be the wrong scale to look for differences – differences may be in travel time rather than the mortality process, and travel time differences are likely to come from high water velocity that accompanies high spill and high TDG. At any rate, the authors have not convinced me that their inferences are valid. It is particularly concerning because their only significant results are on the daily survival scale; results on the total survival scale are not significant. If we could be confident that there was a difference in the mortality process caused by high TDG, this would be important, even if those differences do not appear in total survival through the somewhat limited study area; instead, there is a distinct possibility that increased travel rate accounts for all the differences observed. Had this been a carefully controlled study designed to test for chronic effects of high TDG, then a lack of significant results (on the total survival scale) would mean something and would be worthy of publication. But as an opportunistic, observational study, non-significant results are less compelling, and instead of spurring further research, as the authors promote, may actually convince readers that the question of high TDG is not worth further study.

Although I appreciate the effort that the authors have put into this manuscript, I cannot recommend publication for the manuscript as it is. What might make this paper worthy of publication would be a discussion of the assumptions and drawbacks of measuring effects on the daily survival rate scale: there is no difference on the survival probability scale, there is a difference on the daily survival rate scale, that might reflect an effect on the mortality process that may exhibit actual differences in total survival over a longer time period, or it might instead reflect only differences in travel rate if mortality is not a time-based process, and here is why we believe survival to be a time-based process (if they do believe it – this point requires careful consideration, because there are non-time based mortality processes to consider).

This type of discussion should lead to much more careful consideration of how a future study could address these questions, and what is really necessary to be able to either convincingly support or convincingly not support the hypothesis that high TDG exposure has chronic effects.

Regarding my concern about basing conclusions on differences in estimates of daily survival rate: Measuring differences on that scale is certainly statistically feasible but **to** conclude that such differences represent differences in the actual mortality process is not possible here, because survival is measured only at fixed distances, not over fixed time periods. Making inferences to the daily survival rate requires measuring survival at fixed time periods, not fixed distances. Differences in S^(1/T) between groups may be due to an acute mortality effect in one group with no subsequent delayed effect in either survival or travel rate (different total survival, common travel times) (as the authors demonstrate in their estimation of acute mortality), or to common survival among the two groups but different travel times. In the latter case, the treatment may have affected a temporal mortality process, but it is also possible that the mortality process is not a temporal process, but rather a distance process. If mortality is actually a distance process, then the treatment had no effect at all on survival because all fish had to travel the same distance (ignoring routing differences), but treatment did affect travel time (ignoring other confounding); the slower group will have a higher "daily survival rate" (although that measure is meaningless in this case) simply because it was moving more slowly, and even though actual survival and the mortality process were the same between the two groups. If the probability of surviving to a destination is the same between the groups, then it is not possible to conclude that the treatment had a survival effect. It may have had a travel time effect (which seems likely in this setting, since high TDG comes with high flow), or it may have had a survival effect – or perhaps a combination of the two. The level of information available on these fish is not enough to allow you to distinguish between these two possibilities. The findings for the IR group are approximately consistent with this scenario: common survival probability through both the lower river and the plume, but the HE group moved considerably faster than the LE group, so that on the daily scale, the HE group had a lower perceived survival rate than the LE group. But the authors have not convinced me that the treatment had any effect on survival rate per day, rather than on travel time. In particular, in order to make inference to daily survival rate, it is necessary to measure survival over fixed periods of time, rather than fixed distances (or fixed site receivers).

Furthermore, the concept of a daily survival rate implies that that daily survival rate is constant over time (i.e., not increasing as fish recover from high TDG exposure, or possibly decreasing as delayed effects set in), and that all fish in each group have not only the same survival (either on the daily scale or on the reach scale) but also the same rate of travel. Indeed, a mix of travel rates among a group that has a common survival rate will result in a negatively biased estimate of daily survival rate. The author's assumption that the daily survival rate does not vary among individuals takes care of part of the problem (if reasonable), but it is also necessary to assume that all individuals in a group have the same rate of travel.

I find it disingenuous to first assume that survival is a temporal process and attribute differences in estimated "daily survival rate" to chronic or delayed effects of treatment, and then to assume that there is in fact no difference in daily survival rate in order to estimate an acute mortality effect. You can't have it both ways. The estimation of acute mortality depends on there being no difference in daily survival rate. Perhaps the authors meant to offer an acute mortality effect as an alternative to a chronic effect, so that any excess mortality not accounted for by the expected acute mortality effect (20%) must be evidence of a chronic effect? That was not made clear, either in the methods or in the results, and in fact the uncertainty on the 20% prediction would need to be quantified in order to perform a hypothesis test. My interpretation of the results, based on the Discussion, was that there was no evidence of a delayed or chronic effect for the IR group in the lower river (only an acute effect), and there may have been evidence of a chronic effect in the plume, if the concept of a daily survival rate were suitable given the level of data available. The fact that there was no difference in absolute survival between the HE and LE groups in either region, however, makes it difficult to conclude that there were delayed effects, based on these data.

These considerations make me hesitate about recommending this paper, despite its timely topic, many improvements, and generally good writing. I appreciate the authors' recommendation for a follow-up study and I hope that it will be conducted. I also recommend a much denser array of receivers to at least approximate data collection on a temporal scale (although it will still be spatial).

Specific Comments

Page 5, Lines 75-83: Not all differences between groups can be attributed to TDG, since there were other differences (or potential differences) in condition: season, temperature, degree of smoltification, possibly in predator densities.
We have added text at the end of the paragraph to briefly highlight this point, and we reference the extended examination in the Discussion (beginning line 545)

Page 9, Line 170: typo
Corrected.

Page 10, Lines 189-191: As I understand it, you had 6 smolts detected south of the CR mouth, only 1 of which was later detected on the array north of the mouth, so you then assumed that the other 5 also both turned around and survived to the array north of the mouth, even though you did not detect them there, and your detection probability at that array was estimated at 0.71 (so you should have detected about 4 of these 6 fish, not 1). However, if these 5 fish were in fact detected at Cascade Head, they were not directed to Lippy Point based on the available evidence, so would not have passed the Willapa Bay array. If they did turn around and head toward Willapa Bay (which may be a reasonable assumption), then what justification do you have for assuming that they all survived to Willapa Bay? Is there no mortality in the plume? I think there is. Your map shows that there is a considerable distance between the Cascade Head and Willapa Bay arrays (> 100 km). It is invalid to assume that these fish passed Willapa Bay. They should be censored at Sand Island. (Why does this matter? Because Willapa Bay is not the final array. Fish that pass Willapa Bay are looked for at Lippy Point, which allows you to estimate the detection probability at Willapa Bay and survival to Willapa Bay. Fish that are at Cascade Head are not directed to Lippy Point, and assuming they are will bias both the detection probability at Willapa Bay [claiming they were detected there when they weren't] and survival estimate to Willapa Bay.)
We have censored these five fish as recommended by the reviewer, and the resulting (very) small changes to survival estimates have been made in the paper and tables.

Page 11: See my above comments on the daily survival rate.
Comments above.

Page 11, Line 226: Tags detected only at Sand Island should be omitted for the travel time calculation.
We appreciate the reviewer's point, but disagree here. These two arrays are so close in space (approx. 10km) and smolt travel time (2.8 hours; reported in the revised manuscript at Line 184) that, in our view, the inclusion of the data provides a more robust estimate.

Page 11, Line 229: How can you attempt to measure plume departure time at Cascade Head if you assume they departed the plume at Willapa Bay? You absolutely cannot use travel time to Cascade Head for these 5 fish to represent travel time to Willapa Bay. Nor do you need to – you are assuming that observed travel time is representative of the release group (but see the next comment), so just use travel time of the fish you see at the array where you are measuring travel time. That is, not Cascade Head.
As noted above, we have censored the five fish and deleted reference to Cascade Head in this line.

Pages 11-12, lines 231-232: If different fish have different travel times AND survival is time-dependent, as you assume in your interpretation of the results, then the measured travel time will be weighted to the faster-moving fish and the weights will include survival, rather than representing the travel time of the entire group that was released. Very unfortunate, although practically speaking the bias may be small. If survival is not time-dependent, though, then the faster-moving fish should have the same

survival as the slow-moving fish, and then the measured travel time should represent the release group (average).
We may have misinterpreted the reviewers comment on the first submission and provided an ineloquent response. The assumption regarding the representativeness of measured travel times would be better stated as suggested above: we are assuming that any affect on the measured travel times is sufficiently small and affects the groups that are compared similarly so that the results are not affected. Text to this effect has been added beginning line 233, and also in the Discussion, beginning line 545.

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Page 12, Line 237: Define the log odds ratio, or at least identify which group is in the numerator and which in the denominator. Usually the control group is in the denominator.
We have added the definition, beginning line 242.

Page 12, Lines 249 – 253: Also assume that fish that are detected have the same probability of future detection as those (surviving) that are not detected – not really met for the 5 Cascade Head fish.
This has been added.

Page 13: Making inferences to S^(1/T) assumes a constant mortality rate – that is, no acute mortality. So which is it?
Acute mortality isn't instantaneous, but represents a small fraction of the time the smolts were observed and would have occurred close to the point of release. In that respect, a constant mortality rate in the lower river isn't excluded. We have added language to make this clearer.

Page 13, Line 269: How precise is that 20%? How might it vary for fish in the river, who may evade very high exposure but also have to deal with the physical process of going through very high spill (e.g., high turbulence, aside from high TDG)?
We have added bounds on the 20% estimate (beginning line 284), although without the original data from Mesa et al. and others, we cannot be precise. We have also added text in the Discussion (beginning line 437) to point out that it will be affected by variability in survival in the lab, as well as additional factors in the field that are not present in controlled laboratory experiments.

Page 14, Lines 269-271: So, is this your null hypothesis – that in the absence of chronic effects, the ratio of daily survival rates should be 0.8? What is your alternative?
We are having difficulty understanding how the reviewer has structured this hypothesis, but it was not our intent to conduct a strict hypothesis test here. As the reviewer points out above (and as we have attempted to expand on in the paper), we are comparing an imprecise laboratory measurement with derived results from an uncontrolled field exposure. We cannot determine whether acute, chronic, or both (or neither) effects of TDG are present from the data at hand. For completeness, we have explored and presented the acute and chronic alternatives.

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Page 15, Line 303: Detection efficiency of 0.71 – does this include treating Cascade Head detections as actually at Willapa Bay? That is inappropriate. If there is an effect of including the CH detections, then you shouldn't include them. If there is no effect, then don't include them.
We have not included them.

Page 16, Line 332: log odds ratio of 0.14 – needs to be interpreted; most fisheries biologists don't think about log odds ratios much.
We have added an interpretation, including a calculation of the odds that may further aid the fisheries biologist, beginning line 342.

Page 17 and elsewhere: Your results are estimates, not the actual parameters. Talk about "estimated survival", not "survival" – you don't know what survival actually was.
We have made this correction throughout the document.

Page 17: It seems to me that mortality might have been a distance-based process rather than a time-based process, or there may be other possibilities than just a time-based process – which means that your conclusions based on differences in estimated daily survival rates are invalid.
As discussed above, we have added significantly to the Discussion (beginning line 545) to address this point and the limitations of our analytical approach.

Page 17, Line 362: Survival is a decimal, so acute mortality is a decimal. Is there a standard error on the acute mortality rate estimate, or a confidence interval?
Correction made, and a bootstrapped standard error (SE=0.03) is now included.

Page 17, lines 366-367: Your acute mortality estimate was computed under the assumption of no differences in daily survival rate. The fact that your acute mortality estimate is consistent with the anticipated level of acute mortality means that your S^(1/T) comparisons are inappropriate, at least for the lower river reach. That is, you can make the comparisons, but cannot infer differences to the actual daily survival rate. So it looks like only the plume shows any evidence of chronic effects, although even there survival is the same between groups.
We think the variance still leaves open the possibility of chronic mortality in the river as well (if the acute mortality estimate is correct). This was clearer in earlier drafts, and we have added language to make this point (line 437).

Page 19, Line 405: But only on S^(1/T) scale, which may or may not be suitable.
Addressed as described in response to Comments to the Author above.

Page 19, Lines 405-413: If acute mortality accounts for survival differences in the lower river then you shouldn't compare S^(1/T) for that reach.

The acute mortality estimate, as with others, are statistical in nature. We have noted both alternatives on line 414 (now line 435), since the information we have does not allow us to rule one out.

Page 20, Line 417: typo
We have searched, but cannot find the typo.

Page 23, Line 503: "may lead to chronic effects expressed later in the life stage" – very possibly, but that has not really been shown in this paper.
We have tweaked the language slightly, but focus on addressing this concern in the expanded discussion described above.

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

Sent: Tue Aug 23 15:45:50 2016

To: 'David.Welch@kintama.com'

Cc: 'ian.g.brosnan@nasa.gov'

Subject: Re: Elder et al 2016

Importance: Normal

Thank you.

I might share with our new water quality person Kim Johnson.

Best
Christine

----- Original Message -----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, August 23, 2016 03:38 PM Pacific Standard Time
To: Petersen,Christine H (BPA) - EWP-4
Cc: BROSNAN, IAN G. (ARC-SG) <ian.g.brosnan@nasa.gov>
Subject: RE: Elder et al 2016

Thanks, Christine-- I appreciate the perspective-- the Columbia River "juggernaut" has gotten so massive that sometimes it is hard to sort out why people say and do some of the things that they do. I think that the answer is "Groupthink" and it is not something unique to the region or the Columbia River biologists... there is a great book called "Criminal Investigative Failures" (Rossmo, D. K. (2008). Criminal investigative failures: CRC Press.) that takes apart a number of very high profile wrongful criminal convictions to see what went wrong. (I went to this literature because here the pressure on public officials to come up with an answer is even greater and the sometimes "unprofessional" behavior of the individuals that results has an even greater impact than what occurs in operating the dams).

One of the key points from that book is that groupthink tends to come to dominate a group of detectives when they feel beleaguered, all sit around the same table, and develop tunnel vision... they become convinced they have the correct culprit far too early/quickly and narrow the investigation process down and exclude potential offenders... and then they become motivated to defend those initial decisions because they all sat around the table and collectively made them and they now feel the need to defend the integrity of their colleagues and "the process", rather than push the "restart button". I see strong analogies to the lack of willingness of salmon biologists coast-wide to admit that a lot of the salmon problems are out at sea, and that they need to address them head on rather than continue to fight for continued efforts to do things in freshwater.

I copy Ian Brosnan for his knowledge that I have given you the accepted copy of the manuscript. Please keep this within tight bounds at BPA until it is published... No sense in giving the FPC any extra time to prepare one of their memos trashing a result that they don't like...

-----Original Message-----
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Sent: Tuesday, August 23, 2016 3:21 PM
To: David Welch
Subject: RE: Elder et al 2016

Hi David,
No problem at all - at many places with various organizational structures, it is perfectly fine to talk with anyone on the 'team' about a contract matter. Our own organizational structure can be a bit hard to discern - the set of folks at your presentation were from both 'power generation' and our F&W program.

It would be nice to see your current TDG paper, and I would not disperse it widely. I saw a version from two years ago. Tomorrow, a couple of us are going to the Corps temperature modeling presentation. Water quality will play a big role in this EIS, and there are a number of small debates that we have not chosen to engage in recently.

Yes, when we were talking about how the Columbia River area came to have the arrangement of agency roles, with FPC serving as an unofficial biometry experts/policy voices. In a sense, I think the 'action agencies' (Corps, BPA, Bureau) don't effectively do their PR job. We have staff who put together presentations showing our side of the story, and I think they get presented internally and don't reach outside news agencies. Our rarely visited youtube channel has some great pieces on projects we've funded, done by John Tyler. There is a weekly meeting called FPAC which is attended by the state agencies, tribes, and one NOAA rep, where FPC play the role of presenting environmental conditions and fish numbers every week, and they also tend to push the agenda that is reflected in the memos that they write up. I rarely paid attention, but I noticed that Jason Sweet sometimes listens to their online recordings in order to see what the hot issues are. There have been examples where there is suddenly a set of news articles which claim the same thing (that dams are heating the river, or lack of spill is killing fish yet a little bit more could double returns) and this can be traced back to FPAC and press releases that are sent out. We are not able to really write a rebuttal to a memo because it isn't exactly our place as a government agency. (b)(5) [redacted]

(b)(5) [redacted]

http://blogs.idahostatesman.com/a-primer-on-the-salmon-science-debate-underlying-spill-test-proposal/
http://www.oregonlive.com/opinion/index.ssf/2015/05/planned_cormorant_slaughter_is.html

-----Original Message-----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, August 19, 2016 2:12 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Elder et al 2016

Right-- it was-- I just falsely assumed that since I had been talking with you about issues this week that you had taken over as COTR sometime after I had left on holidays.

It would be good to talk about the TDG paper and get your take on it, but can I send you the accepted draft copy without having it too broadly distributed at this point (discreet discussion at BPA is fine)? I just don't want to be seen as lobbying over the results-- the study has limitations, but it also is the first paper I know of that documents the possibility that sub-lethal TDG exposure can potentially be causing elevated mortality later in the plume, and multiple days after exposure. This is presumably because of stroke-like symptoms from TDG making the affected smolts more susceptible to predation but of course we can't get at the mechanism from this sort of observationa; study.

You can see the reviewer's & editor's final comments on it accepting the version I will send you, noting the likely key points of contention, and if you want I can provide the earlier criticisms and our detailed rebuttals. As for actually publication, when it can be freely cited, I'm not sure-- it may well be months before the journal actually puts it on their website.

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, August 19, 2016 1:36 PM
To: David Welch
Subject: Re: Elder et al 2016

Hi,
Sorry, here is where I think the misunderstanding started this morning. I thought you might be wanting to generally talk about what you are doing, or sources of data, or the TDG topic.

Christine

----- Original Message -----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, August 18, 2016 04:21 PM Pacific Standard Time
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Elder et al 2016

Hi Christine--

Are you available to take a brief phone call now? Or should I call you in the morning on Friday?

David

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, August 18, 2016 3:35 PM
To: David Welch
Subject: FW: Elder et al 2016

Hi David,

Agnes just mentioned the status of your paper with Ian Brosnan. I thought I would forward this paper that just went into print. Several thought that Tim Elder's statistical methods were hard to understand, and also didn't understand the inference of a elevated effect from going through multiple dams when his tables seem to show lower mortality with multiple dams (more of a culling effect?).
 Scott and I saw a draft of this when it looked a bit different, and I gave it extra points for selecting this technique which would not require them to presume the shape of the curve of the relationship (like a linear regression) and for considering TDG and barometric pressure as variables. I realized I have to look more into the importance of barometric pressure differential because I havent' considered it before.

Along other lines, was your group able to identify sources of Willamette SARs data? This might be a challenging location due to the history of hatcheries and their various release locations but there are a few people with OSU and the Corps who could probably find wild or reliable hatchery data.

Christine Petersen

-----Original Message-----
From: Bettin,Scott W (BPA) - EWP-4
Sent: Thursday, August 18, 2016 2:51 PM
To: Grimm,Lydia T (BPA) - A-7; Bodi,Lorri (BPA) - E-4; Francis,Rose (BPA) - LN-7; Barco III,John W (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

http://www.fpc.org/documents/memos/47-16.pdf

It appears Michele is catching up on her reading. A 12 page review of the document was kicked off with this sentence. "The subject analysis is so extensively flawed that the conclusions reached are not credible or applicable to any fish passage management questions." -
s

-----Original Message-----

From: Petersen,Christine H (BPA) - EWP-4
Sent: Friday, August 12, 2016 12:54 PM
To: Bettin,Scott W (BPA) - EWP-4; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

Charlie spotted that this paper you got from Mark Weiland a couple years ago got into print. I think they get a bonus point for considering TDG and even having this as a major risk around dams. I'm not sure how the rest of the world will perceive it. They aren't dwelling on the routes the fish went through.

-----Original Message-----
From: Charlie Paulsen [mailto:cpaulsen@paulsenenvironmentalresearch.com]
Sent: Friday, August 12, 2016 10:23 AM
To: Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5
Subject: Elder et al 2016

Christine & Julie:

I saw this discussed in CBB this morning, and I'm not quite
sure what to make of it. If you get a chance to look at it
I'd appreciate hearing your views.

Charlie

From: David Welch

Sent: Tue Aug 23 15:56:38 2016

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

Subject: RE: Elder et al 2016

Importance: Normal

No opinion on the Kokanee vs sockeye debate in the Okanogan... sorry, but I just don't know enough to be able to comment intelligently!

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Tuesday, August 23, 2016 3:55 PM
To: David Welch
Subject: Re: Elder et al 2016

Oh,
 Here is a question from left field. Do you have an opinion on whether they should open the fish ladder at Okanagan Lake and let sockeye enter there? I believe the controversy is over whether they would crowd out the kokanee. Jeff Fryer was showing me some of the locations there.

I think another good example of a small set of experts spreading their idea is in the film Dam Nation from last year. Patagonia clothing awards some profits for projects like this. The concept for their first 30 min was spot on- there are thousands of unmaintained dam and agricultural diversions structures around the world that are unmaintained, outdated, and just need funding for removal or modification. But the director seemed like he had only a few months to do research so he set upon material from around 2001 to cocclude that the lower Snake dams are currently the worst, and worthy of a special campaign- even though a billion was just spent on upgardes. The filmmakers were unable to identify any of the hundreds of better candidates to profile. Their economics argument for power vs maintenance cost was flawed. Their recreation argument was flawed too. Nobody would kayak the Snake. Reservoirs are popular for boating.

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Subject: RE: Elder et al 2016

Right-- it was-- I just falsely assumed that since I had been talking with you about issues this week that you had taken over as COTR sometime after I had left on holidays.

It would be good to talk about the TDG paper and get your take on it, but can I send you the accepted draft copy without having it too broadly distributed at this point (discreet discussion at BPA is fine)? I just don't want to be seen as lobbying over the results-- the study has limitations, but it also is the first paper I know of that documents the possibility that sub-lethal TDG exposure can potentially be causing elevated mortality later in the plume, and multiple days after exposure. This is presumably because of stroke-like symptoms from TDG making the affected smolts more susceptible to predation but of course we can't get at the mechanism from this sort of observationa; study.

You can see the reviewer's & editor's final comments on it accepting the version I will send you, noting the likely key points of contention, and if you want I can provide the earlier criticisms and our detailed rebuttals. As for actually publication, when it can be freely cited, I'm not sure-- it may well be months before the journal actually puts it on their website.

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, August 19, 2016 1:36 PM
To: David Welch
Subject: Re: Elder et al 2016

Hi,
Sorry, here is where I think the misunderstanding started this morning. I thought you might be wanting to generally talk about what you are

doing, or sources of data, or the TDG topic.

Christine

----- Original Message -----
From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, August 18, 2016 04:21 PM Pacific Standard Time
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Elder et al 2016

Hi Christine--

Are you available to take a brief phone call now? Or should I call you in the morning on Friday?

David

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, August 18, 2016 3:35 PM
To: David Welch
Subject: FW: Elder et al 2016

Hi David,

Agnes just mentioned the status of your paper with Ian Brosnan. I thought I would forward this paper that just went into print. Several thought that Tim Elder's statistical methods were hard to understand, and also didn't understand the inference of a elevated effect from going through multiple dams when his tables seem to show lower mortality with multiple dams (more of a culling effect?).
Scott and I saw a draft of this when it looked a bit different, and I gave it extra points for selecting this technique which would not require them to presume the shape of the curve of the relationship (like a linear regression) and for considering TDG and barometric pressure as variables. I realized I have to look more into the importance of barometric pressure differential because I havent' considered it before.

Along other lines, was your group able to identify sources of Willamette SARs data? This might be a challenging location due to the history of hatcheries and their various release locations but there are a few people with OSU and the Corps who could probably find wild or reliable hatchery data.

Christine Petersen

-----Original Message-----
From: Bettin,Scott W (BPA) - EWP-4
Sent: Thursday, August 18, 2016 2:51 PM

To: Grimm,Lydia T (BPA) - A-7; Bodi,Lorri (BPA) - E-4; Francis,Rose (BPA) - LN-7; Barco III,John W (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

http://www.fpc.org/documents/memos/47-16.pdf

It appears Michele is catching up on her reading. A 12 page review of the document was kicked off with this sentence. "The subject analysis is so extensively flawed that the conclusions reached are not credible or applicable to any fish passage management questions." - s

-----Original Message-----
From: Petersen,Christine H (BPA) - EWP-4
Sent: Friday, August 12, 2016 12:54 PM
To: Bettin,Scott W (BPA) - EWP-4; Sweet,Jason C (BPA) - PGB-5
Subject: FW: Elder et al 2016

Charlie spotted that this paper you got from Mark Weiland a couple years ago got into print. I think they get a bonus point for considering TDG and even having this as a major risk around dams. I'm not sure how the rest of the world will perceive it. They aren't dwelling on the routes the fish went through.

-----Original Message-----
From: Charlie Paulsen [mailto:cpaulsen@paulsenenvironmentalresearch.com]
Sent: Friday, August 12, 2016 10:23 AM
To: Petersen,Christine H (BPA) - EWP-4; Doumbia,Julie A (BPA) - PGB-5
Subject: Elder et al 2016

Christine & Julie:

I saw this discussed in CBB this morning, and I'm not quite
sure what to make of it. If you get a chance to look at it
I'd appreciate hearing your views.

Charlie

From: David Welch

Sent: Mon Aug 29 12:57:59 2016

To: amcreason@bpa.gov (amcreason@bpa.gov)

Subject: Checking in...

Importance: Normal

Hello, Anne-

I thought that I should drop you an email, and ask if there are any changes that are needed to the draft SOW and Sole Source Justification that I had sent you earlier?

Also, I belatedly realized that I wanted to modify some of the text around "PIT-tag based estimates of survival" to make it much clearer what was actually envisaged in this contract, but failed to remember to do so until after I had hit "Send"! I can most easily clarify what our intention is if we discuss by phone first, as the issue is very open-ended, but potentially quite important.

Regards, David

David Welch, Ph.D.

kintamav_RGB

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P Please consider the environment before printing this e-mail

From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Mon Aug 29 14:26:22 2016

To: David Welch (david.welch@kintama.com)

Cc: Creason,Anne M (BPA) - EWL-4; Erin Rechisky (Erin.Rechisky@kintama.com)

Subject: funding issue

Importance: Normal

(b)(5) [redacted]

Sorry for the mixed news. I'll share another update as soon as I learn more about what our options are.

Ben

From: David Welch

Sent: Wed Aug 31 11:21:27 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Touching base...

Importance: Normal

Great—ttyt.

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Wednesday, August 31, 2016 10:54 AM
To: David Welch
Subject: RE: Touching base...

Would tomorrow at 10 work for a call?

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, August 30, 2016 3:55 PM
To: Zelinsky,Benjamin D (BPA) - EWP-4
Subject: Touching base...

Hi Ben—

I was wondering if we could have a quiet chat at some point as to exactly where you think things will go. Two months ago out of the blue I received a very good offer to purchase the building we work out of, which as I think you know, I had spent a lot of time (& $) having constructed to support our tagging operations.

Since the field work that requires the tagging infrastructure is not currently being supported on either side of the border, my decision was to sell the building, put all of the high end equipment into temperature controlled storage, and move three of us into a smaller rental office somewhere until scientific interest and revenues increased to support the larger facility. (This building is 8,500 square feet, and has work space for up to 14 staff).

From BPA's perspective, this change should be of no consequence, because you folks are only contracting us for 3 (perhaps now 2) reports. However, it is of concern to me because I need to make some decisions about what sort of office space to lease, and how many staff to keep on to support analysis and writing of these reports.

We will not be moving out of the current offices until the end of November, so there is no immediate urgency concerning the move, but the slow and unpredictable nature of government contracting does make me concerned about making any further decisions until I can be sure something will go through.

(b)(5) [redacted]

(b)(5) [redacted]

However, there is not a lot of point making strategic recommendations to you if there is not a budget available. Your guidance would be appreciated.

Best, David

David Welch, Ph.D.

kintamav_RGB

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P Please consider the environment before printing this e-mail

From: Pisces

Sent: Thu Sep 01 11:57:02 2016

To: Pisces

Bcc: bknichols@bpa.gov; hadondy-kaplan@bpa.gov; dssutro@bpa.gov; adhoang@bpa.gov; bdzelinsky@bpa.gov; dxaffonso@bpa.gov; jmmccloud@bpa.gov; jcwilson@bpa.gov; mballen@bpa.gov; dwwelch@bpa.gov; mahutson@bpa.gov; induran@bpa.gov; ktwolfe@bpa.gov; esgresh@bpa.gov; ewwilt@bpa.gov; rmkerseg@bpa.gov; daroberts@bpa.gov; docollins@bpa.gov; aesenters@bpa.gov; rlgolden@bpa.gov; tswinschel@bpa.gov; cjmatthew@bpa.gov; kcgrange@bpa.gov; sxross@bpa.gov; jilien@bpa.gov; chpetersen@bpa.gov; jdgrinolds@bpa.gov; kwingert@bpa.gov;?krjule@bpa.gov; aamendenhall@bpa.gov; eccomplete@bpa.gov; drboorse@bpa.gov; sagreen@bpa.gov; FWSupportGroup@bpa.gov; dldocherty@bpa.gov; jdtyler@bpa.gov; jdgoodman@bpa.gov; pskey@bpa.gov; jehorn@bpa.gov; ezolmajd-haghighi@bpa.gov; kmscheidt@bpa.gov; sulee@bpa.gov; jtstabe@bpa.gov; sldonahue@bpa.gov; hmhaserot@bpa.gov; rkeanini@bpa.gov; mmomalley@bpa.gov; djkaplowe@bpa.gov; rwshull@bpa.gov; jepeterson@bpa.gov; abrudolph@bpa.gov; ejleitzinger@bpa.gov; mmfoster@bpa.gov; kswinn@bpa.gov; wjsaway@bpa.gov; kpmote@bpa.gov; spmarsh@bpa.gov; rebeaty@bpa.gov; tatrinh@bpa.gov; cdmcclory@bpa.gov; alnaef@bpa.gov; rcparadis@bpa.gov; jpkarnezis@bpa.gov; mxguay@bpa.gov; lfmendoza@bpa.gov; myquinata@bpa.gov; mamatera@bpa.gov; jasnyder@bpa.gov; wjzimmerman@bpa.gov; gfschadler@bpa.gov; mldelong@bpa.gov; sjackley@bpa.gov; clread@bpa.gov; ltgrimm@bpa.gov; slfrye@bpa.gov; smtalkington@bpa.gov; rljaramillo@bpa.gov; sdgrant@bpa.gov; jtmoffett@bpa.gov; jmwilson@bpa.gov; chfurey@bpa.gov; pawalters@bpa.gov; amplatt@bpa.gov; jikeiski@bpa.gov; almcmahon@bpa.gov; mcbodine@bpa.gov; jklord@bpa.gov; tepansky@bpa.gov; amcreason@bpa.gov; kmmcdonald@bpa.gov; ahcummings@bpa.gov; bmdick@bpa.gov; baguirre@bpa.gov; jcleary@bpa.gov; RMESupport@bpa.gov; jwbarco@bpa.gov; jayarman@bpa.gov; jebrady@bpa.gov; aemai@bpa.gov; bkmercier@bpa.gov; safife@bpa.gov; jacleveland@bpa.gov; swbettin@bpa.gov; cmtikotsky@bpa.gov; gjdondlinger@bpa.gov; ekbowers@bpa.gov; memoody@bpa.gov; jkstier@bpa.gov; allheureux@bpa.gov; skgagnon@bpa.gov; bashields@bpa.gov; kabowen@bpa.gov; jtskidmore@bpa.gov; blpham@bpa.gov; tyerxa@bpa.gov; rxcallejas@bpa.gov; rwscranton@bpa.gov; lldexter@bpa.gov; kgcannell@bpa.gov; gmcclintock@bpa.gov; gmsmith@bpa.gov; jwconnor@bpa.gov; taholtcamp@bpa.gov; crbelt@bpa.gov; makavanagh@bpa.gov; smlopez@bpa.gov; spwelch@bpa.gov; kpruder@bpa.gov; lsnorris@bpa.gov; lnrenan@bpa.gov; cawoodall@bpa.gov; MLJanssen@bpa.gov; rttapp@bpa.gov; ckbrown@bpa.gov; mmwalk@bpa.gov; jrnichols@bpa.gov; dfcorkran@bpa.gov; tlhauser@bpa.gov; mthaight@bpa.gov; jlwoodward@bpa.gov;? dagambetta@bpa.gov; rxmazaika@bpa.gov; vlwatts@bpa.gov; ptlofy@bpa.gov; Eric.E.Hockersmith@usace.army.mil;

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Subject: Pisces Release at 5pm Tonight – PLUS an update on Pisces Web Project! How it impacts you…

Importance: High

Greetings Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you are logged out prior to then.

Today's release is a bit different, as we are rolling out some initial Pisces Web functionality into the CBfish.org environment.

What does this mean to you?

The change means, briefly, that you can now access and manage certain core aspects of contract management activities normally done in Pisces Desktop – via the web. Those include:

- CR Initialization *(Internal BPA functionality)*
- Contacts
- Contract Summary

· CR Initialization

· SOW Development

o Milestones *(notifications limited to system defaults)*

o Metrics

o Location

o Focal Species

o Budgets

· Environmental Compliance *(Internal BPA functionality)*

We are excited about making this functionality available for users to explore – and there will be more communication and some training opportunities rolled out gradually!

Success tips for working in the new environment:

· You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!

· We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

· While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do you everyday work in Pisces. Future training will support users with tips and tricks for how to be successful

· If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always...

For system access, bugs, or feedback on new functionality – email support@cbfish.org.

For questions about the Pisces Web project – email pisces@bpa.gov.

We will soon launch an online resource where users can go for updates, reference guides, updated how-to aids, etc.

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all BPA and non-BPA users, the Pisces Team, and additional BPA staff as appropriate.

From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Fri Sep 16 15:57:52 2016

To: David Welch

Subject: RE: Touching base?

Importance: Normal

Thanks David

You too

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/16/16 3:56 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: RE: Touching base?

OK—Thanks for the update. ((b)(6) [redacted], so please call my cell).

Hope you have a great weekend!

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Friday, September 16, 2016 3:54 PM
To: David Welch
Subject: RE: Touching base?

David - I have a meeting on the 22nd that should determine whether we can find funding this year

I'll call you right after that to check in

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/14/16 8:56 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: Touching base?

Hey Ben—

I was wondering if we could touch base so that I could get a sense of whether BPA is likely to fund the work we proposed (i.e., whether funds without an earmark actually exist).

I'm in and out on Thursday, but around all day Friday; you can try giving me a call on my cell and I will answer if I can, otherwise let me know a time to call you and I will on Friday or later.

Best, David

David Welch, Ph.D.

kintamav_RGB

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From: David Welch

Sent: Wed Sep 28 11:38:09 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Any updates?

Importance: Normal

Great—Thursday & Friday are both Pro-D days, so I will be working at home

House: [redacted]

Cell: [redacted]

& thanks!

d

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Wednesday, September 28, 2016 10:09 AM
To: David Welch
Subject: RE: Any updates?

Yes - let's chat

How about tomorrow at noon?

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/27/16 10:18 AM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: FW: Any updates?

Hey Ben-- I know you must be busy, but I was hoping we could have a brief update on your current thoughts.

David

From: David Welch
Sent: Friday, September 23, 2016 10:37 AM

To: Ben Zelinsky
Subject: Any updates?

Hi Ben—

Just wondering if you had your meeting yesterday, and if there was any progress worth discussing.

David

David Welch, Ph.D.

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From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Thu Sep 29 06:39:01 2016

To: David Welch

Subject: RE: Phone call...

Importance: Normal

I'll call you at 8. Thanks David.

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/28/16 7:59 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: RE: Phone call...

Either works—Please call the house when convenient: (b)(6) [redacted]

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Wednesday, September 28, 2016 6:17 PM
To: David Welch

Subject: RE: Phone call...

Can we switch to 8 or 8:30? I have a 9 that I wasn't out in my calendar.

Sorry

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/28/16 4:35 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: RE: Phone call...

Friday at 9 it is.

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Wednesday, September 28, 2016 4:07 PM
To: David Welch

Subject: RE: Phone call...

Tomorrow is really booked - how about Friday at 9?

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 9/28/16 2:21 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: Phone call...

Sorry, just realized [redacted] but they just called to confirm). Anytime [redacted] tomorrow works... Your choice.

d

David Welch
M: +[redacted]
Kintama Research Services
Sent from my iPhone

From: David Welch

Sent: Fri Oct 14 10:59:58 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: Re: decision status

Importance: Normal

Thanks for the follow up info... looking forward to hearing more next week.

Have a good weekend with your family yourself

Regards, David

David Welch
M: +[redacted]
Kintama Research Services
Sent from my iPhone

On Oct 14, 2016, at 10:02 AM, Zelinsky,Benjamin D (BPA) - EWP-4 <bdzelinsky@bpa.gov> wrote:

David,

I have a meeting on Monday morning with the budget manager to attempt to get the money transferred to the project so that we can issue the contract.

I’ll follow up with you Monday afternoon.

Hope your weekend treats you well.

Ben

From: David Welch

Sent: Tue Oct 18 09:35:07 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Checking in on progress?

Importance: Normal

Just checking in on this, Ben.

Did the budget folks get the clarification they need to move forward?

Regards, David

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Tuesday, October 11, 2016 1:56 PM
To: David Welch
Subject: RE: Checking in on progress?

David - sorry - off yesterday and in Boise today. Lorri sent out an email that was mildly confusing but supportive of moving forward. I need to make sure the budget folks got what they need to move forward. I'll do that tomorrow when I'm back in the office.

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 10/11/16 11:54 AM (GMT-07:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Subject: FW: Checking in on progress?

Hi Ben- As below.

Cheers, David

From: David Welch
Sent: Friday, October 07, 2016 9:18 AM
To: Ben Zelinsky
Subject: Checking in on progress?

Hey Ben—

No doubt you will be regretting telling me to bug you if I hadn't heard further from you by today—but you did!

Any progress to report and, in particular, is there anything further that I can do to facilitate things from our end?

Regards, David

David Welch, Ph.D.

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From: David Welch

Sent: Fri Oct 21 14:02:07 2016

To: Ben Zelinsky

Subject: Moving forwards--

Importance: Normal

Hi Ben—

After due consideration, I am prepared to move forwards with the abbreviated contract (and thank you for your support and efforts in this).

(b)(5) [redacted]

[redacted] Give me a call at the house after 2:30 (or email) if you need further discussion in order to move forward—I believe that the narrative for the SOP that we sent BPA earlier is probably sufficient to move forwards, but of course I'm not in a position to be certain.

Thank you, David

David Welch, Ph.D.

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From: David Welch

Sent: Mon Oct 24 23:03:29 2016

To: Ben Zelinsky; amcreason@bpa.gov (amcreason@bpa.gov); Lut,Agnes (BPA) - KEWR-4; Petersen,Christine H (BPA) - EWP-4

Subject: TDG Paper...

Importance: Normal

Attachments: Brosnan et al (Survival Rates of Out Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas Supersaturated Water-JAAH 2016).pdf

Ben, Anne, Agnes, & Christine--

Just a quick heads up. This paper by my former PhD student just came out today in the Journal of Aquatic Animal Health (an American Fisheries Society Journal). No doubt it will generate a memo or two, so I am sending it on to you to disseminate internally if you deem it appropriate.

Ian Brosnan (the senior author) is a bright light—just before he finished his PhD working with me (but through Cornell) he landed a job at NASA as Chief of Planning for the NASA Ames Lab down in California. I think he is lost to fisheries science unfortunately, but I think it was an excellent career switch for him.

His FaceBook post today on this paper pretty well sums up the rough ride he got from Voldermort in the review process at several journals prior to it being accepted in this one: *"A publication that I expected to be a relatively simple, but proved one of the longest and most difficult things I have done, in both a technical and a political* *sense, is out today. Custom derivations, 32-core parallel processing, and fishy politics, all in one wee little paper.".*

Regards, David

[redacted]

David Welch, Ph.D.

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Survival Rates of Out-Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas-Supersaturated Water

Ian G. Brosnan, David W. Welch & Melinda Jacobs Scott

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DOI: 10.1080/08997659.2016.1227398

ARTICLE

Survival Rates of Out-Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas-Supersaturated Water

Ian G. Brosnan*[1]
Cornell University, 4122 Snee Hall, Ithaca, New York 14850, USA

David W. Welch[2] **and Melinda Jacobs Scott**[2]
Kintama Research Services, Ltd., 10-1850 Northfield Road, Nanaimo, British Columbia V9S 3B3, Canada

Abstract
In 2011, unusually high flows caused total dissolved gas (TDG) levels in the Columbia River, USA, to escalate well above the 120% regulatory limit that was imposed to prevent harmful impacts to aquatic organisms. After observing gas bubble trauma (GBT) in dead yearling Chinook Salmon *Oncorhynchus tshawytscha* (smolts) held in tanks, we compared estimated survival rates of acoustic-tagged in-river-migrating (IR) and transported (TR) smolts that were released below Bonneville Dam prior to and during the period of elevated TDG (>120%). The log odds of estimated daily survival in the lower river and plume was significantly lower for IR smolts that were released during elevated TDG (maximum possible exposure = 134%) than for IR smolts released when TDG was less than 120%. The TR smolts that were released 10–13 km below Bonneville Dam during elevated TDG had lower maximum possible exposure levels (126% TDG), and the log odds of estimated daily survival in the lower river and plume did not differ from that of TR smolts released when TDG was less than 120%. Direct mortality due to GBT is probably reduced in natural settings relative to laboratory experiments because smolts can move to deeper water, where pressure keeps gasses in solution, and can migrate downstream of the spillway, where TDG levels decrease as the river returns to equilibrium with the atmosphere. However, initially nonlethal GBT may reduce survival rates by increasing smolt susceptibility to predation and infection. Although our findings are limited by the observational nature of the study, our analysis is the first direct assessment of gas supersaturation's potential influence on survival of free-ranging smolts in the river and coastal ocean below a large dam. Experiments using simultaneous releases of control and gas-exposed groups are warranted and should consider the possibility that the chronic effects of TDG exposure on survival are important and persist into the early marine period.

The practice of spilling water over dams can induce gas bubble trauma (GBT; also termed gas bubble disease) in aquatic species, including salmon smolts, by increasing total dissolved gas (TDG) levels in the river below the spillways. Globally, as the number of hydropower projects grows, there is increasing concern about the effects of TDG on fish health (Wang et al. 2015). An extensive body of literature has evaluated the physical, biological, and ecological effects of dissolved gas and GBT on salmon smolts (reviews by Weitkamp and Katz 1980; McGrath et al. 2006; Maynard 2008). Most of the direct mortality effects at TDG exposures of up to 125% can be avoided when fish are at liberty to compensate by migrating (Weitkamp and Katz 1980). However, even nonlethal GBT experiences may affect survival by increasing the susceptibility of juvenile salmon to predation (Mesa and Warren 1997), bacterial infections (Huchzermeyer 2003), and fungal infections (Weitkamp

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1976; Lutz 1995). Existing infections and multiple exposures may also reduce salmon resistance to GBT such that otherwise nonlethal exposures to supersaturated water are rendered deadly (Cramer 1996; Weiland et al. 1999).

Juvenile salmon that pass through spillways avoid the physical effects of powerhouse passage, and this may contribute to improved salmon survival—an issue of particular concern with regard to salmonids that are listed as threatened or endangered under the U.S. Endangered Species Act (Budy et al. 2002; Petrosky and Schaller 2010; USOFR 2012). The states of Oregon and Washington balance the impacts of spill against its potential benefits by imposing modified water quality standards that permit elevated TDG levels in dam forebays (115%) and tailraces (120%) during smolt out-migration (USEPA 1986; Washington State Legislature 2003; OSA 2003; ODEQ–EQC 2009). These regulatory measures are intended to prevent juvenile salmon from experiencing TDG levels above 120%, with exceptions for high-flow events, when powerhouse capacities are exceeded and spill is involuntary. Total dissolved gas levels often exceed regulatory limits for several days each year and for a variety of reasons, such as flood, flow, and temperature control; equipment maintenance or malfunctions; or communication failures. In the Columbia River basin, 2011 was unusual for having sustained, systemic exceedances resulting from high flow that triggered exemptions to the TDG limits (USACE 2011).

Previous research into the effects of TDG exposure has focused on the symptoms and effects of GBT induced by exposure to gas-supersaturated water in laboratory and cage studies or has involved field surveys of GBT symptoms. No previous work has measured survival effects in the lower Columbia River and plume, partly because the technology for conducting such studies (e.g., acoustic telemetry) was not available when the majority of the studies were conducted. However, in 2011, high flows in the Columbia River resulted in TDG reaching 134% below Bonneville Dam, which was fortuitously coincident with the release of both barge-transported and in-river-migrating, acoustic-tagged juvenile yearling Chinook Salmon *Oncorhynchus tshawytscha* (henceforth, smolts) during a long-term study (Rechisky et al. 2012, 2013, 2014; Brosnan et al. 2014). During this period of high TDG, mortality due to GBT was observed in 17 of 59 smolts that were held for tagging in tanks supplied with water taken from the upper face of Bonneville Dam. This was the first observation of GBT among fish used during the long-term study.

Because the timing of tagged smolt releases covered the period before and after TDG levels climbed above the state limits, we were given a unique opportunity to compare the potential effect of exposure to gas supersaturation on the subsequent survival of free-ranging Chinook Salmon smolts in the lower Columbia River and estuary (Bonneville Dam to Astoria; henceforth, lower river) and the Columbia River plume (Astoria to Willapa Bay; Figure 1). Our objective with this retrospective cohort study was to compare the survival of transported (TR) and

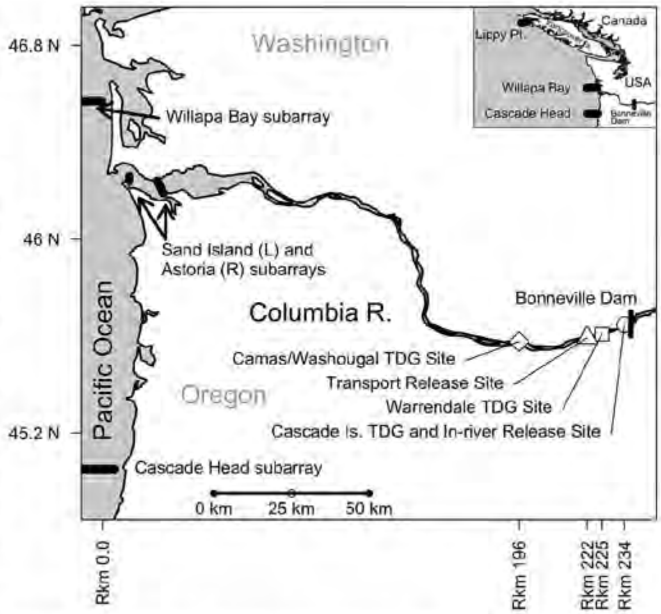

FIGURE 1. Locations of total dissolved gas (TDG) monitoring sites in the Columbia River below Bonneville Dam, release sites for tagged Chinook Salmon, and subarrays of acoustic receivers. In-river-migrating smolts were released at the Bonneville Dam smolt monitoring facility (~1 km downstream of the Cascade Island TDG monitoring site). Transported smolts were released between river kilometer (rkm) 222 and rkm 225 on the Columbia River; the Warrendale TDG monitoring site is located at rkm 225. The plume encompasses the region between the Astoria and Willapa Bay subarrays.

in-river-migrating (IR) smolts that were released into gas-supersaturated waters below the 120% state water quality limits (i.e., classified as "low exposure") with that of their counterparts, which were released when TDG levels were above the limits (classified as "high exposure"; Figure 2). Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT, did not appear to play an important role in survival over the study period (see Discussion).

We evaluated the TR and IR smolts separately because of their handling differences; we pooled smolts that were released several days apart (Figure 3; Table 1). Low-exposure TR smolts were released at an average TDG of 116%, and high-exposure TR smolts were released when TDG averaged 125% TDG. Because direct mortality effects may be avoided at up to 125% TDG (Weitkamp and Katz 1980), we hypothesized that there would be lower survival among the high-exposure smolts due to chronic GBT effects but not acute effects. Low-exposure IR smolts were released at an average TDG of 118%, and high-exposure IR smolts were released at 132% TDG. Thus, we hypothesized that survival effects in the high-exposure smolts would be acute, chronic, or a combination of acute and chronic (Cramer 1996).

We developed our hypotheses from the existing body of research regarding TDG effects on salmonids. In laboratory settings, chronic effects on fish health, such as increased

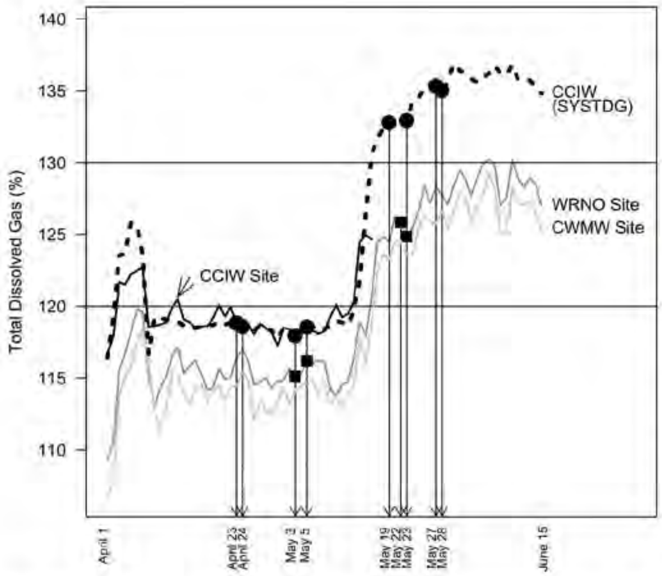

FIGURE 2. Average daily total dissolved gas (TDG; %) below Bonneville Dam on the Columbia River, calculated using the Oregon methodology from data recorded at three downstream TDG monitoring stations (CCIW = Cascade Island; WRNO = Warrendale; CWMW = Camas–Washougal) between April 1 and June 15, 2011. Solid lines denote measured values at each station. The dotted line represents the TDG prediction for Cascade Island from the U.S. Army Corps of Engineers' SYSTDG model. Horizontal lines mark the 120% TDG limit for dam tailraces in Oregon and Washington and the 130% TDG level referenced in the Discussion; arrows mark the release dates for in-river- migrating (circles overlaid on CCIW data) and transported (squares overlaid on WRNO data) groups of Chinook Salmon smolts.

susceptibility to bacterial infections (Huchzermeyer 2003) and fungal infections (Weitkamp 1976; Lutz 1995), appear in chronic exposures of up to 120% TDG, with acute mortality from GBT occurring at higher levels (Mesa et al. 2000). However, TDG exposure decreases with depth and distance downstream of dams; in field settings, where smolts are at liberty to migrate, mortality effects may be absent below 125% TDG (Weitkamp and Katz 1980). Multiple sublethal exposures may also result in chronic effects on salmonids (White et al. 1991), and although horizontal and vertical migrations in field settings may not mimic the continuous exposures that have been studied in the laboratory, multiple exposures are possible and may affect survival. For example, Cramer (1996) concluded that multiple exposures affected the survival of smolts exposed to 130% TDG below Ice Harbor Dam (Snake River) when TDG levels at upstream dams exceeded 110–115% TDG.

METHODS

Hatchery- and wild-origin smolts (n = 780) collected at Lower Granite Dam (Snake River) and Bonneville Dam (Columbia River) received surgically implanted Vemco V7-2L acoustic transmitters (7 × 20 mm; 1.6 g in air) and PIT tags (a detailed description of the tagging methods can be found in Rechisky et al. 2014). To analyze the impact of exposure to TDG levels above 120% (the Oregon and Washington tailrace water quality standard) on TR and IR smolts, we assigned each smolt to one of four groups: transport low exposure (TR-LOW), transport high exposure (TR-HIGH), in-river low exposure (IR-LOW), or in-river high exposure (IR-HIGH; Table 1). In-river smolts were assigned to the high-exposure group if they were released after May 13, when daily TDG levels exceeded 120% at the Cascade Island TDG monitoring site; otherwise, IR smolts were assigned to the low-exposure group (Figures 1, 2). Transported smolts were assigned to the high-exposure group if they were released after May 17, when daily TDG levels exceeded 120% at the Warrendale TDG monitoring site; otherwise, the TR smolts were assigned to the low-exposure group (Figures 1, 2). We conducted comparisons within the TR and IR groups but not between the two groups because they were not similarly handled (Figure 3). Therefore, the TR-LOW group served as the control for the TR-HIGH group, and likewise the IR-LOW group acted as the control for the IR-HIGH group.

In-river migrants (n = 580) were collected at Bonneville Dam and were held in 1-m-deep flow-through tanks that were flushed with river water drawn from the upper dam face. The IR smolts were tagged either on the day of capture or the next day, and they were released on the fourth day at the smolt monitoring facility below the dam (river kilometer [rkm] 234 on the Columbia River; Figures 2, 3). Of the IR smolts, 300 were released in late April or early May, and 280 were released in late May (Table 1). Transported smolts (n = 200) were collected at Lower Granite Dam; they were tagged on the day after collection, were transported downstream in barges (with gas-stripping equipment) 3 d after capture, and were released 10–13 km below Bonneville Dam on day 4 (rkm 222–225 on the Columbia River; Figures 2, 3). Half of the TR smolts were released in early May, and half were released in late May (Table 1). Smolts that were assigned to the same group but released on different days were pooled because TDG levels were similar and we did not expect the small difference in release dates to affect survival (Table 1).

The IR-HIGH smolts were released at an average TDG of 132%, and IR-LOW smolts were released when average TDG was 118%. The river water above Bonneville Dam was also supersaturated; TDG averaged across the five U.S. Geological Survey (USGS) monitoring sites above Bonneville Dam from April 1 to May 25 (from the start of the fish migration season and voluntary spill at the Columbia River dams through the last capture date) was 113% (Tanner et al. 2011; USGS 2013). Based on laboratory studies (e.g., Mesa et al. 2000) and field studies (Cramer 1996), we hypothesized that potential exposure prior to tagging of fish followed by their release at TDG levels exceeding 130% would result in chronic effects, acute effects, or a combination of effects that would be evident in the reduced survival of the IR-HIGH group relative to the IR-LOW group.

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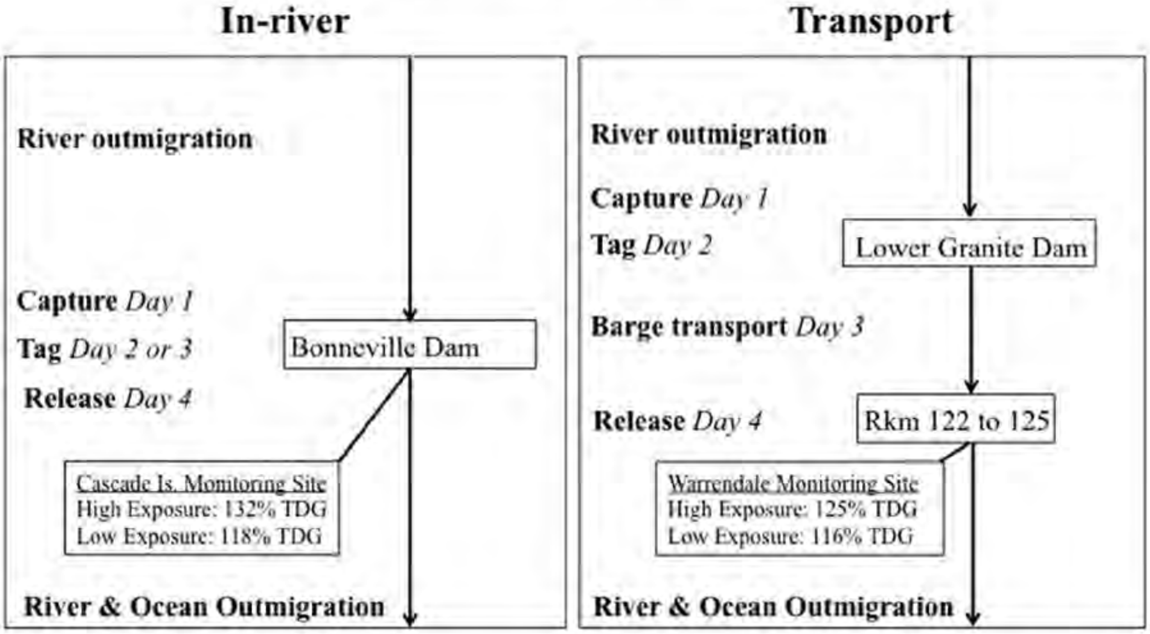

FIGURE 3. Treatment of the in-river-migrating and transported groups of Chinook Salmon smolts, indicating the timing of tagging events at Bonneville Dam (Columbia River) and Lower Granite Dam (Snake River). Total dissolved gas (TDG) levels presented for the high- and low-exposure groups were averaged over the release dates shown in Table 1. Panels are not to scale with regard to distance between locations.

The TR-HIGH smolts were released when average TDG was 125%, and the TR-LOW smolts were released at an average TDG of 116%. The river above Lower Granite Dam was also supersaturated; average TDG during April 1–May 25 at the two monitoring sites above Lower Granite Dam was 107%. Since the TR-HIGH group experienced an average TDG of 125%, we did not expect their acute mortality to be greater than that of the TR-LOW group (Weitkamp and Katz 1980; Cramer 1996), but we hypothesized that chronic effects would be evident.

Tagged smolts were tracked downriver and then north in the coastal ocean to Lippy Point, British Columbia, with listening lines ("subarrays") of acoustic receivers (Figure 1). We assumed that smolts swam northward shortly after entering the ocean and that the cross-shelf extent of the ocean subarrays was sufficient to bound the early marine migratory path

TABLE 1. Release groups, tagging sites (with release sites in parentheses), release dates, and numbers of Chinook Salmon smolts that were tagged in the Columbia River system (rkm = river kilometer) during 2011 (total dissolved gas [TDG] monitoring sites: CCIW = Cascade Island; WRNO = Warrendale; SYSTDG = SYSTDG model estimates of TDG).

Tagging site (release site)	Group	TDG treatment	Release date	Number released	TDG (%) at release (TDG monitoring site)
Lower Granite Dam (rkm 111–115)	Transported	Low exposure	May 3	47	115.1 (WRNO)
			May 5	53	116.1 (WRNO)
		High exposure	May 21	50	125.8 (WRNO)
			May 22	50	124.8 (WRNO)
Bonneville Dam (Bonneville Dam)	In-river	Low exposure	Apr 23	100	118.8 (CCIW)
			Apr 24	100	118.5 (CCIW)
			May 3	50	118.0 (CCIW)
			May 5	50	118.5 (CCIW)
		High exposure	May 19	48	131.0 (SYSTDG)
			May 22	101	131.3 (SYSTDG)
			May 27	72	133.8 (SYSTDG)
			May 28	59	133.3 (SYSTDG)

of similar proportions of the compared groups. These assumptions are well-supported by decades of trawl and telemetry observations, which consistently demonstrated a shelf-confined, rapid northward migration of juvenile yearling Chinook Salmon beyond the near vicinity of the Columbia River mouth and its strong tidal currents (Miller et al. 1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010; Rechisky et al. 2014).

Although acoustic-tagged smolts have been detected on the southwest and western terminus of receiver arrays placed within approximately 15 km of the Columbia River mouth (McMichael et al. 2013), these detections occurred during outgoing tides and reflect the influence of the tidal plume, where currents can exceed smolt swimming speeds (Horner-Devine et al. 2009). We do not believe that these reflect coastal ocean migration patterns reported in previous trawl and telemetry studies (e.g., Miller et al. 1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010), and they do not suggest a violation of our assumptions.

The median difference in the time of detection between the subarrays at Astoria and Sand Island was only 2.8 h (SE = 0.25); due to the limited information and statistical penalty involved in estimating four additional parameters for survival of IR-HIGH, IR-LOW, TR-HIGH, and TR-LOW smolts in this small region, the detections at Sand Island were combined with the Astoria subarray detections to estimate survival in the lower Columbia River and estuary region (Figure 1). Six IR-LOW smolts were detected on a subarray of receivers at Cascade Head, Oregon (Figure 1), and one of those smolts was subsequently detected as rapidly migrating northward across the Willapa Bay and Lippy Point (British Columbia) subarrays. We only used the detections of the five remaining smolts at Sand Island–Astoria in the survival model, thus apportioning their mortality to the plume region.

Survival (φ) in each migration segment for high- and low-exposure IR and TR fish and the detection probability (p) at each subarray were estimated by using the Cormack–Jolly–Seber (CJS) live-recapture modeling framework, which was implemented with the RMark package in R (Lebreton et al. 1992; White and Burnham 1999; R Development Core Team 2011; Laake 2012). We used Akaike's information criterion (AIC) corrected for overdispersion and small-sample bias ($QAIC_c$) to select from three hypothesized models of the parameter p, including (1) a model with a single common p at each subarray, (2) a model with a unique p for each group at each subarray, and (3) a model with a unique p for each group at Astoria (freshwater) and a common p at each ocean array (Rechisky et al. 2014).

We considered AIC difference (ΔAIC) values greater than 2 to be significant for selecting the top-ranked model (model 1), which was used for all subsequent analyses. The ΔAIC between models 1 and 2 was 9.30, and the ΔAIC between models 1 and 3 was 4.86. The parameter φ was estimated for all four groups in the lower river (from release to Astoria) and plume (from Astoria to Willapa Bay). Lippy Point was the final array along the migratory path, and the estimated φ was thus confounded with p on that array.

We used the median $\hat{c}$ method to evaluate the model for overdispersion, a condition where the sampling variance exceeds the expected theoretical variance due to a lack of model fit or due to violations of CJS assumptions, and we adjusted the parameter variances of the selected model to avoid overestimating the precision of the parameters (White and Burnham 1999; Burnham and Anderson 2002). We used data from an ancillary tag life study conducted in 2011 (see details in the Supplement available in the online version of this article) and program ATLAS methods to correct the φ estimates for possible tag failure during migration to Lippy Point (Lady et al. 2012); tag-life-corrected survival estimates are denoted S.

High river flows that elevate TDG also shorten the time interval (or residence time) over which survival is observed, and it is important to scale the measured survival values by the observational period as $S^{\frac{1}{T}}$, where S is the corrected φ estimate and T is the travel time. Calculating daily survival rates (S'_D) in the lower river ($S'_{D,River}$) and plume ($S'_{D,Plume}$) required the group travel times in the lower river (T_{River}) and plume (T_{Plume}). We defined T_{River} as the median of individual lower-river travel times (d), which were calculated by subtracting the release date from the time of entry into the plume, where entry time is taken as the final detection time of an individual at Astoria or Sand Island. The T_{Plume} was the median of individual plume travel times, which were calculated by subtracting the time of plume entry from the time of plume departure (the final detection of an individual at the Willapa Bay subarray).

In making this calculation, we assumed that survival rates per unit time were constant and that any effects on the measured travel times from the differential survival of slower- or faster-moving smolts were sufficiently small and similar between the compared groups such that the results were not affected. An alternative measure, survival per kilometer traveled, $S^{\frac{1}{km}}$, could also be used if individual travel distances between detection sites were known. However, the average distances between subarrays—particularly between Astoria and Willapa Bay—were likely not representative of distances traveled because the smolts' migration path between receivers was unknown.

We examined the effect of TDG exposure within groups by using the log odds ratio,

$$\log_e\left(\frac{S_{LOW}}{1-S_{LOW}}\bigg/\frac{S_{HIGH}}{1-S_{HIGH}}\right),$$

and z-scores for estimated S and S'_D, where S_{LOW} and S_{HIGH} denote survival or daily survival estimates for the low-exposure and high-exposure groups, respectively. The SE of the log odds was estimated using the delta method, and z-scores were evaluated at the 0.05 level. A log odds ratio greater than zero indicates that the odds of survival is greater for the low-exposure group than for the high-exposure group. Travel times were nonnormally distributed, so the variability of each group's travel time was evaluated by using the median absolute deviation (MAD). The variances of the estimated survival rates were determined by bootstrap resampling of the capture histories and travel times within each group; estimating the φ, S, and S'_D for the resampled groups; and then calculating the variance of the results. The incorporation of bootstrap resampling of travel times captured the variability in $S^{\frac{1}{T}}$ resulting from variability in travel time.

In estimating survival, we made the standard CJS assumptions that (1) every tagged individual has an equal probability of survival and detection after release, (2) sampling periods are instantaneous, (3) emigration is permanent, (4) tags are not lost, and (5) the fish that are detected have the same probability of future detection as tagged fish that are alive but undetected. Results from tag effects and tag retention studies supporting these assumptions are reported in the Supplement.

At high levels of gas supersaturation (TDG > 130%), acute mortality due to GBT may occur within hours (Mesa et al. 2000). We were unable to determine whether acute mortality occurred in the IR-HIGH group because we could not count the surviving smolts until they reached Astoria several days after exposure. If acute mortality occurred quickly and close to the point of release and if the subsequent mortality rate was constant, then the following formula can be used to estimate the acute mortality at release that would result in the estimated survival to Astoria for the high-exposure group, assuming that the estimated daily survival rate of the low-exposure group in the lower river represented a base rate that was common to both high- and low-exposure groups:

$$M_a = 1 - \left[\frac{S_{R(e)}}{S'_{D(u)}{}^{T_{R(e)}}} \right],$$

where M_a is acute mortality, $S_{R(e)}$ is the estimated net lower-river survival of the high-exposure group, $S'_{D(u)}$ is the estimated daily survival rate (denoted by a prime) of the low-exposure group, and $T_{R(e)}$ is the lower-river residence time of the high-exposure group. The time to 20% mortality (LT_{20}) at 130% TDG was 3–6 h in the laboratory (Mesa et al. 2000). The SE of M_a was obtained by using the bootstrap routine described above. If these smolts experienced acute mortality due to GBT within a few hours of exposure to supersaturated water, then we would expect a comparable M_a estimate, with differences being potentially attributable to chronic mortality. This estimate should be received with care, however. Exposures in the field and laboratory may be very different, and the mortality in smolt groups exposed to 130% or greater TDG levels in the laboratory was variable: mortality at 3 h ranged from approximately 0% to 20%, and mortality at 6 h was approximately 20–65% (Mesa et al. 2000).

Hourly TDG levels recorded by automated water quality monitoring stations were provided by the U.S. Geological Survey (USGS 2013). Monitoring stations were located at (1) Cascade Island, situated immediately below Bonneville Dam and 1 km from the IR release site; (2) Warrendale, Oregon, 9 km downstream of the dam at rkm 225 and 0–3 km from the TR release sites; (3) Camas–Washougal, 40 km downstream (Figure 1); and (4) five upriver stations. Monitoring site locations and quality assurance measures for the TDG data were described by Tanner et al. (2011). Levels of TDG at the Lower Granite Dam forebay and at the Dworshak Dam tailrace were obtained from the U.S. Army Corps of Engineers (USACE) via the Columbia Basin Research portal (CBR 2013). The TDG levels declined, on average, 0.5% per kilometer between Cascade Island and Warrendale, so we expected that the TDG values recorded at these monitoring sites would be comparable to the TDG occurring at the release sites.

High discharge through the Bonneville Dam spillway destroyed the Cascade Island monitoring site on May 18, 2011, just prior to the release of 280 acoustic-tagged fish at the Bonneville Dam smolt monitoring facility (Table 1; Tanner et al. 2011). In lieu of field observations, we obtained estimates of hourly TDG at Cascade Island from SYSTDG, a sophisticated model that is used by USACE to predict TDG levels and support spill management decisions in the Columbia River basin (Schneider and Hamilton 1999; L. Hamilton, USACE, personal communication). The SYSTDG output compared well with observed TDG at Cascade Island when the monitoring station was intact (Figure 1), indicating that the use of mixed-source TDG data was unlikely to affect our grouping of IR smolts and analysis of their survival.

RESULTS

Overall, 523 smolts were detected at the Astoria subarray, 480 were detected at the Sand Island subarray, 105 were detected at the Willapa Bay subarray, 31 were detected at the Lippy Point subarray, and 6 were detected at the Cascade Head subarray. In total, 608 smolts were detected at the combined Sand Island–Astoria subarray, with an estimated p of 0.96 (SE = 0.02). At the Willapa Bay subarray, 110 smolts were detected, with an estimated p of 0.71 (SE = 0.10; Table 2).

Seventy-two IR-LOW fish were detected at the Columbia River mouth and remained somewhere upriver of the Astoria and Sand Island subarrays after May 14, when TDG reached 120% in the Bonneville Dam tailrace. Of those 72 smolts, 68 fish subsequently crossed the river mouth by May 23, 3 fish crossed by May 28, and the single remaining fish crossed on June 13. The final two TR-LOW fish to be detected at the river mouth crossed on May 15. Applying a back-calculation of their individual average travel speeds and the rate of decline in TDG from Bonneville Dam to the Camas–Washougal TDG

TABLE 2. Detection probabilities (p) at each subarray, survival estimates before (φ) and after (S) correction for tag life, daily survival (S'_D), travel time (T; d), and log odds ratios for Chinook Salmon smolts in the lower Columbia River and plume (IR = in-river-migrating smolts; TR = transported smolts; HIGH = high TDG exposure; LOW = low TDG exposure; MAD = median absolute deviation). Log odds ratios in bold italics denote z-tests that were significant at the 0.05 level.

Lower river	p	φ (SE)	S (SE)	Log odds (SE)	T (MAD)	S'_D (SE)	Log odds (SE)
				Lower River			
IR-HIGH	0.96 (0.02)	0.80 (0.03)	0.82 (0.03)	0.14 (0.25)	2.7 (0.05)	0.93 (0.01)	***1.90 (0.27)***
IR-LOW		0.82 (0.03)	0.84 (0.03)		15.4 (1.23)	0.99 (0.002)	
TR-HIGH		0.86 (0.04)	0.88 (0.04)	−0.63 (0.45)	3.3 (0.11)	0.96 (0.01)	−0.25 (0.47)
TR-LOW		0.78 (0.05)	0.80 (0.05)		4.6 (0.04)	0.95 (0.01)	
				Plume			
IR-HIGH	0.71 (0.10)	0.28 (0.05)	0.28 (0.05)	−0.10 (0.25)	4.2 (0.94)	0.74 (0.05)	***0.85 (0.26)***
IR-LOW		0.26 (0.04)	0.26 (0.04)		9.4 (1.26)	0.87 (0.02)	
TR-HIGH		0.19 (0.05)	0.19 (0.06)	−1.08 (0.60)	4.0 (3.25)	0.66 (0.20)	0.98 (1.04)
TR-LOW		0.07 (0.04)	0.07 (0.04)		14.9 (0.14)	0.84 (0.13)	

monitoring station (Figure 2), we estimated that only the single IR fish that crossed on June 13 was potentially exposed to TDG above 120%, and we made no adjustments to the group assignments. We believe that the use of average travel speeds—and therefore constant rates of travel—was reasonable; Carter et al. (2009) found that acoustic-tagged smolts were detected on their acoustic arrays in the lower Columbia River nearly equally during all hours of the day, indicating constant travel.

The median $\hat{c}$ of the survival model was 1.45 (SE = 0.32). Lebreton et al. (1992) and Burnham and Anderson (2002) suggested that $\hat{c}$-values should not exceed 3 or 4. A value of 1.45 was thus very weak evidence for overdispersion and indicated limited violations of our assumptions and a good structural fit of the model. Estimated φ, S, travel times, S'_D, and log odds ratios are presented in Table 2, along with the probability of detection (p) at each array.

In the lower Columbia River, estimated S was 0.82 (SE = 0.03) for the IR-HIGH group and 0.84 (SE = 0.03) for the IR-LOW group. The log odds ratio was 0.14 (SE = 0.25), which means that the odds of surviving to the Columbia River plume was 1.15 times greater for the IR-LOW group, calculated as $e^{0.14}$; these estimates are provided only for significant results hereafter. The log odds ratio was not significant at the 0.05 level (z = 0.57, P = 0.57). Median travel times were 2.7 d (MAD = 0.05) for the IR-HIGH group and 15.4 d (MAD = 1.23) for the IR-LOW group. Estimated $S'_{D,River}$ was 0.93 (SE = 0.01) for the IR-HIGH group and 0.99 (SE = 0.002) for the IR-LOW group. The log odds ratio of $S'_{D,River}$ estimates was 1.90 (SE = 0.27) and was significant at the 0.05 level (z = 7.12, $P = 1.06 \times 10^{-12}$). This means that the odds of surviving to the plume was 6.69 times greater for the IR-LOW group than for the IR-HIGH group.

The estimated S for the TR-HIGH smolts in the lower river was 0.88 (SE = 0.04), and the estimated S for the TR-LOW group was 0.80 (SE = 0.05). The log odds ratio was −0.63 (SE = 0.45) and was not significant at the 0.05 level (z = −1.39, P = 0.16). Median travel times were 3.3 d (MAD = 0.11) for the TR-HIGH group and 4.6 d (MAD = 0.04) for the TR-LOW group. Estimated $S'_{D,River}$ was 0.96 (SE = 0.01) for TR-HIGH smolts and 0.95 (SE = 0.01) for TR-LOW smolts. The log odds ratio of estimated $S'_{D,River}$ was −0.25 (SE = 0.47) and was not significant at the 0.05 level (z = −0.54, P = 0.59).

In the Columbia River plume, estimated S was 0.28 (SE = 0.05) for the IR-HIGH group and 0.26 (SE = 0.04) for the IR-LOW group. The log odds ratio was −0.10 (SE = 0.25) and was not significant at the 0.05 level (z = −0.04, P = 0.69). Median travel times were 4.2 d (MAD = 0.94) for the IR-HIGH group and 9.4 d (MAD = 1.26) for the IR-LOW smolts. The $S'_{D,Plume}$ was estimated at 0.74 (SE = 0.05) for the IR-HIGH group and 0.87 (SE = 0.02) for the IR-LOW group. The log odds ratio of estimated $S'_{D,Plume}$ was 0.85 (SE = 0.26) and was significant at the 0.05 level (z = 3.26, P = 0.001). This means that the odds of surviving through the plume was 2.34 times greater for IR-LOW fish than for IR-HIGH smolts.

For the TR-HIGH group, estimated S in the plume was 0.19 (SE = 0.06); for TR-LOW smolts, estimated S in the plume was 0.07 (SE = 0.04). The log odds ratio was −1.08 (SE = 0.60) and was not significant at the 0.05 level (z = −1.8, P = 0.07). Median travel times were 4.0 d (MAD = 3.25) and 14.9 d (MAD = 0.14), respectively, for TR-HIGH and TR-LOW smolts. The $S'_{D,Plume}$ was estimated at 0.66 (SE = 0.20) for the TR-HIGH group and 0.84 (SE = 0.13) for the TR-LOW group. The log odds ratio of estimated $S'_{D,Plume}$ was 0.98 (SE = 1.04) and was not significant at the 0.05 level (z = 0.95, P = 0.34).

We estimated M_a at 0.16 (SE = 0.03), meaning that 16% of the IR-HIGH group would have to succumb shortly after release to realize the observed $S_{R(e)}$ of 82% (SE = 0.03). This compares reasonably well with the LT_{20} of 3–6 h for fish that were held at 130% TDG in the laboratory (Mesa et al. 2000). An M_a of 20% would require $S_{R(e)}$ to equal 79%, which is within one SE of the observed $S_{R(e)}$. The estimate of M_a

suggests that direct mortality effects of high TDG are possible in this group, but it does not eliminate the possibility of chronic effects.

DISCUSSION

There is substantial prior evidence that exposure to elevated TDG levels can be harmful to aquatic organisms. Similar to divers suffering decompression sickness (Todnem et al. 1991), smolt mortality after TDG exposure may occur in (1) an acute phase of GBT that can produce blockages of the vascular system (emboli) and internal and external soft tissue damage, wherein mortality is relatively quick and is directly caused by embolism or emphysema blocking blood flow to critical organs; or (2) a chronic phase in which mortality may occur later and over much longer time periods and may indirectly result from predators targeting smolts with reduced fitness, reduced resistance to bacterial and fungal infections, or impairments in motor skills, brain function, or lateral line function that could increase susceptibility to predation (Bouck et al. 1976; Schiewe and Weber 1976; Bouck 1980; Mesa and Warren 1997; Weiland et al. 1999; Mesa et al. 2000; Huchzermeyer 2003). By definition, chronic effects on survival are much more difficult to quantify in laboratory settings. Our results are consistent with the known effects of TDG exposure, but they rest on assumptions (discussed in detail below) that are uncertain.

It is clear that elevated TDG levels affected the IR-HIGH group held at the Bonneville Dam smolt monitoring facility. Daily maximum TDG levels in the Bonneville Dam forebay reached 123% on May 27 and 122% on May 28 (USGS 2013). Exposure to the forebay-sourced water in the 1-m-deep holding tanks produced GBT in 17 smolts that were found dead in a tank on May 28 and were examined by the Lower Columbia River Fish Health Center (the 59 remaining smolts did not appear to be affected). This was the only large mortality event that was observed during tagging at Bonneville Dam, and it occurred as TDG levels peaked (Figure 2), demonstrating lethality.

Of the 75 smolts that were held prior to release, 3 individuals also perished on May 27, presumably due to GBT, but they were not examined. No additional mortalities attributable to elevated TDG were observed during tagging at Bonneville Dam or at Lower Granite Dam, where TDG levels in the forebay peaked at 107% (CBR 2013). There were no reported incidences of GBT in TR smolts, and the barges that were used for transporting the smolts from Lower Granite Dam for release below Bonneville Dam operated gas-stripping equipment to prevent GBT during transit. Thus, there was compelling evidence for the lethality of river water reaching the upstream face of Bonneville Dam, despite some opportunity for off-gassing as the water flowed downstream from John Day Dam just prior to spill, further increasing the TDG levels below Bonneville Dam.

Although we cannot demonstrate causality, the differences in estimated survival rates between the IR-HIGH and IR-LOW groups were consistent with the effects of GBT. The IR-HIGH group experienced multiple exposures to elevated TDG: potentially in the Columbia River upstream of Bonneville Dam; certainly in the holding tank at the dam; and then again upon release into the river below the dam, when TDG levels were further elevated (130–134% TDG; Table 1). The estimated survival rates of the IR-HIGH smolts in the lower river and plume were reduced relative to those of the IR-LOW group but not significantly so. However, when the residence time between successive acoustic subarrays was considered, the IR-HIGH group experienced a significantly reduced odds of survival in the lower river and the plume, which could potentially be explained by the direct and indirect effects of GBT on survival. Unfortunately, we could not distinguish whether acute effects, chronic effects, or both were operating on survival, so we presented both for purposes of completeness. Although our M_a estimate was strikingly consistent with expectations, this laboratory-to-field comparison should be interpreted with care because (1) LT_{20} values in the laboratory are variable at high levels of TDG and (2) exposures in a field setting will be more variable than those occurring in the laboratory and may include additional factors.

The TR-HIGH group did not experience the same repeated exposures to supersaturated water. Although they were potentially exposed while migrating to Lower Granite Dam, they subsequently traveled in barges with gas-stripping equipment and were released at a location with lower levels of gas supersaturation (maximum TDG = 126%). Their limited exposure and rapid movement downstream (median = 3.3 d) may explain the lack of a significant effect on estimated survival rates in the lower river: either TDG was too low or observation time was insufficient to permit the detection of any effect. However, the point estimate of the effect on plume survival for TR smolts was similar to that for IR smolts, which could indicate chronic impacts on fitness from otherwise nonlethal exposure. Unfortunately, because fewer than 100 smolts reached the Willapa Bay subarray, it was not possible to draw a statistically robust inference. Any GBT effect that is manifested in the plume would probably not be caused by stress related to seawater acclimation (Nebeker et al. 1979).

Although the differences were not statistically significant, it is interesting that the TR-HIGH smolts had higher estimated survival in the lower Columbia River and plume and a higher estimated $S'_{D\,River}$ than the TR-LOW smolts. Scaling by time nearly removed the effect in the lower river, but these results were contrary to the commonly held belief that smolt mortality increases over the migratory season; we have no clear explanation for this finding.

Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT, may also affect smolt survival in the Columbia River and plume, and such factors cannot be separated from the potential TDG effects in this

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study. However, it is unclear whether these factors would have affected survival during the study period. Water temperature measured at the Warrendale monitoring station (Figure 1) was between 8°C and 13°C when IR and TR smolts were released; these temperatures are well below lethal levels (22–25°C) or the levels that affect growth in juvenile Chinook Salmon (15°C; Richter and Kolmes 2005).

Turbidity increased between the release times of the low- and high-exposure groups, thereby reducing visibility (Secchi depth) from approximately 0.91 m (3 ft) to 0.61 m (2 ft) in the Bonneville Dam forebay (CBR 2013) and increasing the measured turbidity from approximately 6 NTU to 12 NTU at rkm 85 (CMOP 2016). Increasing turbidity is generally expected to improve rather than reduce smolt survival. For example, Gregory and Levings (1998) found that predation on juvenile salmonids by piscivorous fish was significantly reduced in the turbid Fraser River (26–106 NTU) relative to the clear Harrison River and Nicomen Slough (<6 NTU), although those authors examined a wider range of turbidity.

Other diseases also do not seem likely to have played a role. Differences in the proportion of smolts exhibiting signs of disease other than GBT on dates when IR-HIGH and IR-LOW smolts were collected for tagging were not significant at the 0.05 level (*z*-tests; Fish Passage Center 2013b). The proportion of diseased smolts recorded at Bonneville Dam was 0.011 when IR-LOW smolts were collected ($n = 145$ fish examined on April 20; $n = 100$ fish examined each day on April 21, 30, and May 2) and 0.015 when IR-HIGH smolts were collected ($n = 100$ fish examined each day on May 16 and 24; $z = -0.39$, $P = 0.69$). No disease data were recorded on May 19 or May 25. The proportion of diseased smolts recorded at Lower Granite Dam was 0.02 when TR-LOW smolts were collected ($n = 100$ fish examined each day on April 30 and May 2) and 0.00 when TR-HIGH smolts were collected ($n = 84$ fish examined on May 18; $n = 80$ fish examined on May 19; $z = 1.82$, $P = 0.069$).

The effect of emigration timing on plume survival is unclear. The timing of ocean entry has been linked to smolt-to-adult survival rates; Scheuerell et al. (2009) found that smolt-to-adult return rates improved among fish entering the ocean in early to mid-May relative to mid-June but not during the April–May period used here. However, their approach measured the effect of the entire marine life cycle on smolt-to-adult return rates, including a survival period encompassing the smolts' first winter at sea—not just the brief period of plume occupancy (Beamish and Mahnken 2001). Because survival was measured at adult return (2–3 years after ocean entry), it is unclear whether the timing of plume entry would have resulted in a reduced odds of daily survival. Brosnan et al. (2014) found that daily plume survival rates measured using acoustic telemetry varied little from 2008 to 2011.

The effect of emigration timing on river survival has been better studied, although the results differ. In the Columbia River basin, Smith et al. (2002) examined the effect of release date on juvenile Chinook Salmon survival in the lower Snake River (280 km upstream of Bonneville Dam) and found no significant correlation between release date and survival. Schreck et al. (2006) found that in 2 of 6 years, mortality of both the transported smolts and the combined (pooled) transported and in-river smolts increased in the lower Columbia River during the fish migration season. In contrast, however, McMichael et al. (2011) found that lower river survival of yearling Chinook Salmon smolts increased significantly from early May to late May, similar to our finding of improved (although nonsignificant) lower river survival in the later-arriving TR-HIGH group.

Columbia River basin smolts are observed to display GBT symptoms when in-river TDG levels are elevated (Fish Passage Center 2013a), and exposure to supersaturated water leading to sublethal GBT experiences may have secondary effects that impact survival rates (Weitkamp 1976; Lutz 1995; Cramer 1996; Mesa and Warren 1997; Huchzermeyer 2003). Although horizontal and vertical avoidance of supersaturated waters is potentially possible, it is clearly insufficient to completely protect smolts from GBT effects because they are routinely found with evidence of GBT when TDG levels reach 125%. The question of whether TDG levels can be raised above their current limits to 125% to allow increased spill in the Federal Columbia River Power System without affecting smolt survival (e.g., ISAB 2014) is challenging to answer due to (1) the complexity of exposure histories that are not easily replicated in the laboratory; and (2) consequently, poor characterization of the effects of such exposures in the field. Results from the TR smolts examined here can be interpreted as indicating that exposure at approximately 125% TDG when previous exposure is limited has little direct impact on smolt survival but may lead to chronic effects that are expressed later in the life history. However, similar to the observations made by Cramer (1996) and based on our analysis of IR smolts, we find that exposure to approximately 130% TDG, when accompanied by previous sublethal exposures to gas-supersaturated water, may reduce survival via acute effects, chronic effects, or a combination thereof.

Retrospective cohort studies are useful in evaluating survival effects when exposure to the causative agent is rare and difficult to replicate, as is the case here. However, it is the nature of such studies that the results are potentially confounded with other unidentified differences, which in our study would involve other uncontrolled mortality factors (e.g., predator abundance in the Columbia River plume) that may covary with the differing arrival times of the high- and low-exposure groups. Although mortality due to GBT is a parsimonious explanation for the observed differences in survival estimates, it is not possible to exclude other potential causes for the measured differences in survival rate.

Our conclusions also rest on several assumptions: (1) survival is a time-based process rather than being strictly distance based; (2) the survival rate is constant; and (3) any effect on the measured travel times from differential survival of slower-or faster-moving smolts is similar between the compared groups such that the results are not affected.

We measured statistically significant differences in daily survival rates, and in our view, the drivers of smolt mortality in the Columbia River region are predominantly time based: if smolts did not migrate, they would still be subject to predation and disease over time—and (likely) at a consistent rate—while physically remaining in a particular location. In this time-based case, the lack of significant differences in estimated aggregate plume survival measured between the Astoria and Willapa Bay subarrays might have resulted from the observation period being of insufficient duration (~1 week).

The question of whether survival estimates measured between different geographic subarrays should be normalized by the time required for the different smolt groups to reach the sub-arrays may be contentious. Because smolts that were exposed to high TDG levels also migrated between subarrays more quickly, likely due to the higher flow rates that occurred under high-flow conditions, their survival was measured over a shorter time period than was used for smolts that were exposed to lower TDG levels. It can be argued that measured survival may simply be related to the distance traveled rather than time, so scaling for observation time may be inappropriate. We do not have sufficient information to rule out purely distance-based mortality processes (e.g., strong spatial variability in predation pressure) operating in the lower Columbia River, estuary, and coastal plume.

Although our results are consistent with the known effects of TDG, the uncertainty in the underlying assumptions calls for a controlled experiment to clarify how survival in the lower freshwater reaches of the Columbia River and the coastal ocean is affected by TDG exposure. A formal experiment that uses simultaneous paired releases of smolts that are exposed to different levels of TDG along with control groups of unexposed smolts could easily be performed by using the same techniques described here and by Rechisky et al. (2012, 2013). Fixed-time sampling would address assumptions about survival rates and the difficulty presented by different observation periods. In the absence of fixed-time sampling, which poses a significant technical challenge, greater spatial sampling (i.e., more densely spaced arrays over a larger area) would improve inferences about survival rates. Extending the period of observation beyond 1 month would also help to elucidate survival differences that are not clearly distinguishable by the time the smolts reach Willapa Bay. Such an experiment seems especially warranted within the Columbia River basin given the potentially significant conservation and economic costs of transitioning to higher spill levels (National Marine Fisheries Service 2013) and could inform new lines of inquiry globally, as increasing numbers of hydropower projects are raising concerns about fish health (Huang and Yan 2009; Finer and Jenkins 2012; Wang et al. 2015).

ACKNOWLEDGMENTS

We thank Laura Hamilton (USACE) for providing SYSTDG model predictions for the Cascade Island site, and we are grateful to Dean Ballinger (Pacific States Marine Fisheries Commission) and the staff at the Bonneville Dam smolt monitoring facility for their invaluable support during the 2011 tagging season. The U.S. Department of Energy, Bonneville Power Administration, provided funding to Kintama Research under Project Number 2003-114-00. I.G.B. gratefully acknowledges the support of the U.S. Department of Defense through the National Defense Science and Engineering Graduate Fellowship Program. Finally, we would like to thank the three anonymous reviewers for their insightful comments.

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From: Creason,Anne M (BPA) - EWL-4

Sent: Mon Oct 24 23:03:55 2016

To: David Welch

Subject: Automatic reply: TDG Paper...

Importance: Normal

I am out of the office this afternoon (10/24). I will return tomorrow, 10/25.

If you need immediate assistance, please contact Jennifer Yarman at 503-230-4981 or Bryan Pham at 503-230-4101.

From: David Welch

Sent: Tue Oct 25 09:30:09 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Importance: Normal

Thanks, Ben—It will go no farther. I deeply appreciate your support (& your current frustration with government!).

D.

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Tuesday, October 25, 2016 9:15 AM
To: David Welch
Subject: FW: Comparison of Surival in Large Western Rivers Analysis

David,

I'm sharing this internal email thread with you so you know what we decided. Please don't distribute.

The short answer is that we officially have $110k (not $119k) for a contract that we can move forward on now. Anne Creason is going to New Zealand for a month so Christine Petersen will take over as the COTR. I have a meeting with Anne and Christine today to discuss next steps so expect a follow up from one or both of them to wrap up the contract preparation and submit a package to procurement. I support your recommendation to focus on analysis product number 3.

Thanks again for your patience,

Ben

From: Mercier,Bryan K (BPA) - EW-4
Sent: Monday, October 24, 2016 5:35 PM
To: Zelinsky,Benjamin D (BPA) - EWP-4; Barco III,John W (BPA) - EWP-4; Dondlinger,Gregory J (BPA) - E-4; Skidmore,John T (BPA) - EWL-4
Cc: Sweet,Jason C (BPA) - PGB-5; Dick,Ben M (BPA) - EWB-4; Lane,Jeffrey W (BPA) - EWB-4; Petersen,Christine H (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; McDonald,Katie M (BPA) - EWP-4
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

No transfer, but begin contracting. We'll note that the budget is forthcoming.

Bryan K Mercier

503.230.3991

From: Zelinsky,Benjamin D (BPA) - EWP-4
Sent: Monday, October 24, 2016 4:51 PM
To: Mercier,Bryan K (BPA) - EW-4; Barco III,John W (BPA) - EWP-4; Dondlinger,Gregory J (BPA) - E-4; Skidmore,John T (BPA) - EWL-4
Cc: Sweet,Jason C (BPA) - PGB-5; Dick,Ben M (BPA) - EWB-4; Lane,Jeffrey W (BPA) - EWB-4; Petersen,Christine H (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; McDonald,Katie M (BPA) - EWP-4
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

OK - thanks Bryan

So can we transfer the money in to the Bioanalyst project now so we can begin contracting but hold off on taking the money out of the 15 mile creek until after the 15th? Or do we need to wait on the whole thing?

Ben

-------- Original message --------
From: "Mercier,Bryan K (BPA) - EW-4" <bkmercier@bpa.gov>
Date: 10/24/16 3:18 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>, "Barco III,John W (BPA) - EWP-4" <jwbarco@bpa.gov>, "Dondlinger,Gregory J (BPA) - E-4" <gjdondlinger@bpa.gov>, "Skidmore,John T (BPA) - EWL-4" <jtskidmore@bpa.gov>

Cc: "Sweet,Jason C (BPA) - PGB-5" <jcsweet@bpa.gov>, "Dick,Ben M (BPA) - EWB-4" <bmdick@bpa.gov>, "Lane,Jeffrey W (BPA) - EWB-4" <jwlane@bpa.gov>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>, "Creason,Anne M (BPA) - EWL-4" <amcreason@bpa.gov>, "McDonald,Katie M (BPA) - EWP-4" <kmmcdonald@bpa.gov>
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Meeting with ODFW on Nov. 15th and it will be a tell. Smart closeout of 15 Mile RME. Details will still need to be worked out, but its safe to proceed with Kintama and $110k in FY17...

Bryan K Mercier

503.230.3991

From: Zelinsky,Benjamin D (BPA) - EWP-4
Sent: Monday, October 24, 2016 1:03 PM
To: Mercier,Bryan K (BPA) - EW-4; Barco III,John W (BPA) - EWP-4; Dondlinger,Gregory J (BPA) - E-4
Cc: Sweet,Jason C (BPA) - PGB-5; Dick,Ben M (BPA) - EWB-4; Lane,Jeffrey W (BPA) - EWB-4; Petersen,Christine H (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; McDonald,Katie M (BPA) - EWP-4
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Bryan,

Is the meeting with Council and ODFW a tell or a discuss? When in Nov will the meeting be happening? I want to help set expectations appropriately with Kintama. They have some personnel and lease decisions that depend on all of this.

Thanks,

Ben

From: Mercier,Bryan K (BPA) - EW-4
Sent: Thursday, October 20, 2016 12:12 PM
To: Zelinsky,Benjamin D (BPA) - EWP-4; Barco III,John W (BPA) - EWP-4; Dondlinger,Gregory J (BPA) - E-4
Cc: Sweet,Jason C (BPA) - PGB-5; Dick,Ben M (BPA) - EWB-4; Lane,Jeffrey W (BPA) - EWB-4; Petersen,Christine H (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; McDonald,Katie M (BPA) - EWP-4
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Small correction, but the likely value from 15 Mile is $110k. Please hold off transferring anything until we speak with ODFW and Council next month.

Bryan K Mercier

503.230.3991

From: Zelinsky,Benjamin D (BPA) - EWP-4
Sent: Thursday, October 20, 2016 11:16 AM
To: Mercier,Bryan K (BPA) - EW-4; Barco III,John W (BPA) - EWP-4; Dondlinger,Gregory J (BPA) - E-4
Cc: Sweet,Jason C (BPA) - PGB-5; Dick,Ben M (BPA) - EWB-4; Lane,Jeffrey W (BPA) - EWB-4;

Petersen,Christine H (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; McDonald,Katie M (BPA) - EWP-4
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Bryan and I met this week to disuss next steps and although Lorri would like to move forward on this, the budget will not allow us to do that fully. Bryan did agree to using the $119,000 savings from 15 mile to fund this work in part. That amount should be enough to move forward on 1 of the 3 analyses and buy us time to look for additional funding moving forward.

Bryan please confirm that Ben D should transfer $119000 from 15 mile to the Bioanalyst project to support this work.

Thanks

Ben Z

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: "Bodi,Lorri (BPA) - E-4" <florrainebodi@bpa.gov>
Date: 9/30/16 12:36 PM (GMT-08:00)
To: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>, "Mercier,Bryan K (BPA) - EWB-4" <bkmercier@bpa.gov>, "Barco III,John W (BPA) - EWP-4" <jwbarco@bpa.gov>, "Dondlinger,Gregory J (BPA) - E-4" <gjdondlinger@bpa.gov>
Cc: "Sweet,Jason C (BPA) - PGB-5" <jcsweet@bpa.gov>, "Dick,Ben M (BPA) - EWB-4" <bmdick@bpa.gov>, "Lane,Jeffrey W (BPA) - EWB-4" <jwlane@bpa.gov>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>, "Creason,Anne M (BPA) - EWL-4" <amcreason@bpa.gov>, "McDonald,Katie M (BPA) - EWP-4" <kmmcdonald@bpa.gov>
Subject: RE: Comparison of Surival in Large Western Rivers Analysis

Let's sit down at some point and figure out priorities and funding approach for our tech services and BiOp analyses. Where will we reduce and where prioritize for key analyses? I agree we should proceed with Welch, and likely with Hinrichsen replacement. We may have done other items as well as we flesh out the BA in the next month or so.

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Date: 9/30/16 11:44 AM (GMT-08:00)
To: "Mercier,Bryan K (BPA) - EWB-4" <bkmercier@bpa.gov>, "Bodi,Lorri (BPA) - E-4" <florrainebodi@bpa.gov>, "Barco III,John W (BPA) - EWP-4" <jwbarco@bpa.gov>, "Dondlinger,Gregory J (BPA) - E-4" <gjdondlinger@bpa.gov>

Cc: "Sweet,Jason C (BPA) - PGB-5" <jcsweet@bpa.gov>, "Dick,Ben M (BPA) - EWB-4" <bmdick@bpa.gov>, "Lane,Jeffrey W (BPA) - EWB-4" <jwlane@bpa.gov>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>, "Creason,Anne M (BPA) - EWL-4" <amcreason@bpa.gov>, "McDonald,Katie M (BPA) - EWP-4" <kmmcdonald@bpa.gov>
Subject: Comparison of Surival in Large Western Rivers Analysis

At yesterday's RME Update, Lorri confirmed her decision to fund Kintama Research Group to provide some additional analysis to inform our NEPA and BiOp planning. This decision included prioritizing the comparison of SARs between large rivers and comparing juvenile survival in the mainstem and ocean using acoustic tag data. She decided to hold off on comparing Fraser and Columbia juvenile survival data for now.

This work will require additional funds to be added to the Technical Service Fund (~$300,000) for FY17 and then transferred to Project 1996-017-00 - Technical and Analytical Support for ESA Activities/Issues.

Lorri plans to follow up with Bryan to keep him in the loop and to discuss how to accommodate the funding needs. Ben Dick will need confirmation from management to transfer the funds at which point Anne can move forward on the contracting.

Let me know if you have any questions.

Ben Zelinsky

Fish Biologist

Bonneville Power Administration

905 NE 11th Ave

Portland, OR 97232

503-230-4737 (w)

(b)(6) [redacted] (c)

bdzelinsky@bpa.gov

From: Creason,Anne M (BPA) - EWL-4

Sent: Tue Oct 25 14:58:45 2016

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

Cc: Zelinsky,Benjamin D (BPA) - EWP-4; McDonald,Katie M (BPA) - EWP-4; david.welch@kintama.com; 'Erin Rechisky'; Read,Christine L (BPA) - EWB-4

Subject: BPA COTR for Kintama technical services contract

Importance: Normal

Attachments: SOW Kintama-DRAFT (19 Aug 2016).docx; SoleSourceJustification Kintama-DRAFT (19 Aug 2016).docx; LineItemBudgetTemplate.xls

Hi Christine—

Per our discussion with Ben, because I will be out of the office for the month of November you will be taking over as the BPA COTR for the new technical services contract with Kintama (thank you!). It is my understanding that you'll need to complete the following for a BPA technical services contract:

- Pisces SOW: Please see attached a SOW that Kintama has already started working on; you should be able to use this to develop the SOW in Pisces
- A Sole Source Justification: See attached the justification that Kintama worked on. You'll need to write this from your perspective and I recommend getting Chris Read to review before submitting.

- Line Item Budget: Provide the template attached to Kintama to start working on the LIB

- I'm not sure who or how you submit the documents for contracting; you'll need to ask Chris Read or Dave Kaplowe for guidance since they have been through this process before

Once you've got the SOW in Pisces, we can meet to look at your Work Elements. I am available to meet in person tomorrow morning or Monday of next week only.

Thank you—

Anne

Contractor Name

Project/Contract Name # YYYY-xxx-xx
Contract Period
CR-xxxxxx

	Qty2	Qty1		Unit Cost	COST	
						DEL
						Yellow sh shading i
						Use Qty1 blank for
Natural Resource Spec. 3		1.0 mo.	@	$4,346 /mo.	$4,346	
Natural Resource Spec. 1		10.5 mo.	@	$2,470 /mo.	$25,935	
Seasonal Tech. 1	2 pers.	4.0 mo.	@	$1,560 /mo.	$12,480	
	FTE Technical	*15.5*				
Secretary		2.0 mo.	@	$2,064 /mo	$4,128	
	FTE Admin	*2.0*				
				Subtotal Salaries	*$46,889*	
Fringe:		NRS 1,3	@	35.10%	$10,629	These rov requireme
		Seasonals	@	15.15%	$1,891	
		Admin	@	32.00%	$1,321	
		Subtotal Benefits			*$13,840*	
						Include d
Per diem: Field Work	3 pers.	10 days	@	$39 /day	$1,170	
Lodging: Field Work	3 pers.	5 nights	@	$70 /nite	$1,050	To check
Per Diem: Habitat restoration seminar (Portland)		2 days	@	$49 /day	$98	http://www
Lodging: Habitat restoration seminar (Portland)		2 nights	@	$116 /nite	$232	
POV Mileage	4 mo.	150 mi./mo.	@	$0.550 /mi	$330	To check
Misc. (specify)			@		$0	http://www
Registration: Habitat rest. Seminar - NRS 3		1 person	@	$200	$200	Include w
					$0	
						Insert row within bu
GSA pickup lease		12 mo.	@	$275 /mo.	$3,300	
GSA pickup mileage	12 mo.	1,200 mi./mo.	@	$0.175 /mi	$2,520	
GSA sedan lease		5 mo.	@	$275 /mo.	$1,375	Include e
GSA sedan mileage	5 mo.	600 mi./mo.	@	$0.175 /mi	$525	
Vehicle liability insurance		12 mo.	@	$65	$780	
			@		$0	
Office Supplies/Non-Capital Equipment						
(list large items and categories of items)			@		$0	
			@		$0	

ETE INSTRUCTIONS BEFORE LOADING INTO PISCES

ading = input cells/areas. You may wish to remove
n your version.

first, then Qty2, if needed. Formulas can accomodate a
Qty2.

vs and formulas can be adapted to each contractor's
ents by category or individual.

estination and purpose.

for the latest per diem rates:
/perdiem

for the latest mileage rates:
/mileage

ho is attending (by job title).

/s as needed in the center of blocks. Do not leave $0 lines
dget.

ach GSA vehicle individually.

			@		$0		
		Subtotal Office			**$0**		
Field Supplies/Non-Capital Equipment							
(list large items and categories of items including equipment rentals)			@		$0		
			@		$0		
			@		$0		
		Subtotal Field			***$0***		
Office space		12 mo.	@	$250 /mo.	$3,000		
Materials storage space		12 mo.	@	$150 /mo.	$1,800		
Phones	2 lines	12 mo.	@	$35 /mo.	$840		
Cell phone (NRS-3/NRS-1)		11.5 mo.	@	$40 /mo.	$460		
Cell phone (Shared by technicians)		4 mo.	@	$40 /mo.	$160		
Internet service provider		12 mo.	@	$50 /mo.	$600		
Heat (propane)		12 mo.	@	$60 /mo.	$720		
Copier rental		12 mo.	@	$30 /mo.	$360		
	25.00%	**of Items 1 thru 6:**					**Example (to reflect (**
			@		$0		**Use defin**
			@		$0		
							Do not inc
Subcontract for Work Element(s) __			@		$52,741		**Insert det on secon column K**
			@		$0		
			@		$0		
							Note: This non-contr Budget pa

only: Adjust overhead/indirect rate and applicable items
entity's requirements.

ition or dollar criteria provided by your accountants.

clude contractor names without sole source justification.

ail here (if short) or attach detail for subcontractor budgets
dary worksheet (see attached example) and link total into
.

s should match the contract value. Do not include
ract costs (e.g., PIT tags) on this page. Use Pisces Project
age to check the cost allocation for your project.

Note: Contingency amounts are NOT allowed on subcontracts. No lump sums. Costs must be split out as shown in the example below, although the format is optional. However, if the subcontract is for a firm fixed price and has already been bid out, documentation may be a simple summary of bid results and basis for why the subcontractor was chosen. This template is intended for design and/or construction costs for a commercial firm. If your subcontract is with a government entity, use the template on sheet 1 ("Budget").

DELETE

For guidance on subcontractor budgets, please see: http://efw.bpa.gov/contractors/docs/Guidance_on_sub

Subcontract Budget for Work Element(s) __

Project/Contract Name # YYYY-xxx-xx
Contract Period
CR-xxxxxx

Yellow shadi
shading in yo

	Qty2	Qty1			Unit Cost		COST	
								Use Qty1 firs blank for Qty
Senior Engineer		24.0	hrs.	@	$115	/hr.	$2,760	
Staff Engineers	2 pers.	20.0	hrs.	@	$87	/hr.	$3,480	
CAD		18.0	hrs.	@	$78	/hr.	$1,404	Insert rows a
Surveying	3 pers.	15.0	hrs.	@	$85	/hr.	$3,825	lines within b
Construction Supervisor	1 pers.	40.0	hrs.	@	$73	/hr.	$2,920	
Construction Labor	5 pers.	40.0	hrs.	@	$55	/hr.	$11,000	
Admin		12.0	hrs.	@	$53	/hr.	$636	
		169.0	hrs.					
Per diem (specify destination)	3 pers.	2	day	@	$46	/day	$276	To check for
Lodging (specify destination)	3 pers.	1	nite	@	$77	/nite	$231	http://www.gsa
POV Mileage		480	mi.	@	$0.510	/mi	$245	To check for
Fuel for equipment		230	gal	@	$3.50	/gal	$805	http://www.gs
Misc. (specify)				@			$0	
Office Supplies/Equipment								
(list items)				@			$0	
Interpretive sign for entrance to project site		1	each	@	$375	/ea	$375	
				@			$0	
				@			$0	
		Subtotal Office					***$375***	
Field Supplies/Equipment								
(list items)				@			$0	Specify whet
Excavator rental (with operator)	2 each	3	days	@	$900	/day	$5,400	
Dump truck rental (no operator)		2	days	@	$400	/day	$800	
Rootwads		60	each	@	$225	/ea	$13,500	

Grass seeds for re-seeding area	140.0 lbs.	@	$4.50 /lb.	$630		
Trees (red alder, douglas fir)	275 each	@	$1.50 /ea	$413		
	Subtotal Field			***$20,743***		
	8.30% of Items 1 thru 3:					**Example onl state or local**
		@		$0		
		@		$0		**Use definitio**
		@		$0		
attach sufficient detail for subcontractor budgets				$0		
on second sheet or insert here				$0		
				$0		

From: David Welch

Sent: Wed Oct 26 17:46:29 2016

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

Cc: Erin Rechisky

Subject: Re: BPA COTR for Kintama technical services contract

Importance: Normal

That's fine Christine--

We should both be in by 9 [redacted]

Regards, David

David Welch, Kintama Research
Tel: +1 (250) 729-2600 x223
Cell: [redacted]
Sent from my iPad

On Oct 26, 2016, at 16:25, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Hello,

Are you available for a call tomorrow between 9-12? I also had a meeting cancelled at 2pm. I spent some time going over this contract with Anne Creason today. [redacted]

We have a few things to discuss, and I only got up to speed on our financial situation two days ago when Ben Zelinsky asked me to step in for Anne. Initially we will have $110,000 available, which will come from savings from another project which is ending in November. This means we will probably have to discuss some truncation of what you could do within this budget, given the multiple components of the proposal that you presented to us.

Let's talk tomorrow or Friday and both of you are invited to participated in the call if you wish,

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Wednesday, October 26, 2016 10:52 AM
To: Creason,Anne M (BPA) - EWL-4; Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky
Subject: RE: BPA COTR for Kintama technical services contract

Hi Christine--

Let Erin and I know if there is anything we can do to facilitate the work items that you need to do. I am only in the office until 1:30 PM each day this week as I am [redacted] and gone on Friday. However, Erin is in all days [redacted]

If you need to discuss with me, please use my mobile #.

David

<image001.jpg>

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

From: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: Tuesday, October 25, 2016 2:59 PM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Zelinsky,Benjamin D (BPA) - EWP-4; McDonald,Katie M (BPA) - EWP-4; David Welch; Erin Rechisky; Read,Christine L (BPA) - EWB-4
Subject: BPA COTR for Kintama technical services contract

Hi Christine—

Per our discussion with Ben, because I will be out of the office for the month of November you will be taking over as the BPA COTR for the new technical services contract with Kintama (thank you!). It is my understanding that you'll need to complete the following for a BPA technical services contract:

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- I'm not sure who or how you submit the documents for contracting; you'll need to ask Chris Read or Dave Kaplowe for guidance since they have been through this process before

Once you've got the SOW in Pisces, we can meet to look at your Work Elements. I am available to meet in person tomorrow morning or Monday of next week only.

Thank you—

Anne

From: Erin Rechisky

Sent: Thu Oct 27 11:25:50 2016

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

Subject: FW: BPA Contracting-- email #2

Importance: High

Attachments: CR299513-SoleSourceJustification.docx; SOW Template.docx

And the second.

Erin

From: Creason,Anne M (BPA) - EWL-4 [mailto:amcreason@bpa.gov]
Sent: July 26, 2016 2:18 PM
To: Erin Rechisky; David Welch
Cc: Zelinsky,Benjamin D (BPA) - EWP-4
Subject: BPA Contracting-- email #2
Importance: High

Okay, that was quick!

See attached the following:

1) Sole Source Justification example: I just need your help with Section 1 (what Kintama will be doing) and Section 3—the justification. This should be written in a way that demonstrates why Kintama is uniquely qualified to conduct this particular analysis. Even if you want to just give me a blurb for each, I can plug this in to the document and add more as well.

2) Technical Services Contract SOW template: Focus on this version of the SOW rather than the Pisces version.

Please let me know if you have any questions when working on these.

Thanks—

Anne

Complete a non-competitive justification for procurements with an anticipated value of over $10,000 following this format as it applies. A non competitive transaction justification is not required for procurements under $10,000, procured from Federal Prison Industries, other federal agencies, AbilityOne Nonprofit Agencies for the Blind or other Severely Handicapped, Government Printing and Binding or for utility services. (BPI 11.7.1.1)

1. **Description of Materials or Services:**
Provide a complete description of the requirement, what program or project it supports and how it supports the mission of BPA. Quantities and detailed descriptions are not required unless as a part of the justification contained in section 3 of this justification. If requesting materials, include the Manufacturer, Manufacturer's part number, and indicate whether or not a time critical outage schedule for use of these items applies.

(b)(5) [redacted]

2. **Non Competitive Authority:** *From the list below check the applicable BPI authority permitting the proposed non-competitive transaction. Contact your Contracting Officer or Team Lead if you need assistance.*

- ☐ Repair parts, accessories, supplemental equipment or services required for supplies or services previously furnished or contracted for which are available from only one contractor. (BPI 11.7.1.2(a));
- ☐ Required by law or Executive Order (BPI 11.7.1.2(b));
- ☐ The entity has the responsibility to manage the property or resource to be affected by the services performed. (BPI 11.7.1.2 (c));
- ☐ BPA standard items, when a Business Line Vice President or equivalent level manager has determined in writing that BPA must standardize the use of the item, and that determination is available for review by the HCA. (BPI 11.7.1.2 (e));
- ☐ Agreements with nonprofit research organizations such as the Electric Power Research Institute (EPRI) for the purposes identified in this section (BPI 11.7.1.2 (f) (1-6));
- ☐ Establish or maintain an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or a federally funded research and development center. (BPI 11.7.1.3 (a));
- ☐ When other parties have offered BPA an opportunity to participate in specific projects on a cost-sharing basis, and the sponsor has arranged for a substantial portion of the required funding for the entire project. (BPI 11.7.1.3(b));
- X☐ This is the only feasible source which can meet BPA's requirement and no other supplies or services will satisfy agency requirements (BPI 11.7.2);

3. **Justification:**

Provide sufficient information to support the proposed non competitive transaction based on the authority cited above and instructions of this section. Keep in mind that this document is reviewed and that your explanations may be formally questioned and protested if your justification is insufficient or not valid. For the BPI authorities 11.7.1.2 (f), 11.7.1.3(a) and 11.7.1.3(b), be sure to address the specific information required by those sections. For the BPI authority 11.7.2, unique source, all of the following elements must be provided: (1) The minimum mandatory requirements for the procurement (may be addressed in Section 1, Description of Materials or Services); (2) Identify what other sources were considered during market research (may be addressed in Section 6, Market Survey, below) and why those sources do not meet the minimum mandatory requirements and are not feasible due to form, fit, function, capabilities, capacity, experience, price, or delivery timeframe; (3) Demonstrate that the proposed contractor is the only feasible source based on unique capabilities, unique experiences, or unique attributes.

PCTrask

Bonneville Power Administration has contracted with PC Trask and Associates, Inc. under project #2007-389-00 since October, 2006 for Estuary related FCRPS Biological Opinion (BiOp) issues.

Why BPA is doing Estuary Habitat Restoration:

(b)(5) [redacted]

History of Sole Source to PCTrask:

(b)(5) [redacted]

Why we still need PCTrask services:

(b)(5) [redacted]

(b)(5) [redacted]

(b)(2) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

University of Washington

(b)(5) [redacted]

Ron Thom

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

Below is a quick Bio on Ron as well as a link to his full Bio on the PNNL web page.

Ron has conducted research in coastal and estuarine ecosystems since 1971. His research includes coastal ecosystem restoration; adaptive management of restored systems; effects of pollution; benthic primary production; climate change; and ecology of fisheries resources. He has a Ph.D in Fisheries and has published numerous papers on estuarine related topics.
http://marine.pnnl.gov/staff/staff_info.asp?staff_num=749

4. **Actions to Promote Competition:** At the onset of each procurement, all unique source justifications are scrutinized and screened for the possibility of further competition by Supply Chain. Further, competition barriers are discussed with the customer and options explored when available. *This section is prefilled and needs no editing.*

5. **Project Estimated Amount:** The anticipated price to the Government is $316,736
Requester must fill in the estimated or actual amount here (attach any and all quotes received). At time of award the Contracting Officer will determine if price is fair and reasonable.
This value has been available to this project since 2011. It is slightly higher with the addition of Ron's work. (b)(5) [redacted]

6. **Market Survey:** *Describe the market research that was performed that led you to your conclusion that there was need to waive competition. If no market research was performed, such as in instances of Urgent and Compelling, explain in detail here.*
See justification

7. **Requirements Certification:** I certify that the requirement outlined in this justification is a bonafide need of the Bonneville Power Administration and that the supporting data under my cognizance, which are included in the justification, are accurate and complete to the best of my knowledge and belief.
(Signature of the responsible manager)

John Skidmore F&W Implementation Manager 7/17/2015
Name & Title Date

8. **Approval** *This part is filled out by Contracting Staff as part of the Justification*

   a. **Contracting Officer's Certification: (required)** I certify that the foregoing justification is accurate and complete to the best of my knowledge and belief.

Contracting Officer Signature Date

BPA-2021-00513-F 0584

Statement of Work Template

A statement of work should address each of the following topics in the sequence presented below. In the event that a topic is not relevant to a specific acquisition action, it need not be covered.

Part A General

A.1 Objective

In just a few sentences, this section should outline the intended outcome of the work under this contract. For example, "The objective of this contract is to obtain an analysis of the materials management system currently in use at BPA. A further objective is to obtain specific recommendations for improving the accountability for material by BPA property custodians". This is often considered the scope of the contracted activity.

A.2 Background

Briefly explain the general program or project being supported, in order to place the purchase in the context of the overall BPA program. This information will help contractors as they prepare their proposals and perform the work. Your explanation should generally describe how need for the project developed and the overall maturity of the associated programs and systems. This explanation should not go into excessive detai -- length shouldn't exceed two paragraphs.

A.3 Location of Project

Describe the location of the project here. For example, "This project will be performed in the BPA service area of the Pacific Northwest", "This project will be performed at BPA Headquarters in Portland, Oregon", "This project will be performed at the Celilo Converter Station,two miles east of The Dalles, Oregon", or a similar statement. This heading may be excluded entirely if work is not site-specific.

A.4 BPA-Furnished Property or Services

Indicate the nature and extent of property or services to be provided to the contractor by BPA in support of this contract. Also provide the location at which the property will be delivered to the contractor, and the date and time it will be provided, in the format below:

Description	Point of Delivery	Date to be Delivered

A.5 Contractor-Furnished Property or Service

Generally this will be phrased, "The Contractor shall provide all property and services to perform the work of this contract, except the items mentioned under A.4 above".

A.6 Definitions

New terms or acronyms within the work statement, particularly those of a specialized or technical nature, should be defined in this section. It's not necessary to define such common terms as BPA, Regional Act, etc.

A.7 Documentation

Specifications and standards (either Federal or industry-wide) which are to be used in the performance of work are listed here, for incorporation by reference into the contract.

Part B Technical Approach/Tasks

B.1 General Requirements

Here provide a one-paragraph description of the general requirements to be accomplished in this contract, expanding on the description in A.1 above.

B.2 Methods to be Used

Generally, BPA should specify the end results to be achieved, and leave the choice of methods to the contractor. However, any methods essential to BPA's mission may be specified. Care should be taken to ensure that these specific methods do not prevent the accomplishment of the requirements described below.

For cost-type contracts, the contract may be identified as either a "level-of-effort" or "completion" contract. A completion contract is one in which the scope of work is a clearly defined task or job with a definite goal and a specific end product. A level of effort contract describes the desired effort in sufficient detail to assure that BPA receives the effort it requires, but gives contractors enough flexibility to adjust to new circumstances without the need for repeated contract modifications. The required effort can be expressed in the amount of time to be devoted to performance through the use of terms such as person-hours, person-days or person-months.

B.3 Specific Requirements

The specific steps or activities to be accomplished by the contractor will be described in sufficient detail for the prospective contractor to prepare thorough proposals. If BPA approval or review is required at specific points, they should be defined in this Subpart. In general, this section should include the following elements in chronological order.

Phases *(may contain go, no go, decision points). For each phase, include the following:*

> Tasks *(may contain go, no go decision points) and detailed activities. Include sub tasks as needed. For each Task, include a due date expressed in elapsed days after award, not in specific calendar dates, as well as the following:*
>
> > *Deliverables. Deliverables could be specific products such as computer disks or printouts, copies of a publication or a report, presentation of workshops or briefings, test plans, specifications, drawings, test data, or other types of measurable results.*

Quality Assurance. This section should clearly state the manner in which BPA will determine whether the contractor has met the requirements of each Task or Deliverable. If BPA reserves the right to reject a report as incomplete or inaccurate, the criteria by which that decision will be made should be outlined. Indicate the minimum quality level, and the range of deviation acceptable. Also describe how rejection or variances outside the acceptable range of deviation may reduce or nullify payments and will require the contractor to rework or submit a plan for remedy.

Payment. A description of how pricing, as shown in the Schedule of Prices of the contract Terms, correlates with each Task or Deliverable. Also include any instructions about the payment process that are unique to this task. For example, "Upon completion of this Task, BPA will pay the contractor the fixed price indicated in the Schedule of Prices. Contractor shall not invoice BPA for this Task prior to BPA acceptance of the work."

B.4 Summary of Deliverables.

A table summarizing the specific material items which are to be delivered to BPA should be listed in this section.

Description	Format	Due Date	Days for BPA Review

This table is for summary purposes only. Omissions or alteration of those requirements from this table does not relieve the contractor of the responsibility for timely delivery of items required in Section B.3 Tasks or elsewhere in this contract.

Part C Inspection and Acceptance (Quality Assurance)

This section should provide a summary of the methods that the COTR and Field Inspectors will use to perform quality assurance. At a minimum, BPA should describe its intent to conduct periodic surveillance. Other methods may include Trend Analysis, Third-Party Audits, and Contractor Reported Data.

Part D Technical Exhibits

In some instances, voluminous and detailed data is required to provide the contractor with sufficient information to develop a proposal. Such detail should be appended as exhibits to the work statement.

From: Pisces

Sent: Thu Oct 27 12:08:57 2016

To: Pisces

Subject: Pisces Release at 5pm Tonight – Please wrap up your work & log out prior to then!

Importance: Normal

Greetings Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you are logged out prior to then. The system should be back online no later than 6pm – we will reach out if anything changes.

We hope that you've had a chance to try out some of the functionality in the Web environment and will be rolling out more soon.

Again – while you don't have to manage any of your work via Pisces Web, we strongly encourage it and would like your feedback on your experience. Here's what you can do out there currently – more to come!

- CR Initialization *(Internal BPA functionality)*
- Contacts

· Contract Summary

· CR Initialization

· SOW Development

o Milestones *(notifications limited to system defaults)*

o Metrics

o Location

o Focal Species

o Budgets

· Environmental Compliance *(Internal BPA functionality)*

Success tips if you choose to explore some functionality on Pisces Web:

· There is a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

· While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do you every-day work in Pisces. Future training will support users with tips and tricks for how to be successful

· If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

For system access, bugs, or feedback on new functionality – email support@cbfish.org.

For questions about the Pisces Web project – email pisces@bpa.gov.

We will soon launch an online resource where users can go for updates, reference guides, updated how-to aids, etc.

Regards,

The Pisces Team

Bonneville Power Administration

This email was sent to all BPA and non-BPA users, the Pisces Team, and additional BPA staff as appropriate.

From: Cbfish.org Support

Sent: Thu Oct 27 12:51:41 2016

To: David Welch

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

Subject: Re: (Case 33699) Password problem?

Importance: Normal

[redacted] is your temporary password. Please try again.

Make sure you download the latest version of Pisces from https://pisces.bpa.gov.

--
Cbfish.org Support (Tuan)
support@cbfish.org

-----Original Message-----
From: "David Welch" <David.Welch@kintama.com>
Reply-To: "David Welch" <David.Welch@kintama.com>
Date: Thu, 27 Oct 2016 18:50:50 +0000
To: "support@cbfish.org" <support@cbfish.org>
Cc: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: Password problem?

>Hi-
>
>I was trying to log-in to PISCES (which we haven't used for a number of years), and all efforts to do so have failed.
>
>Could you please check and provide a password reset for my login name [redacted].
>

>Thank you,
>
>David Welch, Ph.D.
>[kintamav_RGB]
>President, Kintama Research Services Ltd.
>10-1850 Northfield Road, Nanaimo, BC, Canada V9S 3B3
>Office Tel: (250) 729-2600 (x) 223 Fax: (250) 729-2622 Mobile: [redacted]
>Skype: david.welch.kintama
>david.welch@kintama.com<mailto:david.welch@kintama.com>
>
>www.kintama.com<http://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: Thu Oct 27 15:53:35 2016

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

Subject: RE: Pisces

Importance: Normal

Yes, thank you—it is there. I assumed that because the Project # started with 1996 it was an old project.

Let me know what we should do to facilitate the contracting phase.

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, October 27, 2016 1:48 PM
To: David Welch
Subject: RE: Pisces

Let's see – the CR number is 304692 under project 1996-017-00. Can you find this via a search query?

I do have your accounts associated with the contract.

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, October 27, 2016 1:38 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Pisces

Christine—Thanks. I can now successfully log in, so no need to worry about this further. (However, after logging in, I can only see the old account data, nothing under a new one for this year—I presume that this is what would be expected right now).

Thanks for your help!

D

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, October 27, 2016 11:37 AM
To: David Welch

Subject: RE: Pisces

Hi,

Let's see – we might want to give you a new account under the new email address, and alert them to remove the old one (this is easier than changing the email address for an existing account). They could do this today, and I could add you to the contract by tomorrow.

Sign up for the new account here: https://pisces.bpa.gov/PAR/Index

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, October 27, 2016 11:33 AM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Pisces

Hi Christine—

I am unable to log-in. My records have my old log in details as:

BPA PISCES Application: username: [redacted] password: [redacted]

But that isn't working. It may be an old version (we no longer support this email address, having gone to something shorter), but I tried several more "modern" variants, but in each case the log-in page just clears the entries and sits there.

Suggestions?

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, October 27, 2016 11:06 AM
To: David Welch; Erin Rechisky
Subject: Pisces

Hi,

Here is the link for Pisces download

https://pisces.bpa.gov/

Your contract should appear visible for your login name. If you go to the project rather than contract page (by clicking on the project number) it will show that this contract is placed under the Bioanalyst/technical services project.

Christine Petersen

(503)230-4695

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

Sent: Fri Oct 28 15:30:35 2016

To: David Welch

Subject: RE: TDG Paper...

Importance: Normal

By the way, thank you for sending this. I will share it with our water quality expert from the Corps, Kim Johnson.

The review process sounded pretty frustrating – there can sometimes be an opinionated reviewer #3 to respond to. In this case, I don't think there is a very large range of potential reviewers that the editors can draw from. Jim Anderson has some stories along these lines.

Let's check in early next week, regarding the contract.

Have a nice weekend

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Monday, October 24, 2016 11:03 PM

To: Zelinsky,Benjamin D (BPA) - EWP-4; Creason,Anne M (BPA) - EWL-4; Lut,Agnes (BPA) - BDP-3; Petersen,Christine H (BPA) - EWP-4
Subject: TDG Paper...

Ben, Anne, Agnes, & Christine--

Just a quick heads up. This paper by my former PhD student just came out today in the Journal of Aquatic Animal Health (an American Fisheries Society Journal). No doubt it will generate a memo or two, so I am sending it on to you to disseminate internally if you deem it appropriate.

Ian Brosnan (the senior author) is a bright light—just before he finished his PhD working with me (but through Cornell) he landed a job at NASA as Chief of Planning for the NASA Ames Lab down in California. I think he is lost to fisheries science unfortunately, but I think it was an excellent career switch for him.

His FaceBook post today on this paper pretty well sums up the rough ride he got from Voldermort in the review process at several journals prior to it being accepted in this one: *"A publication that I expected to be a relatively simple, but proved one of the longest and most difficult things I have done, in both a technical and a political sense, is out today. Custom derivations, 32-core parallel processing, and fishy politics, all in one wee little paper.*".

Regards, David

[redacted]

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

10-1850 Northfield Road, Nanaimo, BC, Canada V9S 3B3

Office Tel: (250) 729-2600 (x) 223   Fax: (250) 729-2622 Mobile: [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: Erin Rechisky

Sent: Thu Nov 03 16:51:47 2016

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

Subject: RE: contract

Importance: Normal

No worries!
Erin

On Nov 3, 2016 2:08 PM, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov> wrote:

> Oh, sorry for writing Eric below- I can't type well on this smartphone.
>
> I will see if I can check in tomorrow afternoon
>
> Christine
>
> Sent from my Verizon 4G LTE smartphone
>
> -------- Original message --------
> From: Erin Rechisky <Erin.Rechisky@kintama.com>
> Date: 11/3/16 1:02 PM (GMT-08:00)
> To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
> Subject: RE: contract

Thanks.

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 3, 2016 11:53 AM
To: Erin Rechisky
Subject: RE: contract

Hi Eric

Let's see- we are placing the contract under that project, but you will not need to interact with Bioanalyst in any way. Many of our other projects might involve construction work with a few separate vendors. Perhaps the title of the project is the only thing to pay attention to. I could ask if we should add to the contacts list in any way.

I believe the COAST project was closed out. I do not quite understand whether we could open a technical services contract under the old project... but it might be the situation that very thing in our 'BiOp' program is supposed to go through ISRP review with the NW power and conservation Council. This contract is funded via another budget and can skip the ISRP

Yes, please update the analyze/interpret work element with more details. Do not become overly detailed to the point that you lose flexibility, but more background information will be helpful.

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 11/3/16 10:30 AM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: contract

Hi Christine,

I am exploring Pisces to get familiar with it again.

When I go to "My stuff", and click on contract number CR-30469, I see a Summary tab that has correct Contract Contacts, but I believe the Project #, Project Title and Project Manager are for project number 1996-017-00, Bioanalysts. Our project number from the past is 2003-114-00. You mentioned that our project would fall under bioanalysts, but Bioanalysts is a consulting company right? I guess I don't understand how this works.

Also, would you like me to edit the "Analyze/Interpret Data" Work Element with updated information base on our conversation the other day (fresh water survival vs early marine survival)?

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 2, 2016 5:12 PM
To: Erin Rechisky; David Welch
Subject: RE: contract

Hello,

Yes, I have this and I will try to keep polishing. There are a few factors – having collected the data that you will use is not a foolproof sole source argument because someone could say that the data should be given to a second party.

Anyway, I asked about start dates. They said it might be safer to pick January 1 in case some of their staff had long breaks during December. However, I would like to know when you would optimally really like or need to start? Many state agencies always want something to start on the first of the month so that all their invoicing is aligned. With Kintama, we could attempt to pick a date like Dec. 15 and see if that is possible. If we could finalize the SOW and start our review process, we could see what gets flagged initially and then assess if we need to make any changes, or if our contract writer tells us they will require several weeks. I will run the sole source statement by a few people first so that we don't run the risk of having it turned down.

Thanks

Christine

Ps, I will be in Astoria for the next two days but in email contact. I just might not be able to log into Pisces.

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Wednesday, November 02, 2016 9:11 AM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: contract

Thanks Christine,

David and I both managed to log into Pisces after requesting new passwords.

Do you have the draft sole source justification statement that we sent to Anne?

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 1, 2016 11:18 AM
To: David Welch; Erin Rechisky
Subject: contract

Hi,

I was able to talk with a few folks who have developed contracts for Technical Services, outside of our regular Fish and Wildlife contracting procedures. While I wasn't able to track down our actual contracting officer or writer (who gets the last word), my best understanding is that we should proceed in Pisces with a very similar set of steps to what you are familiar with from your earlier COAST project. I need to develop a sole source justification statement.

I copied a few paragraphs over from the earlier SOW that your worked on into the background and work element sections in Pisces. You might want to improve the text for analyses, evaluation that you plan to do under the 'analyze/interpret data' work element. The journal article description can have some background, but otherwise should have reasonable dates for getting a draft done.

I need our contracting officer to tell me when it is feasible to get started. December could be possible if we get all our materials to our CO, who can then hopefully tell us if anything else is required.

Christine

From: David Welch

Sent: Mon Nov 07 10:18:57 2016

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

Subject: RE: phone call?

Importance: Normal

Attachments: SOW Initial Work Element only Kintama-FINAL (4 Nov 2016).docx

Thanks, Christine—I am just about to enter the info that I can into PICSCES. You will see that Erin and I have substantially streamlined the attached material, and have highlighted one part that would make an excellent justification for the Sole Source designation—I probably won't be able to add that to PISCES, but we'll see.

I am leaving for a conference tomorrow morning (Tuesday), so if we don't touch base today it is probably easiest to deal directly with Erin until I am back in the office next Tuesday, 15 November. I can always be contacted on my cell if need be.

Regards, David

kintamav_RGB

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Monday, November 07, 2016 9:32 AM
To: David Welch; Erin Rechisky
Subject: phone call?

Hi,

Would you like to check in, within the next couple of days – on the status of the contract? We could go over any remaining questions about Pisces, and select dates for various milestones.

I have some time free this afternoon, tomorrow after 3 or around noon, Wednesday is pretty free.

Talk to you soon,

Christine Petersen

(503)230-4695

Statement of Work Template

A statement of work should address each of the following topics in the sequence presented below. In the event that a topic is not relevant to a specific acquisition action, it need not be covered.

Part A General

A.1 Objective

(b)(5) [redacted]

Christine: The text in the next paragraph should be moved to the Sole Source Justification for why the work should be awarded sole-source…

(b)(5) [redacted]

A.3 Location of Project

This project will be performed at the Kintama Research Services office in Nanaimo, BC Canada.

A.4 BPA-Furnished Property or Services

Description	Point of Delivery	Date to be Delivered
NONE		

A.5 Contractor-Furnished Property or Service

The Contractor shall provide all property and services to perform the work of this contract.

A.6 Definitions

SARs-Smolt to Adult Survival

A.7 Documentation

Specifications and standards (either Federal or industry-wide) which are to be used in the performance of work are listed here, for incorporation by reference into the contract.

Part B Technical Approach/Tasks

B.1 General Requirements

(b)(5) [redacted]

Contract Description:

B.2 Methods to be Used

This is a completion contract. One report will be completed and submitted to BPA for internal use and review, and submitted for peer review and publication in a scientific journal. Further funding may be negotiated to support publication of two additional reports.

B.3 Specific Requirements

Christine—Let's keep this as simple and clean as possible. Any boilerplate you can provide?

The specific steps or activities to be accomplished by the contractor will be described in sufficient detail for the prospective contractor to prepare thorough proposals. If BPA approval or review is required at specific points, they should be defined in this Subpart. In general, this section should include the following elements in chronological order.

Phases *(may contain go, no go, decision points). For each phase, include the following:*

Tasks *(may contain go, no go decision points) and detailed activities. Include sub tasks as needed. For each Task, include a due date expressed in elapsed days after award, not in specific calendar dates, as well as the following:*

Deliverables. Deliverables could be specific products such as computer disks or printouts, copies of a publication or a report, presentation of workshops or briefings, test plans, specifications, drawings, test data, or other types of measurable results.

Quality Assurance. This section should clearly state the manner in which BPA will determine whether the contractor has met the requirements of each Task or Deliverable. If BPA reserves the right to reject a report as incomplete or inaccurate, the criteria by which that decision will be made should be outlined. Indicate the minimum quality level, and the range of deviation acceptable. Also describe how rejection or variances outside the acceptable range of deviation may reduce or nullify payments and will require the contractor to rework or submit a plan for remedy.

Payment. A description of how pricing, as shown in the Schedule of Prices of the contract Terms, correlates with each Task or Deliverable. Also include any instructions about the payment process that are unique to this task. For example, "Upon completion of this Task, BPA will pay the contractor the fixed price indicated in the Schedule of Prices. Contractor shall not invoice BPA for this Task prior to BPA acceptance of the work."

Phase 1

(b)(5) [redacted]

Payment: 35% upon signing of contract. The remainder to be billed monthly in arrears.

Phase 2

(b)(5) [redacted]

Payment

B.4 Summary of Deliverables.

Description	Format	Due Date	Days for BPA Review
(b)(5) [redacted]	White paper report for internal BPA use & comment on management implications	1 March 2017	1 month
	Correspondence with journal seeking agreement to review manuscript, final formatting to meet specific journal	1 April 2017	N/A

	requirements, web submission to start review		

Part C Inspection and Acceptance (Quality Assurance)

This section should provide a summary of the methods that the COTR and Field Inspectors will use to perform quality assurance. At a minimum, BPA should describe its intent to conduct periodic surveillance. Other methods may include Trend Analysis, Third-Party Audits, and Contractor Reported Data.

Part D Technical Exhibits

In some instances, voluminous and detailed data is required to provide the contractor with sufficient information to develop a proposal. Such detail should be appended as exhibits to the work statement.

From: David Welch

Sent: Mon Nov 07 10:20:00 2016

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

Subject: Sole Source Justification...

Importance: Normal

Christine: The text in the next paragraph should be moved to the Sole Source Justification for why the work should be awarded sole-source…

(b)(5) [redacted]

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Monday, November 07, 2016 9:32 AM
To: David Welch; Erin Rechisky
Subject: phone call?

Hi,

Would you like to check in, within the next couple of days – on the status of the contract? We could go over any remaining questions about Pisces, and select dates for various milestones.

I have some time free this afternoon, tomorrow after 3 or around noon, Wednesday is pretty free.

Talk to you soon,

Christine Petersen

(503)230-4695

From: Erin Rechisky

Sent: Tue Nov 08 11:15:06 2016

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

Subject: RE: phone call?

Importance: Normal

Ok. 250-729-2600 x224

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 8, 2016 11:11 AM
To: Erin Rechisky; David Welch
Subject: RE: phone call?

Sounds good – I will call you at 3 today.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Tuesday, November 08, 2016 10:38 AM
To: Petersen,Christine H (BPA) - EWP-4; David Welch

Subject: RE: phone call?

Hi Christine,

I can talk at 3 today.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 7, 2016 12:16 PM
To: Erin Rechisky; David Welch
Subject: RE: phone call?

Thank you.

Please feel free to modify anything that I copied in already, as a placeholder, or to break the analysis work element into separate tasks in a reasonable way.

Maybe I could try to give you a call tomorrow at either noon or 3pm?

Thank you for the sole source language – this is very helpful. (b)(5) [redacted]
(b)(5) [redacted]

Christine

(503)230-4695

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Monday, November 07, 2016 10:24 AM
To: David Welch; Petersen,Christine H (BPA) - EWP-4
Subject: RE: phone call?

Hi Christine,

I am only in the office until 1:00 today, but I'll be in all day tomorrow, and until 2:00 on Wed and Thurs.

Once David edits the info in Pisces, let's have a look and talk tomorrow about what other tasks need to be completed in order to move the contracting process along.

Erin

From: David Welch
Sent: November 7, 2016 10:19 AM
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: phone call?

Thanks, Christine—I am just about to enter the info that I can into PICSCES. You will see that Erin and I have substantially streamlined the attached material, and have highlighted one part that would make an excellent justification for the Sole Source designation—I probably won't be able to add that to PISCES, but we'll see.

I am leaving for a conference tomorrow morning (Tuesday), so if we don't touch base today it is probably easiest to deal directly with Erin until I am back in the office next Tuesday, 15 November. I can always be contacted on my cell if need be.

Regards, David

kintamav_RGB

Office: (250) 729-2600 (x) 223

Mobile: [redacted]

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Monday, November 07, 2016 9:32 AM
To: David Welch; Erin Rechisky
Subject: phone call?

Hi,

Would you like to check in, within the next couple of days – on the status of the contract? We could go over any remaining questions about Pisces, and select dates for various milestones.

I have some time free this afternoon, tomorrow after 3 or around noon, Wednesday is pretty free.

Talk to you soon,

Christine Petersen

(503)230-4695

From: David Welch

Sent: Thu Nov 10 10:11:07 2016

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

Cc: Erin Rechisky

Subject: Re: Pisces details

Importance: Normal

Christine-

I'm at a PICES science meeting and can't easily connect with Erin today except at lunch. I will try to connect with her later on today, but she will need to address your requests for us--I think all are quite straightforward for us to address. I have a time-based budget estimate for the piece of work that is proposed for funding here, but I'm not sure if Erin has that... if she doesn't I can try to upload that into Pisces later this afternoon/evening.

David

David Welch, Kintama Research
Tel: +1 (250) 729-2600 x223
Cell: [redacted]
Sent from my iPad

On Nov 10, 2016, at 10:01, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Let me see if I can contact the USGS staff who seem to run that site. A few months ago, they seemed to be deleting some of the methods that they decided were in draft rather than final form (which was actually a large fraction of them).

In any case, I think it is fine to take care of it later – it would just be convenient to link to the already published set of methods.

We can link to oceantrack on one of the tabs in Pisces.

Are you around this morning? Have you made progress with the line item budget?

When I go over the SOW with a manager (Peter Lofy rather than Ben Zelinsky, who is out on leave), we probably will have small suggested edits to wording.

I changed the start date to Dec. 15 in Pisces and we can see if this will be acceptable to our contracting officer, but there is a chance she could ask us to push it out further.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Wednesday, November 09, 2016 12:17 PM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

Thanks. I'm working on this again now.

I searched monitoringmethods.org for our survival analysis methods (and other methods) but could not find them. We submitted three methods documents to BPA in the past. If they are not on monitoringmethods.org, where would they be?

All of the detection data from the COAST project is on the Ocean Tracking Network website: http://members.oceantrack.org/data/discovery/KNTM.htm

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 9, 2016 10:20 AM
To: Erin Rechisky; David Welch
Subject: Pisces details

Hi Erin and David,

Here are a few things to work on in Pisces

**We need to upload the line item budget as an Excel attachment in Pisces. You have worked on the budget already. Some minor modifications might need to be made to the dates later. The 'work element budget' tab isn't really as relevant to this contract as for contracts under the NPCC council program, but if you just fill in some estimates, it will make the error message go away.

**Regarding start and end dates – I spoke to Peter Lofy who will review this contract as a manager after we get it ready. He agreed with me in suggesting a full year contract, even if you schedule no activities or invoicing after April. However, in his opinion, our agency cannot prevent you from doing uninvoiced activity on a volunteer basis, in the form of interacting with journal editors and responding to peer review. (I was a bit fuzzy on this point, because I have heard of examples involving construction, where an employer would have to give a stop work order, and could not avoid paying overtime labor hours that staff performed on the basis of an agreement that a job should only take X hours). In any case, we find your plan to do most of the writing this winter and to set an April deadline to be advantageous to our goals. We can keep the April milestone deadlines for many of the journal article and data analysis tasks.

I am going to try to set a Dec. 15 start date and see if this would work for our contracting officer. She may turn out to reject it. We should really try to get all of our materials together and approved by my manager, hopefully by next Monday?

**For the BPA article review description "In order to maintain scientific independence, our request is that BPA staff confine their comments to the application of the scientific findings to management, so that Kintama can identify and expand upon those areas deemed of greatest importance for translating the scientific findings into useful management advice. Kintama staff will retain sole scientific authority over the scientific analysis and publication of the results."

I spoke with David about this matter a couple of weeks ago. I personally agree. I suspect my manager and Ben Zelinsky will agree. I will run it by them, as far as text for a contract like this. It is also optional to delete the milestone, but you may request to have it included somewhere in the contract anyway.

**I am pretty happy with the straightforward description for the analysis WE description and the summary Contract Description. As we discussed over the phone, I think both sections would benefit from just a couple more sentences of expanded description of the source of tag detection data, and background clarification for anyone unfamiliar with the project. Perhaps some sentences from your original COAST proposal that the ISRP reviewed would suffice. Keep the current first paragraph for the contract description, and present the current paper as a new concept that does a new data analysis from the multiyear dataset. Some amount of redundancy is not a problem.

**Is the Kintama data from COAST in any sort of a public database? Did you ever do the Monitoringmethods.org procedure with the COAST project?

From: Erin Rechisky

Sent: Tue Nov 15 08:50:07 2016

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

Subject: RE: Pisces details

Importance: Normal

ok

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 15, 2016 8:43 AM
To: Erin Rechisky
Subject: RE: Pisces details

Sounds good. I'll give you a call.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Monday, November 14, 2016 8:05 PM
To: Petersen,Christine H (BPA) - EWP-4

Cc: David Welch
Subject: RE: Pisces details

Let's try for 10.
Thanks,
Erin

On Nov 14, 2016 1:13 PM, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov> wrote:

Okay – I have 8am or 10-12 open tomorrow. I will try to have the sole source justification ready, and look over everything that is currently on Pisces.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Monday, November 14, 2016 12:33 PM
To: Erin Rechisky; Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

I have to leave here soon, so let's plan to talk first thing tomorrow.

Thanks,
Erin

From: Erin Rechisky
Sent: November 10, 2016 4:56 PM
To: 'Petersen,Christine H (BPA) - EWP-4'; David Welch
Subject: RE: Pisces details

Hi Christine,

Tomorrow is a holiday for us too.

I just made some updates to the SOW. Perhaps we can review it on Monday. I am in the office from, 9-1 on Mondays.

Have a great weekend!

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 10, 2016 10:59 AM
To: Erin Rechisky; David Welch
Subject: RE: Pisces details

Okay – We have a veteran's day holiday tomorrow, but I will check email.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Thursday, November 10, 2016 10:24 AM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

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I have not started working on the budget yet. I am on a conference call and will do so soon.

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Sent: November 10, 2016 10:02 AM
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Sent: Tue Nov 15 12:12:59 2016

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

Subject: RE: Pisces details

Importance: Normal

Attachments: LineItemBudget Kintama Nov 2016.xls

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Kintama Research Services

Project/Contract Name # YYYY-xxx-xx
Contract Period
CR-xxxxxx

	Qty2	Qty1		Unit Cost	COST	
1 PERSONNEL						$89,050
CEO		60.0 day	@	$1,000 /day	$60,000	
Data Analyst		20.0 day	@	$700 /day	$14,000	
Research Manager		20.0 day	@	$700 /day	$14,000	
FTE Technical		*100.0*				
Research Manager		1.5 day	@	$700 /day	$1,050	
FTE Admin		*1.5*				
				Subtotal Salaries	*$89,050*	
Fringe:		NRS 1,3	@	0.00%	$0	
		Seasonals	@	0.00%	$0	
		Admin	@	0.00%	$0	
		Subtotal Benefits			*$0*	
2 TRAVEL						$4,469
Per diem: WA-BC AFS- CEO and Research Manager	1 pers.	4 days	@	$64 /day	$256	
Lodging: WA-BC AFS- CEO and Research Manager	1 pers.	3 nights	@	$96 /nite	$288	
Flights: YCD-GEG (Spokane)	1 pers.	1 R/T fligh	@	$700 /flight	$700	
Per Diem: Salmon Ocean Ecology- CEO and Research Manag	1 pers.	4 days	@	$74 /day	$296	
Lodging: Salmon Ocean Ecology- CEO and Research Manage	1 pers.	3 nights	@	$157 /nite	$471	
Flights: YCD- SEA (Seattle)	1 pers.	1 R/T fligh	@	$700 /flight	$700	
Per diem: BPA- CEO and Research Manager	2 pers.	2 days	@	$64 /day	$256	
Lodging: BPA- CEO and Research Manager	2 pers.	1 nights	@	$151 /nite	$302	
Flights: YCD-PDX (Portland)	2 pers.	1 R/T fligh	@	$600 /flight	$1,200	
POV Mileage	0 mo.	0 mi./mo.	@	$0.550 /mi	$0	
Misc.					$0	
3 PROFESSIONAL MEETINGS & TRAINING						$525
Registration: WA-BC AFS- CEO and Research Manager		1 person	@	$275	$275	
Registration: Salmon Ocean Ecology- CEO and Research Manager		1 person	@	$250	$250	
4 VEHICLES						$0
GSA pickup lease		0 mo.	@	$275 /mo.	$0	
GSA pickup mileage	0 mo.	1,200 mi./mo.	@	$0.175 /mi	$0	
GSA sedan lease		0 mo.	@	$275 /mo.	$0	
GSA sedan mileage	0 mo.	600 mi./mo.	@	$0.175 /mi	$0	
Vehicle liability insurance		0 mo.	@	$65	$0	
			@		$0	
5 SUPPLIES/EQUIPMENT						$0
Office Supplies/Non-Capital Equipment						
(list large items and categories of items)			@		$0	
			@		$0	
			@		$0	
		Subtotal Office			*$0*	
Field Supplies/Non-Capital Equipment						
(list large items and categories of items including equipment rentals)			@		$0	
			@		$0	
			@		$0	
		Subtotal Field			*$0*	
6 RENT/UTILITIES						$0
Office space		0 mo.	@	$250 /mo.	$0	
Materials storage space		0 mo.	@	$150 /mo.	$0	
Phones	2 lines	0 mo.	@	$35 /mo.	$0	
Cell phone (NRS-3/NRS-1)		0 mo.	@	$40 /mo.	$0	
Cell phone (Shared by technicians)		0 mo.	@	$40 /mo.	$0	
Internet service provider		0 mo.	@	$50 /mo.	$0	
Heat (propane)		0 mo.	@	$60 /mo.	$0	
Copier rental		0 mo.	@	$30 /mo.	$0	
7 OVERHEAD / INDIRECT	22.50%	of Items 1 thru 6:		$94,044		$21,160
8 CAPITAL EQUIPMENT						$0
			@		$0	
			@		$0	
9 SUBCONTRACTS						$0
Subcontract for Work Element(s) __			@		$0	
			@		$0	
			@		$0	
TOTAL THIS CONTRACT PERIOD						**$115,204**

DELETE INSTRUCTIONS BEFORE LOADING INTO PISCES

Yellow shading = input cells/areas. You may wish to remove shading in your version.

Use Qty1 first, then Qty2, if needed. Formulas can accomodate a blank for Qty2.

These rows and formulas can be adapted to each contractor's requirements by category or individual.

Include destination and purpose.

To check for the latest per diem rates:
http://www.gsa.gov/perdiem

To check for the latest mileage rates:
http://www.gsa.gov/mileage

Include who is attending (by job title).

Insert rows as needed in the center of blocks. Do not leave $0 lines within budget.

Include each GSA vehicle individually.

Example only: Adjust overhead/indirect rate and applicable items to reflect entity's requirements.

Use definition or dollar criteria provided by your accountants.

Do not include contractor names without sole source

Insert detail here (if short) or attach detail for subcontractor budgets on secondary worksheet (see attached example) and link total into column K.

Note: This should match the contract value. Do not include non-contract costs (e.g., PIT tags) on this page. Use Pisces Project Budget page to check the cost allocation for your project.

Note: Contingency amounts are NOT allowed on subcontracts. No lump sums. Costs must be split out as shown in the example below, although the format is optional. However, if the subcontract is for a firm fixed price and has already been bid out, documentation may be a simple summary of bid results and basis for why the subcontractor was chosen. This template is intended for design and/or construction costs for a commercial firm. If your subcontract is with a government entity, use the template on sheet 1 ("Budget").
For guidance on subcontractor budgets, please see: http://efw.bpa.gov/contractors/docs/Guidance_on_sub

DELETE INSTRUCTIONS BEFORE LOADING INTO PISCES

Subcontract Budget for Work Element(s) __

Project/Contract Name # YYYY-xxx-xx
Contract Period
CR-xxxxxx

Yellow shading = input cells/areas. You may wish to remove shading in your version.

	Qty2		Qty1			Unit Cost	COST	
1 PERSONNEL								**$0**
Senior Engineer				hrs.	@	$115 /hr.	$0	
Staff Engineers		pers.		hrs.	@	$87 /hr.	$0	
CAD				hrs.	@	$78 /hr.	$0	
Surveying		pers.		hrs.	@	$85 /hr.	$0	
Construction Supervisor		pers.		hrs.	@	$73 /hr.	$0	
Construction Labor		pers.		hrs.	@	$55 /hr.	$0	
Admin				hrs.	@	$53 /hr.	$0	
			0.0	hrs.				
2 TRAVEL								**$0**
Per diem **(specify destination)**		pers.		day	@	$46 /day	$0	
Lodging **(specify destination)**		pers.		nite	@	$77 /nite	$0	
POV Mileage				mi	@	$0.510 /mi	$0	
Fuel for equipment				gal	@	$3.50 /gal	$0	
Misc. **(specify)**					@		$0	
3 SUPPLIES/EQUIPMENT								**$0**
Office Supplies/Equipment								
(list items)					@		$0	
Interpretive sign for entrance to project site				each	@	$375 /ea	$0	
					@		$0	
					@		$0	
			Subtotal Office				***$0***	
Field Supplies/Equipment								
(list items)					@		$0	
Excavator rental (with operator)		each		days	@	$900 /day	$0	
Dump truck rental (no operator)				days	@	$400 /day	$0	
Rootwads				each	@	$225 /ea	$0	
Grass seeds for re-seeding area				lbs.	@	$4.50 /lb.	$0	
Trees (red alder, douglas fir)				each	@	$1.50 /ea	$0	
			Subtotal Field				***$0***	
4 STATE TAXES on CONSTRUCTION	**8.30%**	**of Items 1 thru 3:**	**$0**					**$0**
5 CAPITAL EQUIPMENT								**$0**
					@		$0	
					@		$0	
					@		$0	
6 SUBCONTRACTS								**$0**
attach sufficient detail for subcontractor budgets							$0	
on second sheet or insert here							$0	
							$0	
TOTAL Subcontract Budget								**$0**

Use Qty1 first, then Qty2, if needed. Formulas can accomodate a blank for Qty2.

Insert rows as needed in the center of blocks. Do not leave $0 lines within budget (hiding unused rows is OK).

To check for the latest per diem rates: http://www.gsa.gov/perdiem
To check for the latest mileage rates: http://www.gsa.gov/mileage

Specify whether equipment rates include operator.

Example only: Adjust tax rate and applicable items to reflect state or local requirements or delete row.

Use definition or dollar criteria provided by your accountants.

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

Sent: Tue Nov 15 13:57:42 2016

To: Erin Rechisky

Subject: RE: Pisces details

Importance: Normal

Attachments: Budget Kintama Nov 2016.xls; Budget Kintama Nov 2016_Trav.xls

Hi Erin,

I'm attaching what I did with the budgets – I'm holding on to the one with travel for reference because it has the reasonable costs that you looked up. For the regular budget, we are supposed to delete the $0 items, so that simplifies it substantially.

I will bring up the travel and our new rules for invoicing at hourly rates with Peter. I've been wondering how this will work when they are essentially asking large state agencies such as WDFW to send invoices with different formatting than they might use for everything else.

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Kintama Research Services

Project/Contract Name # 1996-017-00
Contract Period
CR-304692

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1 PERSONNEL									**$89,796**
CEO		60.0 day	@	$1,000	/day	$125	/hr	$60,000	
Data Analyst		20.6 day	@	$700	/day	$88	/hr	$14,396	
Research Manager		20.0 day	@	$700	/day	$88	/hr	$14,000	
	FTE Technical	*100.6*							
Research Manager		2.0 day	@	$700	/day	$88	/hr	$1,400	
	FTE Admin	*2.0*							
				Subtotal Salaries				*$89,796*	

7 OVERHEAD / INDIRECT	**22.50%**	**of Items 1 thru 6: $89,796**	**$20,204**

TOTAL THIS CONTRACT PERIOD	**$110,000**

Note: Contingency amounts are NOT allowed on subcontracts. No lump sums. Costs must be split out as shown in the example below, although the format is optional. However, if the subcontract is for a firm fixed price and has already been bid out, documentation may be a simple summary of bid results and basis for why the subcontractor was chosen. This template is intended for design and/or construction costs for a commercial firm. If your subcontract is with a government entity, use the template on sheet 1 ("Budget").
For guidance on subcontractor budgets, please see: http://efw.bpa.gov/contractors/docs/Guidance_on_sub

DELETE INSTRUCTIONS BEFORE LOADING INTO PISCES

Subcontract Budget for Work Element(s) __

Project/Contract Name # 1996-017-00
Contract Period
CR-304692

Yellow shading = input cells/areas. You may wish to remove shading in your version.

	Qty2		Qty1			Unit Cost	COST	
1 PERSONNEL								$0
Senior Engineer				hrs.	@	$115 /hr.	$0	
Staff Engineers		pers.		hrs.	@	$87 /hr.	$0	
CAD				hrs.	@	$78 /hr.	$0	
Surveying		pers.		hrs.	@	$85 /hr.	$0	
Construction Supervisor		pers.		hrs.	@	$73 /hr.	$0	
Construction Labor		pers.		hrs.	@	$55 /hr.	$0	
Admin				hrs.	@	$53 /hr.	$0	
			0.0	hrs.				
2 TRAVEL								$0
Per diem **(specify destination)**		pers.		day	@	$46 /day	$0	
Lodging **(specify destination)**		pers.		nite	@	$77 /nite	$0	
POV Mileage				mi	@	$0.510 /mi	$0	
Fuel for equipment				gal	@	$3.50 /gal	$0	
Misc. **(specify)**					@		$0	
3 SUPPLIES/EQUIPMENT								$0
Office Supplies/Equipment								
(list items)					@		$0	
Interpretive sign for entrance to project site				each	@	$375 /ea	$0	
					@		$0	
					@		$0	
			Subtotal Office				***$0***	
Field Supplies/Equipment								
(list items)					@		$0	
Excavator rental (with operator)		each		days	@	$900 /day	$0	
Dump truck rental (no operator)				days	@	$400 /day	$0	
Rootwads				each	@	$225 /ea	$0	
Grass seeds for re-seeding area				lbs.	@	$4.50 /lb.	$0	
Trees (red alder, douglas fir)				each	@	$1.50 /ea	$0	
			Subtotal Field				***$0***	
4 STATE TAXES on CONSTRUCTION	**8.30%**	**of Items 1 thru 3:**	**$0**					$0
5 CAPITAL EQUIPMENT								$0
					@		$0	
					@		$0	
					@		$0	
6 SUBCONTRACTS								$0
attach sufficient detail for subcontractor budgets							$0	
on second sheet or insert here							$0	
							$0	
TOTAL Subcontract Budget								**$0**

Use Qty1 first, then Qty2, if needed. Formulas can accomodate a blank for Qty2.

Insert rows as needed in the center of blocks. Do not leave $0 lines within budget (hiding unused rows is OK).

To check for the latest per diem rates:
http://www.gsa.gov/perdiem
To check for the latest mileage rates:
http://www.gsa.gov/mileage

Specify whether equipment rates include operator.

Example only: Adjust tax rate and applicable items to reflect state or local requirements or delete row.

Use definition or dollar criteria provided by your accountants.

Kintama Research Services

Project/Contract Name # 1996-017-00
Contract Period
CR-304692

	Qty2		Qty1			Unit Cost		COST
CEO			60.0	day	@	$1,000	/day	$60,000
Data Analyst			20.0	day	@	$700	/day	$14,000
Research Manager			20.0	day	@	$700	/day	$14,000
	FTE Technical		*100.0*					
Research Manager			1.5	day	@	$700	/day	$1,050
	FTE Admin		*1.5*					
					Subtotal Salaries			*$89,050*
Fringe:				NRS 1,3	@	0.00%		$0
				Seasonals	@	0.00%		$0
				Admin	@	0.00%		$0
			Subtotal Benefits					*$0*
Per diem: WA-BC AFS- CEO and Research Manager	1	pers.	4	days	@	$64	/day	$256
Lodging: WA-BC AFS- CEO and Research Manager	1	pers.	3	nights	@	$96	/nite	$288
Flights: YCD-GEG (Spokane)	1	pers.	1	R/T fligh	@	$700	/flight	$700
Per Diem: Salmon Ocean Ecology- CEO and Research Mana	1	pers.	4	days	@	$74	/day	$296
Lodging: Salmon Ocean Ecology- CEO and Research Manag	1	pers.	3	nights	@	$157	/nite	$471
Flights: YCD- SEA (Seattle)	1	pers.	1	R/T fligh	@	$700	/flight	$700
Per diem: BPA- CEO and Research Manager	2	pers.	2	days	@	$64	/day	$256
Lodging: BPA- CEO and Research Manager	2	pers.	1	nights	@	$151	/nite	$302
Flights: YCD-PDX (Portland)	2	pers.	1	R/T fligh	@	$600	/flight	$1,200
POV Mileage	0	mo.	0	mi./mo.	@	$0.550	/mi	$0
Misc.								$0
Registration: WA-BC AFS- CEO and Research Manager			1	person	@	$275		$275
Registration: Salmon Ocean Ecology- CEO and Research Manager			1	person	@	$250		$250
		22.50%	**of Items 1 thru 6:**					

Note: Contingency amounts are NOT allowed on subcontracts. No lump sums. Costs must be split out as shown in the example below, although the format is optional. However, if the subcontract is for a firm fixed price and has already been bid out, documentation may be a simple summary of bid results and basis for why the subcontractor was chosen. This template is intended for design and/or construction costs for a commercial firm. If your subcontract is with a government entity, use the template on sheet 1 ("Budget").

DELETE

For guidance on subcontractor budgets, please see: http://efw.bpa.gov/contractors/docs/Guidance_on_sub

Subcontract Budget for Work Element(s) __

Project/Contract Name # 1996-017-00

Contract Period

CR-304692

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shading in yo

	Qty2		Qty1			Unit Cost	COST	
Senior Engineer				hrs.	@	$115 /hr.	$0	
Staff Engineers		pers.		hrs.	@	$87 /hr.	$0	
CAD				hrs.	@	$78 /hr.	$0	
Surveying		pers.		hrs.	@	$85 /hr.	$0	
Construction Supervisor		pers.		hrs.	@	$73 /hr.	$0	
Construction Labor		pers.		hrs.	@	$55 /hr.	$0	
Admin				hrs.	@	$53 /hr.	$0	
			0.0	hrs.				
Per diem (specify destination)		pers.		day	@	$46 /day	$0	
Lodging (specify destination)		pers.		nite	@	$77 /nite	$0	
POV Mileage				mi.	@	$0.510 /mi	$0	
Fuel for equipment				gal	@	$3.50 /gal	$0	
Misc. (specify)					@		$0	
Office Supplies/Equipment								
(list items)					@		$0	
Interpretive sign for entrance to project site				each	@	$375 /ea	$0	
					@		$0	
					@		$0	
			Subtotal Office				***$0***	
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(list items)					@		$0	
Excavator rental (with operator)		each		days	@	$900 /day	$0	
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Rootwads				each	@	$225 /ea	$0	

Use Qty1 firs
blank for Qty

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lines within b

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http://www.gsa
To check for
http://www.gs

Specify whet

Grass seeds for re-seeding area	lbs.	@	$4.50 /lb.	$0		
Trees (red alder, douglas fir)	each	@	$1.50 /ea	$0		
	Subtotal Field			***$0***		
	8.30% of Items 1 thru 3:					**Example only state or local**
		@		$0		
		@		$0		**Use definitio**
		@		$0		
attach sufficient detail for subcontractor budgets				$0		
on second sheet or insert here				$0		
				$0		

From: Erin Rechisky

Sent: Tue Nov 15 14:05:20 2016

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

Subject: RE: Pisces details

Importance: Normal

Thanks Christine. Looks good.

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 15, 2016 1:58 PM
To: Erin Rechisky
Subject: RE: Pisces details

Hi Erin,

I'm attaching what I did with the budgets – I'm holding on to the one with travel for reference because it has the reasonable costs that you looked up. For the regular budget, we are supposed to delete the $0 items, so that simplifies it substantially.

I will bring up the travel and our new rules for invoicing at hourly rates with Peter. I've been wondering how this will work when they are essentially asking large state agencies such as WDFW to send invoices with different formatting than they might use for everything else.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Tuesday, November 15, 2016 12:13 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Pisces details

Hi Christine,

Attached is a draft line item budget. Have a look at the travel section and let me know if I should remove it entirely.

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 14, 2016 1:13 PM
To: Erin Rechisky; David Welch
Subject: RE: Pisces details

Okay – I have 8am or 10-12 open tomorrow. I will try to have the sole source justification ready, and look over everything that is currently on Pisces.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Monday, November 14, 2016 12:33 PM
To: Erin Rechisky; Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

I have to leave here soon, so let's plan to talk first thing tomorrow.

Thanks,
Erin

From: Erin Rechisky
Sent: November 10, 2016 4:56 PM
To: 'Petersen,Christine H (BPA) - EWP-4'; David Welch
Subject: RE: Pisces details

Hi Christine,

Tomorrow is a holiday for us too.

I just made some updates to the SOW. Perhaps we can review it on Monday. I am in the office from, 9-1 on Mondays.

Have a great weekend!

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 10, 2016 10:59 AM
To: Erin Rechisky; David Welch
Subject: RE: Pisces details

Okay – We have a veteran's day holiday tomorrow, but I will check email.

Christine

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
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Hi Christine,

It is likely that our methods were considered a draft and were deleted.

I have not started working on the budget yet. I am on a conference call and will do so soon.

I made some changes yesterday and saw all of the changed dates. Looks good.

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Let me see if I can contact the USGS staff who seem to run that site. A few months ago, they seemed to be deleting some of the methods that they decided were in draft rather than final form (which was actually a large fraction of them).

In any case, I think it is fine to take care of it later – it would just be convenient to link to the already published set of methods.

We can link to oceantrack on one of the tabs in Pisces.

Are you around this morning? Have you made progress with the line item budget?

When I go over the SOW with a manager (Peter Lofy rather than Ben Zelinsky, who is out on leave), we probably will have small suggested edits to wording.

I changed the start date to Dec. 15 in Pisces and we can see if this will be acceptable to our contracting officer, but there is a chance she could ask us to push it out further.

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From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Wednesday, November 09, 2016 12:17 PM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

Thanks. I'm working on this again now.

I searched monitoringmethods.org for our survival analysis methods (and other methods) but could not find them. We submitted three methods documents to BPA in the past. If they are not on monitoringmethods.org, where would they be?

All of the detection data from the COAST project is on the Ocean Tracking Network website: http://members.oceantrack.org/data/discovery/KNTM.htm

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Hi Erin and David,

Here are a few things to work on in Pisces

**We need to upload the line item budget as an Excel attachment in Pisces. You have worked on the budget already. Some minor modifications might need to be made to the dates later. The 'work element budget' tab isn't really as relevant to this contract as for contracts under the NPCC council program, but if you just fill in some estimates, it will make the error message go away.

**Regarding start and end dates – I spoke to Peter Lofy who will review this contract as a manager after we get it ready. He agreed with me in suggesting a full year contract, even if you schedule no activities or invoicing after April. However, in his opinion, our agency cannot prevent you from doing uninvoiced activity on a volunteer basis, in the form of interacting with journal editors and responding to peer review. (I was a bit fuzzy on this point, because I have heard of examples involving construction, where an employer would have to give a stop work order, and could not avoid paying overtime labor hours that staff performed on the basis of an agreement that a job should only take X hours). In any case, we find your plan to do most of the writing this winter and to set an April deadline to be advantageous to our goals. We can keep the April milestone deadlines for many of the journal article and data analysis tasks.

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**For the BPA article review description "In order to maintain scientific independence, our request is that BPA staff confine their comments to the application of the scientific findings to management, so that Kintama can identify and expand upon those areas deemed of greatest importance for translating the scientific findings into useful management advice. Kintama staff will retain sole scientific authority over the scientific analysis and publication of the results."

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**I am pretty happy with the straightforward description for the analysis WE description and the summary Contract Description. As we discussed over the phone, I think both sections would benefit from just a couple more sentences of expanded description of the source of tag detection data, and background clarification for anyone unfamiliar with the project. Perhaps some sentences from your original COAST proposal that the ISRP reviewed would suffice. Keep the current first paragraph for the contract description, and present the current paper as a new concept that does a new data analysis from the multiyear dataset. Some amount of redundancy is not a problem.

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Sent: Tue Nov 15 14:55:04 2016

To: Erin Rechisky

Subject: RE: Pisces details

Importance: Normal

Attachments: SoleSourceJustification Kintama-DRAFT (Nov 2016).docx

Hi,

Can you press 'submit' in Pisces? Then I could route the contract along. It only gets frozen from further edits when it gets sent to our contracting officer. I am attaching the current sole source justification, which Peter Lofy is supposed to sign. I'll try to grab him by the end of the day and go over it with him. I kept most of the text, and just edited parts of it. I think it is pretty much in line with the successful sample that we borrowed from PC Trask.

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BPA-2021-00513-F 0681

Complete a non-competitive justification for procurements with an anticipated value of over $10,000 following this format as it applies. A non-competitive transaction justification is not required for procurements under $10,000, procured from Federal Prison Industries, other federal agencies, AbilityOne Nonprofit Agencies for the Blind or other Severely Handicapped, Government Printing and Binding or for utility services. (BPI 11.7.1.1)

1. **Description of Materials or Services:**
Provide a complete description of the requirement, what program or project it supports and how it supports the mission of BPA. Quantities and detailed descriptions are not required unless as a part of the justification contained in section 3 of this justification. If requesting materials, include the Manufacturer, Manufacturer's part number, and indicate whether or not a time critical outage schedule for use of these items applies.

(b)(5) [redacted]

(b)(5) [redacted]

2. **Non Competitive Authority:** *From the list below check the applicable BPI authority permitting the proposed non-competitive transaction. Contact your Contracting Officer or Team Lead if you need assistance.*

☐ Repair parts, accessories, supplemental equipment or services required for supplies or services previously furnished or contracted for which are available from only one contractor. (BPI 11.7.1.2(a));

☐ Required by law or Executive Order (BPI 11.7.1.2(b));

☐ The entity has the responsibility to manage the property or resource to be affected by the services performed. (BPI 11.7.1.2 (c));

☐ BPA standard items, when a Business Line Vice President or equivalent level manager has determined in writing that BPA must standardize the use of the item, and that determination is available for review by the HCA. (BPI 11.7.1.2 (e));

- ☐ Agreements with nonprofit research organizations such as the Electric Power Research Institute (EPRI) for the purposes identified in this section (BPI 11.7.1.2 (f) (1-6));
- ☐ Establish or maintain an essential engineering, research, or development capability to be provided by an educational or other nonprofit institution or a federally funded research and development center. (BPI 11.7.1.3 (a));
- ☐ When other parties have offered BPA an opportunity to participate in specific projects on a cost-sharing basis, and the sponsor has arranged for a substantial portion of the required funding for the entire project. (BPI 11.7.1.3(b));
- ☒ This is the only feasible source which can meet BPA's requirement and no other supplies or services will satisfy agency requirements (BPI 11.7.2);

3. Justification:
Provide sufficient information to support the proposed non-competitive transaction based on the authority cited above and instructions of this section. Keep in mind that this document is reviewed and that your explanations may be formally questioned and protested if your justification is insufficient or not valid. For the BPI authorities 11.7.1.2 (f), 11.7.1.3(a) and 11.7.1.3(b), be sure to address the specific information required by those sections. For the BPI authority 11.7.2, unique source, all of the following elements must be provided: (1) The minimum mandatory requirements for the procurement (may be addressed in Section 1, Description of Materials or Services); (2) Identify what other sources were considered during market research (may be addressed in Section 6, Market Survey, below) and why those sources do not meet the minimum mandatory requirements and are not feasible due to form, fit, function, capabilities, capacity, experience, price, or delivery timeframe; (3) Demonstrate that the proposed contractor is the only feasible source based on unique capabilities, unique experiences, or unique attributes.

Kintama Research Services

Kintama Research Services is a world leader in the design and use of large-scale underwater acoustic telemetry arrays, with particular experience in applying these technologies to provide novel scientific information relevant to salmon management. Bonneville Power Administration contracted with Kintama Research Services, Ltd. under project #2003-114-00 in the Fish and Wildlife program for in-river, estuary and early marine survival estimates as they relate to delayed mortality due to migration through the hydrosystem or transportation around the FCRPS. Active data gathering and research under this project occurred from 2003 to 2012.

(b)(5)

[redacted]

(b)(5)

[redacted]

(b)(5)

[redacted]

David Welch, the president and founder of Kintama has received multiple awards for his scientific research, including the American Fisheries Society's award for Best Published Paper (2014), the American Fisheries Society's Award of Excellence-Fisheries Management (2012), the Canadian Society for Meteorology & Oceanography's J. P. Tully Medal in Oceanography (2012), and the Prix d'Excellence (2008) and Prix de Distinction (2007) from Fisheries & Oceans Canada for *"Exceptional Scientific Contributions to the Government of Canada"* and *"Outstanding Scientific Contributions Related To National And International Climate Change Research*, respectively. Dr Rechisky has over 20 years of work on acoustic telemetry of marine fish, and completed her PhD at the University of British Columbia analyzing the Columbia River data to look at the credence of the delayed mortality and differential-delayed mortality theories. She is also the current Secretary of the American Fisheries Society's B.C.-Washington Chapter. Aswea Porter, M.Sc., has worked for Kintama since 2006, and is senior data analyst and has primary responsibility for managing Kintama's acoustic telemetry database and much of the underlying preparatory analysis needed for production of scientific reports and published papers, as well as extensive involvement in the writing phase.

Why BPA is doing Estuary and Ocean Research:

(b)(5)

[redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

History of Sole Source to Kintama:

There is no history of sole source contracting with Kintama. The earlier BiOp program project 2003-114-00 was awarded via a bidding process.

Why we still need Kintama's services:

(b)(5) [redacted]

(b)(5)
[redacted]

(b)(5)

[redacted]

----

4. **Actions to Promote Competition:** At the onset of each procurement, all unique source justifications are scrutinized and screened for the possibility of further competition by Supply Chain. Further, competition barriers are discussed with the customer and options explored when available. *This section is prefilled and needs no editing.*

5. **Project Estimated Amount:** The anticipated price to the Government is **$110,000** take the report to White Paper stage, and to complete report revisions during the peer-review process after submission to a scientific journal.

6. **Market Survey:** *Describe the market research that was performed that led you to your conclusion that there was need to waive competition. If no market research was performed, such as in instances of Urgent and Compelling, explain in detail here.*

   See justification

7. **Requirements Certification:** I certify that the requirement outlined in this justification is a bonafide need of the Bonneville Power Administration and that the supporting data under my cognizance, which are included in the justification, are accurate and complete to the best of my knowledge and belief.
   (Signature of the responsible manager)

   Name & Title   Date

8. **Approval** *This part is filled out by Contracting Staff as part of the Justification*

   a. **Contracting Officer's Certification: (required)** I certify that the foregoing justification is accurate and complete to the best of my knowledge and belief.

Contracting Officer Signature

Date

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

Sent: Tue Nov 15 15:06:19 2016

To: Erin Rechisky (Erin.Rechisky@kintama.com)

Importance: Normal

Oh – by the way – regarding the RME protocol and data repository – I wrote to the USGs monitoringmethods website folks, and asked them to add your ocean tracking website link as an option. When they respond, it is a minor detail to add it.

Christine

From: Erin Rechisky

Sent: Tue Nov 15 15:12:51 2016

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

Subject: RE: Pisces details

Importance: Normal

David is reviewing it now...

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 15, 2016 3:11 PM
To: Erin Rechisky
Subject: RE: Pisces details

Okay – Peter isn't at his desk until tomorrow, but I will try to find him tomorrow and prioritize this. He usually has several edits to suggest.

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Erin

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BPA-2021-00513-F 0691

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To: Erin Rechisky; David Welch
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From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Monday, November 14, 2016 12:33 PM
To: Erin Rechisky; Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

Hi Christine,

I have to leave here soon, so let's plan to talk first thing tomorrow.

Thanks,
Erin

From: Erin Rechisky
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To: 'Petersen,Christine H (BPA) - EWP-4'; David Welch
Subject: RE: Pisces details

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I just made some updates to the SOW. Perhaps we can review it on Monday. I am in the office from, 9-1 on Mondays.

Have a great weekend!

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To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: Pisces details

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From: Erin Rechisky

Sent: Tue Nov 15 15:30:49 2016

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

Subject: RE: Pisces details

Importance: Normal

Christine, can you please change our business phone numbers in Pisces? I can edit them.

Erin : (b)(6) [redacted]

David [redacted]

Thanks.

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
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BPA-2021-00513-F 0709

From: Erin Rechisky

Sent: Wed Nov 16 09:58:57 2016

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

Subject: RE: Pisces details

Importance: Normal

Hi Christine,

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Sent: Wed Nov 16 10:51:15 2016

To: Erin Rechisky

Subject: RE: Pisces details

Importance: Normal

Attachments: Budget Kintama Nov 2016_Trav.xls

Hello,

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From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Wednesday, November 16, 2016 9:59 AM
To: Petersen,Christine H (BPA) - EWP-4
Subject: RE: Pisces details

Hi Christine,

I am here until 2 today if I need to make any changes to the SOW.

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Sent: November 15, 2016 3:11 PM
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Subject: RE: Pisces details

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Thanks,
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From: Erin Rechisky
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Subject: RE: Pisces details

Hi Christine,

Tomorrow is a holiday for us too.

I just made some updates to the SOW. Perhaps we can review it on Monday. I am in the office from, 9-1 on Mondays.

Have a great weekend!

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BPA-2021-00513-F 0731

Kintama Research Services

Project/Contract Name # 1996-017-00
Contract Period
CR-304692

	Qty2		Qty1			Unit Cost		COST
CEO			60.0	day	@	$1,000	/day	$60,000
Data Analyst			19.6	day	@	$700	/day	$13,731
Research Manager			19.6	day	@	$700	/day	$13,720
		FTE Technical	*99.2*					
Research Manager			1.5	day	@	$700	/day	$1,050
		FTE Admin	*1.5*					
					Subtotal Salaries			*$88,501*
Per diem: WA-BC AFS- CEO and Research Manager	1	pers.	2	days	@	$64	/day	$128
Lodging: WA-BC AFS- CEO and Research Manager	1	pers.	2	nights	@	$96	/nite	$192
Flights: YCD-GEG (Spokane)	1	pers.	1	R/T fligh	@	$700	/flight	$700
Registration: WA-BC AFS- CEO and Research Manager			1	person	@	$275		$275
		22.50%	**of Items 1 thru 6:**					

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

Sent: Wed Nov 16 11:24:21 2016

To: david.welch@kintama.com; Erin Rechisky (Erin.Rechisky@kintama.com)

Subject: FW: Kintama sole source

Importance: Normal

Hello –

the line in green is something that my manager Peter wished for us to add, so he added a sentence in the sole source justification.

I added a sentence in the contract milestone for submitting the manuscript for publication. It makes clear that we would only publish as gray literature if it hypothetically weren't accepted at several journals, which could go after 2017.

Christine

From: Lofy,Peter T (BPA) - EWU-4
Sent: Wednesday, November 16, 2016 10:49 AM
To: Petersen,Christine H (BPA) - EWP-4

Subject: RE: Kintama sole source

Make sure this is clear with Kintama….

1. **Project Estimated Amount:** The anticipated price to the Government is **$110,000** to take the report to White Paper (manuscript) stage, and to complete report revisions during the peer-review process after submission to a scientific journal. BPA will have the authority to release the manuscript as a deliverable, should it not be publishable.

From: Petersen,Christine H (BPA) - EWP-4
Sent: Wednesday, November 16, 2016 10:27 AM
To: Lofy,Peter T (BPA) - EWU-4
Subject: Kintama sole source

From: Erin Rechisky

Sent: Wed Nov 16 11:54:30 2016

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

Cc: David Welch

Subject: RE: Pisces details

Importance: Normal

Hi Christine,

Yes, I saw those two errors when I submitted the SOW yesterday. Thanks for taking care of that.

Let me know if there is anything else I can do.

Thanks for getting this turned around so quickly!

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: November 16, 2016 11:46 AM
To: Erin Rechisky
Subject: RE: Pisces details

Okay – also, my coworker told me that I needed to add the 'boilerplate' work elements for manage and Administer

Project, and Annual progress report (which I am able to cancel the deliverable report for). These are now added.

Hopefully we can forward it along soon, and I'll hear from our contracting officer if the start date works for her.

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Is there anything else you need me to do?

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From: Salmon Ocean Ecology

Sent: Mon Nov 28 12:20:14 2016

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Subject: Salmon Ocean Ecology Meeting 2017 - Save the Date

Importance: Normal

Good afternoon everyone,
The planning team for the 2017 Salmon Ocean Ecology Meeting would like to inform you of the dates for the meeting and get some initial feedback to help with our planning process. The meeting will be held in Seattle, WA on March 22nd and 23rd, with an optional workshop on March 21st. **Please mark your calendars.**

For our planning, we created a survey monkey (https://www.surveymonkey.com/r/H2273K9) to get a few peices of information from you. In addition to your name, you will be asked:
1) will you be attending the meeting (yes, no, maybe)
2) are you interested in attending the optional workshop (yes, no, maybe)
3) are you planning to give a presentation (yes, no)
4) are you planning to present a poster (yes, no)
5) are you a student (yes, no)

We will be planning for space, etc. based on this survey, so please respond as soon as you can! Also, there will be limited time for presentations, which means you may be asked to give a poster rather than an oral presentation. We understand the many concerns related to this, but please be understanding as we try and find room for us all.

The optional workshop (is still being designed, but) will consist of a small group discussing a pre-specified set of topics - probably centered around the central theme of salmon prey. Space will be made available for other attendees (in an audience format), but the room set-up (microphones, etc) will be arranged for a small-group discussion. We will be charging registration separately for the workshop, so if you're not interested in this discussion, you won't be charged for it.

Looking forward to hearing from you,
Your 2017 SOEM Planning Team:
Michael Schmidt
Kurt Fresh
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BPA-2021-00513-F 0751

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Subject: Pisces Release at 5pm Tonight - Please wrap up your work & log out prior to then!

Importance: High

Good Afternoon Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you are logged out prior to then.

Today's release for Pisces Desktop contains routine bug fixes. Pisces Web, however, has some additional functionality being released into the CBfish.org environment.

What does this mean to you?

More options for carrying out contract management duties! On Pisces Web, these include:

- CR Initialization *(Internal BPA functionality)*
- Contacts management
- SOW Development, including Milestones, Metrics, Location, Focal Species, Budgets
- **NEW!** Status Reports
- **NEW!** Workflow (contract submission)

We are excited about making this functionality available for users to explore – and we welcome feedback!

Success tips for working in the new environment: ***(these are repeats… but important…)***

- You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!
- We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that
- While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do everyday work in Pisces. Future training will support users with tips and tricks for how to be successful
- If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

- For system access, bugs, or feedback on new functionality – email support@cbfish.org.
- For questions about the Pisces Web project – email pisces@bpa.gov.

We will soon launch an online resource where users can go for updates, reference guides, updated how-to aids, etc.

Regards,

The Pisces Team

Bonneville Power Administration

This message is going to all Pisces Desktop users and Pisces Web project team

From: Salmon Ocean Ecology

Sent: Tue Dec 13 15:19:27 2016

To: alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; camfresh@uvic.ca; campblac@dfw.wa.gov; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chrys.Neville@dfo-mpo.gc.ca; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; david.huff@noaa.gov; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; dower@uvic.ca; dstormer@uvic.ca; ebeamer@skagitcoop.org; ed.farley@noaa.gov; elan.downey@cahs-bc.ca; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erik.Neatherlin@dfw.wa.gov; erin.rechisky@kintama.com; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; gruggerone@nrccorp.com; hans@pgst.nsn.us; Eric Hertz; Ian.Perry@dfo-mpo.gc.ca; ibeveridge@lgl.com; ikemp@lltk.org; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; Jackie.King@dfo-mpo.gc.ca; jamal.moss@noaa.gov; jclark@ak.net; Jeff Rutter; jeanette.gann@noaa.gov; jen.zamon@noaa.gov; jenkins@psc.org; jennifer.gosselin@noaa.gov; jessica.miller@oregonstate.edu; jgmusslewhite@fs.fed.us; jgw3@uw.edu; jim.murphy@noaa.gov; jjulin.holden@gmail.com; jkeister@u.washington.edu; joe.orsi@noaa.gov; Joshua.Chamberlin@noaa.gov; joshuarussell0407@gmail.com; journey@uw.edu; jpkarnezis@bpa.gov; juanes@uvic.ca; kathryn.sobocinski@noaa.gov; katrina.vcook@gmail.com; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; kym.jacobson@noaa.gov; Lance.Campbell@dfw.wa.gov; lapointe@psc.org; Laura Kennedy; laurie.weitkamp@noaa.gov; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org; mara.zimmerman@dfw.wa.gov; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; matt@ktoo.org; mckinnell@shaw.ca; mcrewson@tulaliptribes-nsn.gov; megan.moore@noaa.gov; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; meredith.journey@noaa.gov; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; moore.jed@nisqually-nsn.gov; mschmidt@lltk.org; Megan McPhee; ndavis@npafc.org; neala.kendall@dfw.wa.gov; nick.leone@dfo-mpo.gc.ca; pborrett@uvic.ca; pearsalli@psf.ca; peter.w.lawson@noaa.gov; Amy Teffer; rabeamish@shaw.ca; ralexander@lgl.com; raphael.girardin@noaa.gov; rick.brodeur@noaa.gov; rmflagg@uvic.ca; Sandra.ONeill@dfw.wa.gov; sarah.ballard@noaa.gov; scott.hinch@ubc.ca; sean.hayes@noaa.gov; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; sue.grant@dfo-mpo.gc.ca; thomas.wainwright@noaa.gov; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov;

whitney.friedman@noaa.gov; willduguid@hotmail.com; David Welch

Subject: Respond ASAP: Salmon Ocean Ecology Meeting 2017

Importance: Normal

REMINDER. PLEASE RESPOND TO THE FOLLOWING SURVEY BY WEDNESDAY, **DECEMBER 21. YOUR RESPONSE IS CRITICAL FOR PLANNING THE 2017 SOEM MEETING**

The planning team for the 2017 Salmon Ocean Ecology Meeting would like to inform you of the dates for the meeting and get some initial feedback to help with our planning process. The meeting will be held in Seattle, WA on March 22nd and 23rd, with an optional workshop on March 21st. **Please mark your calendars.**

For our planning, we created a survey monkey (https://www.surveymonkey.com/r/H2273K9) to get a few pieces of information from you. In addition to your name, you will be asked:

1) will you be attending the meeting (yes, no, maybe)

2) are you interested in attending the optional workshop (yes, no, maybe)

3) are you planning to give a presentation (yes, no)

4) are you planning to present a poster (yes, no)

5) are you a student (yes, no)

We will be planning for space, etc. based on this survey, so please respond as soon as you can! Also, there will be limited time for presentations, which means you may be asked to give a poster rather than an oral presentation. We understand the many concerns related to this, but please be understanding as we try and find room for us all.

The optional workshop (is still being designed, but) will consist of a small group discussing a pre-specified set of topics - probably centered around the central theme of salmon prey. Space will be made available for other attendees (in an audience format), but the room set-up (microphones, etc) will be arranged for a small-group discussion. We will be charging registration separately for the workshop, so if you're not interested in this discussion, you won't be charged for it.

Looking forward to hearing from you,

Your 2017 SOEM Planning Team:

Michael Schmidt

Kurt Fresh

Brian Beckman

Brian Burke

From: David Welch

Sent: Thu Dec 15 12:09:50 2016

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: Catching up?

Importance: Normal

Glad to. My calendar is pretty well clear between now and end of January, so you can co-ordinate and see what times work for your side.

I suggest that bullet item #2 be split into two parts. The existing Bullet can remain, and the new bullet #3 comes in like this:

- An update on the Chilko results and their implications
- Status update on the current contract and a refresher of the goals and scope of the work

(b)(5) [redacted]

Please make sure that I'm not stepping on any toes here, in discussing this directly with you—I have approached you rather than Christine with this because I get a sense that Christine views her work as more "*managing the process*" than asking how things should be used, but I don't want to create any antipathy either.

Regards, David

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Thursday, December 15, 2016 9:53 AM
To: David Welch
Subject: RE: Catching up?

David,

Well – I'm glad things are moving albeit glacially. What do you think about giving a group of us an update - either via web conference or in person with three goals:

- An update on the Chilko results and their implications
- Discussion of how to share the results with the region and any $ requests associated with that
- Status update on the current contract and a refresher of the goals and scope of the work

I'd be happy to help set that up. I'd want Lorri to be part of it both due to her interest in the work and given that any funding requests would go through her. (b)(5) [redacted] high expectations but I think it would be good for us to know what the options are.

Ben

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Wednesday, December 14, 2016 3:00 PM
To: Zelinsky,Benjamin D (BPA) - EWP-4
Subject: Catching up?

Hi Ben—

The contract process is moving forwards at its usual glacial pace—Erin and I have been working with Christine and I expect that we will have the contract in place either December 15th (don't hold your breath on that one!) or sometime after the start of the New Year.

I did want to catch up with you separately from Christine to get your thoughts and counsel. We have now completed our report on this year's study on Chilko (Fraser River) Chinook movements and survival. The results are quite striking—the Chinook from this population took a month(!) to reach the Fraser River mouth and had 49% survival after release.

We will be documenting this result up as part of a different paper, but this result brings me back to the reasons I reached out to BPA 18(!) months ago—As I reported back in 2008, survival isn't better in the Fraser River, and this [redacted]

This isn't funded, and my question is, is Christine the right person to work with to try to find financial support for this additional piece of work? Or, do I try lobbying someone higher (perhaps Lori directly), to get across the importance of documenting this finding? As you appreciate, BPA is a large organization, and the number of folks prepared to push things forward rather than just go through the motions isn't a large fraction of the staff.

Your candid thoughts and advice would be valued.

Thanks,

David

David Welch, Ph.D.

kintamav_RGB

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P Please consider the environment before printing this e-mail

From: David Welch

Sent: Tue Dec 20 16:26:38 2016

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

Subject: FW: BPA contract start date

Importance: Normal

Hi Christine—

I have to leave the house at 5 PM. Does now work for a discussion, or shall we put the call off until tomorrow?

The house is [redacted] or I can call you.

Regards, David

From: Erin Rechisky
Sent: Tuesday, December 20, 2016 1:27 PM
To: David Welch
Subject: BPA contract start date

Hi David,

Expect a call from Christine after you get home. There is a possibility that our contract will not start until Feb 1 despite her efforts. She will explain.

Erin

Erin Rechisky, PhD

Research Manager

cid:image001.jpg@01D1CBC9.88953580

kintama.com

755 Terminal Avenue • Nanaimo BC V9S 4K1 • Canada

Cell: [redacted]

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

and

Secretary, WA-BC Chapter of the AFS • wabc-afs.org

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

Sent: Wed Dec 21 10:34:52 2016

To: David Welch

Subject: RE: https://www.humanfactors.academy/blog/incompetent-and-unaware-you-don-t-know-what-you-don-t-know

Importance: Normal

This is a nice presentation, and the concept applies to a lot of different things. The wingsuit video is a bit terrifying. I don't want to point out that Donald Rumsfeld is famous for a superficially similar quote?

Anyway – in a totally different direction – a speaker at a groundfish conference once had a good argument that the whole practice of stock assessment is on shaky grounds due to evolution caused by fishing. We typically think that we only have errors in estimating abundance, or perhaps the influence of climate rather than just take on density dependence. But instead we are probably causing traits of fish to evolve as we go along.

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, December 20, 2016 4:40 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: https://www.humanfactors.academy/blog/incompetent-and-unaware-you-don-t-know-what-you-don-t-know

David Welch, Ph.D.

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P Please consider the environment before printing this e-mail

From: David Welch

Sent: Wed Dec 21 16:50:42 2016

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

Subject: RE: Redfish Lake reference...

Importance: Normal

Thanks!

I hadn't remembered the Willamette angle to that paper. Your comment about them being very large smolts as yearlings ties in with something I have been interested in for a long time—theyt I don't think size is a good predictor of marine survival, despite many opinions to the contrary.

If my memory is correct, don't Willamette Chinook have very low SARS, despite the limited dam passage and the very large size of the yearlings?

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Wednesday, December 21, 2016 4:29 PM
To: David Welch
Subject: RE: Redfish Lake reference...

Thank you.

That is interesting that they were able to catch so many.

This was the paper (that I noticed you are an author of!) that showed a pattern with Willamette Chinook being unusually abundant at one transect SEAK – which is surprising because they're not that abundant. Barbara Shield's students apparently were among the first to popularize that quite a few move out of the tributaries as fry, and they can't expect that there is no wetland habitat downstream. (b)(5) [redacted]

https://www.researchgate.net/profile/Marc_Trudel2/publication/239937944_Annual_coastal_migration_of_juvenile_Chinook_salmon_Static_stock-specific_patterns_in_a_highly_dynamic_ocean/links/0c96051c33f92384b0000000.pdf

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Wednesday, December 21, 2016 4:03 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: Redfish Lake reference...

Here is the reference I was referring to... they used CWTs, not PIT tags, to identify the Snake R smolts.

http://www.tandfonline.com/doi/abs/10.1080/00028487.2014.968292

Merry Christmas!

David

David Welch, Ph.D.

kintamav_RGB

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From: Pisces

Sent: Thu Jan 05 12:39:13 2017

To: Pisces

Subject: Pisces Release at 5pm tonight (1/5/17) - Please wrap up your work & log out prior to then!

Importance: High

Good Afternoon Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you have completed your work and are logged out prior to then. The system should be back online by 6pm – we will reach out if anything changes.

There is no new functionality being released to Pisces Web this month, but feel free to reach out with any questions you have. We will be providing access to more tips and tricks in the short-term. We are excited about making this functionality available for users to explore – and there will be more communication and some training opportunities rolled out gradually!

Success tips for managing your contracts in the Pisces Web environment:

· You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!

- We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

- While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do everyday work in Pisces. Future training will support users with tips and tricks for how to be successful

- If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

- For system access, bugs, or feedback on new functionality – email support@cbfish.org.

- For questions about the Pisces Web project – email pisces@bpa.gov.

Happy New Year!

The Pisces Team

Bonneville Power Administration

This message is going to all Pisces Desktop users and Pisces Web project team

From: David Welch

Sent: Wed Jan 11 13:50:17 2017

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

Subject: RE: date change.

Importance: Normal

Attachments: Brosnan et al (Survival Rates of Out Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas Supersaturated Water-JAAH 2016).pdf

Hi Christine—Just to clarify Erin's last comment, we are not "fishing" for a contract at this late date this year, but in our recent TDG paper (attached) we made this comment ((p. 249):

"Although our results are consistent with the known

effects of TDG, the uncertainty in the underlying assumptions

calls for a controlled experiment to clarify how survival

in the lower freshwater reaches of the Columbia River

and the coastal ocean is affected by TDG exposure. A

formal experiment that uses simultaneous paired releases

of smolts that are exposed to different levels of TDG

along with control groups of unexposed smolts could easily be performed by using the same techniques described here

and by Rechisky et al. (2012, 2013).”.

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

This is a big part of what I would like to outline in the conference call.

Best, David

From: Erin Rechisky
Sent: Wednesday, January 11, 2017 12:09 PM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: date change.

Hi Christine,

We'd like to change the following end dates all within Work Element C:

- Milestone A: end on July 31
- Milestone B: end on June 30
- Milestone C: end on August 31
- Milestone E: end on August 31

Regarding the top paper priorities, David and I would like to discuss this with you and Ben, and perhaps Jeff as well. Could you set up a conference call? David and I are available for most of this Friday. We could meet anytime between 9 and 4. We are in the office tomorrow as well, but David has an appointment at 10:30 and I leave at about 2:00 on Thursdays.

Also, can you send a link to the news articles about the preliminary injunction you mentioned? Kintama could potentially submit a proposal to monitor smolts but we'd have to start this work ASAP in order to have the proposal reviewed, approved and then order transmitters prior to the outmigration- which might not be feasible at this late date.

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: January 11, 2017 11:04 AM
To: Erin Rechisky; David Welch
Subject: RE: date change.

Hi Erin,

Can you tell me which dates you would like to change?

I was just talking to the CO in our procurement group and they are still working through their backlog and there could be a possibility of doing last minute changes.

(b)(5) [redacted]

(b)(5) [redacted]

Also of some interest for you or Ian Brosnan, there was a preliminary injunction asking the judge to require a spill to gas cap experiment this spring...there were some news articles about it yeaterday. It would be hard to design monitoring. Will this high snowpack result in high forced spill levels and high gas like in 2011 anyway?

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 1/11/17 9:49 AM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: date change.

Hi Christine,

I wanted to modify some of the milestones end dates in Pisces but I don't seem to have write permission. Can you give me access or should I tell you what we wanted to change.

Thanks,
Erin

From: David Welch
Sent: December 21, 2016 3:08 PM
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: date change.

Thanks, Christine—Sorry for the delay in responding—just back from my annual meeting with our IT service provider.

This sounds sensible—I will ask Erin to put it on her list to review the dates of the intermediate milestones held in PICES next, after she gets a manuscript off her desk and to our co-authors (by Friday, we are hoping).

I will wait for you to get some feedback on the broader issues of whether a pre-award is possible, and then we can more intelligently discuss the possibilities at that point.

If I don't hear from you before Friday noon, Merry Christmas to you and yours!

Regards, David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Wednesday, December 21, 2016 12:41 PM
To: Erin Rechisky; David Welch
Subject: date change.

Hello,

I changed the dates in the contract in a relatively simple way, moving the start and end dates one month forward. You might want to glance at the intermediate milestone dates describing goals like submitting the paper to a journal.

I will try to raise the question of whether it is in any way possible to do a pre-award agreement which would allow invoicing to the period before the final contract is issued, which is a practice we have for most of our regular Fish and Wildlife program contracts.

Talk to you soon,

Christine P.

Journal of Aquatic Animal Health

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Survival Rates of Out-Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas-Supersaturated Water

Ian G. Brosnan, David W. Welch & Melinda Jacobs Scott

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Download by: [David Welch] **Date:** 24 October 2016, At: 20:36

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DOI: 10.1080/08997659.2016.1227398

ARTICLE

Survival Rates of Out-Migrating Yearling Chinook Salmon in the Lower Columbia River and Plume after Exposure to Gas-Supersaturated Water

Ian G. Brosnan*[1]
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David W. Welch[2] **and Melinda Jacobs Scott**[2]
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Abstract
In 2011, unusually high flows caused total dissolved gas (TDG) levels in the Columbia River, USA, to escalate well above the 120% regulatory limit that was imposed to prevent harmful impacts to aquatic organisms. After observing gas bubble trauma (GBT) in dead yearling Chinook Salmon *Oncorhynchus tshawytscha* (smolts) held in tanks, we compared estimated survival rates of acoustic-tagged in-river-migrating (IR) and transported (TR) smolts that were released below Bonneville Dam prior to and during the period of elevated TDG (>120%). The log odds of estimated daily survival in the lower river and plume was significantly lower for IR smolts that were released during elevated TDG (maximum possible exposure = 134%) than for IR smolts released when TDG was less than 120%. The TR smolts that were released 10–13 km below Bonneville Dam during elevated TDG had lower maximum possible exposure levels (126% TDG), and the log odds of estimated daily survival in the lower river and plume did not differ from that of TR smolts released when TDG was less than 120%. Direct mortality due to GBT is probably reduced in natural settings relative to laboratory experiments because smolts can move to deeper water, where pressure keeps gasses in solution, and can migrate downstream of the spillway, where TDG levels decrease as the river returns to equilibrium with the atmosphere. However, initially nonlethal GBT may reduce survival rates by increasing smolt susceptibility to predation and infection. Although our findings are limited by the observational nature of the study, our analysis is the first direct assessment of gas supersaturation's potential influence on survival of free-ranging smolts in the river and coastal ocean below a large dam. Experiments using simultaneous releases of control and gas-exposed groups are warranted and should consider the possibility that the chronic effects of TDG exposure on survival are important and persist into the early marine period.

The practice of spilling water over dams can induce gas bubble trauma (GBT; also termed gas bubble disease) in aquatic species, including salmon smolts, by increasing total dissolved gas (TDG) levels in the river below the spillways. Globally, as the number of hydropower projects grows, there is increasing concern about the effects of TDG on fish health (Wang et al. 2015). An extensive body of literature has evaluated the physical, biological, and ecological effects of dissolved gas and GBT on salmon smolts (reviews by Weitkamp and Katz 1980; McGrath et al. 2006; Maynard 2008). Most of the direct mortality effects at TDG exposures of up to 125% can be avoided when fish are at liberty to compensate by migrating (Weitkamp and Katz 1980). However, even nonlethal GBT experiences may affect survival by increasing the susceptibility of juvenile salmon to predation (Mesa and Warren 1997), bacterial infections (Huchzermeyer 2003), and fungal infections (Weitkamp

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Received October 5, 2015; accepted August 18, 2016

BPA-2021-00513-F 0790

1976; Lutz 1995). Existing infections and multiple exposures may also reduce salmon resistance to GBT such that otherwise nonlethal exposures to supersaturated water are rendered deadly (Cramer 1996; Weiland et al. 1999).

Juvenile salmon that pass through spillways avoid the physical effects of powerhouse passage, and this may contribute to improved salmon survival—an issue of particular concern with regard to salmonids that are listed as threatened or endangered under the U.S. Endangered Species Act (Budy et al. 2002; Petrosky and Schaller 2010; USOFR 2012). The states of Oregon and Washington balance the impacts of spill against its potential benefits by imposing modified water quality standards that permit elevated TDG levels in dam forebays (115%) and tailraces (120%) during smolt out-migration (USEPA 1986; Washington State Legislature 2003; OSA 2003; ODEQ–EQC 2009). These regulatory measures are intended to prevent juvenile salmon from experiencing TDG levels above 120%, with exceptions for high-flow events, when powerhouse capacities are exceeded and spill is involuntary. Total dissolved gas levels often exceed regulatory limits for several days each year and for a variety of reasons, such as flood, flow, and temperature control; equipment maintenance or malfunctions; or communication failures. In the Columbia River basin, 2011 was unusual for having sustained, systemic exceedances resulting from high flow that triggered exemptions to the TDG limits (USACE 2011).

Previous research into the effects of TDG exposure has focused on the symptoms and effects of GBT induced by exposure to gas-supersaturated water in laboratory and cage studies or has involved field surveys of GBT symptoms. No previous work has measured survival effects in the lower Columbia River and plume, partly because the technology for conducting such studies (e.g., acoustic telemetry) was not available when the majority of the studies were conducted. However, in 2011, high flows in the Columbia River resulted in TDG reaching 134% below Bonneville Dam, which was fortuitously coincident with the release of both barge-transported and in-river-migrating, acoustic-tagged juvenile yearling Chinook Salmon *Oncorhynchus tshawytscha* (henceforth, smolts) during a long-term study (Rechisky et al. 2012, 2013, 2014; Brosnan et al. 2014). During this period of high TDG, mortality due to GBT was observed in 17 of 59 smolts that were held for tagging in tanks supplied with water taken from the upper face of Bonneville Dam. This was the first observation of GBT among fish used during the long-term study.

Because the timing of tagged smolt releases covered the period before and after TDG levels climbed above the state limits, we were given a unique opportunity to compare the potential effect of exposure to gas supersaturation on the subsequent survival of free-ranging Chinook Salmon smolts in the lower Columbia River and estuary (Bonneville Dam to Astoria; henceforth, lower river) and the Columbia River plume (Astoria to Willapa Bay; Figure 1). Our objective with this retrospective cohort study was to compare the survival of transported (TR) and

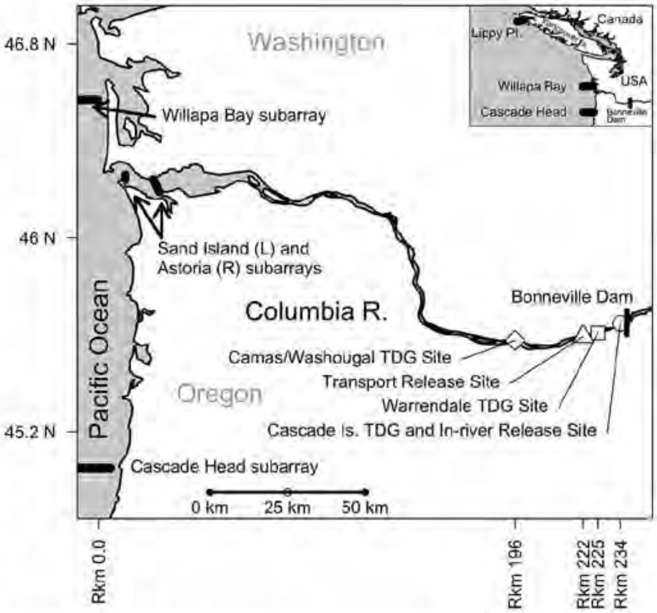

FIGURE 1. Locations of total dissolved gas (TDG) monitoring sites in the Columbia River below Bonneville Dam, release sites for tagged Chinook Salmon, and subarrays of acoustic receivers. In-river-migrating smolts were released at the Bonneville Dam smolt monitoring facility (~1 km downstream of the Cascade Island TDG monitoring site). Transported smolts were released between river kilometer (rkm) 222 and rkm 225 on the Columbia River; the Warrendale TDG monitoring site is located at rkm 225. The plume encompasses the region between the Astoria and Willapa Bay subarrays.

in-river-migrating (IR) smolts that were released into gas-supersaturated waters below the 120% state water quality limits (i.e., classified as "low exposure") with that of their counterparts, which were released when TDG levels were above the limits (classified as "high exposure"; Figure 2). Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT, did not appear to play an important role in survival over the study period (see Discussion).

We evaluated the TR and IR smolts separately because of their handling differences; we pooled smolts that were released several days apart (Figure 3; Table 1). Low-exposure TR smolts were released at an average TDG of 116%, and high-exposure TR smolts were released when TDG averaged 125% TDG. Because direct mortality effects may be avoided at up to 125% TDG (Weitkamp and Katz 1980), we hypothesized that there would be lower survival among the high-exposure smolts due to chronic GBT effects but not acute effects. Low-exposure IR smolts were released at an average TDG of 118%, and high-exposure IR smolts were released at 132% TDG. Thus, we hypothesized that survival effects in the high-exposure smolts would be acute, chronic, or a combination of acute and chronic (Cramer 1996).

We developed our hypotheses from the existing body of research regarding TDG effects on salmonids. In laboratory settings, chronic effects on fish health, such as increased

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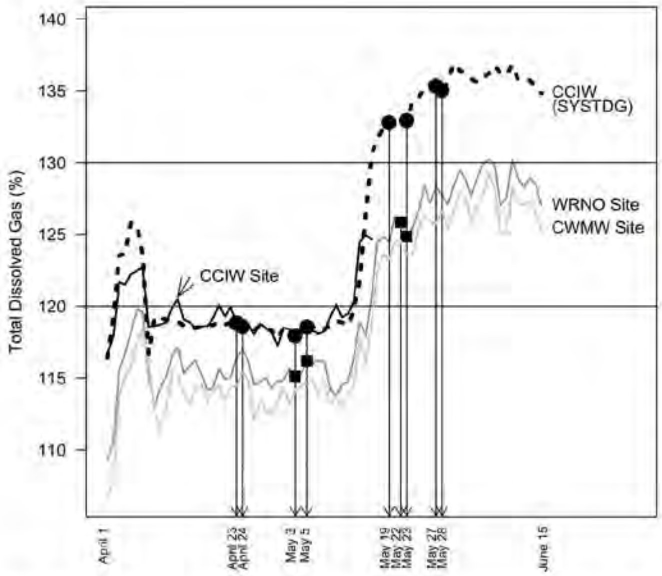

FIGURE 2. Average daily total dissolved gas (TDG; %) below Bonneville Dam on the Columbia River, calculated using the Oregon methodology from data recorded at three downstream TDG monitoring stations (CCIW = Cascade Island; WRNO = Warrendale; CWMW = Camas–Washougal) between April 1 and June 15, 2011. Solid lines denote measured values at each station. The dotted line represents the TDG prediction for Cascade Island from the U.S. Army Corps of Engineers' SYSTDG model. Horizontal lines mark the 120% TDG limit for dam tailraces in Oregon and Washington and the 130% TDG level referenced in the Discussion; arrows mark the release dates for in-river- migrating (circles overlaid on CCIW data) and transported (squares overlaid on WRNO data) groups of Chinook Salmon smolts.

susceptibility to bacterial infections (Huchzermeyer 2003) and fungal infections (Weitkamp 1976; Lutz 1995), appear in chronic exposures of up to 120% TDG, with acute mortality from GBT occurring at higher levels (Mesa et al. 2000). However, TDG exposure decreases with depth and distance downstream of dams; in field settings, where smolts are at liberty to migrate, mortality effects may be absent below 125% TDG (Weitkamp and Katz 1980). Multiple sublethal exposures may also result in chronic effects on salmonids (White et al. 1991), and although horizontal and vertical migrations in field settings may not mimic the continuous exposures that have been studied in the laboratory, multiple exposures are possible and may affect survival. For example, Cramer (1996) concluded that multiple exposures affected the survival of smolts exposed to 130% TDG below Ice Harbor Dam (Snake River) when TDG levels at upstream dams exceeded 110–115% TDG.

METHODS

Hatchery- and wild-origin smolts (n = 780) collected at Lower Granite Dam (Snake River) and Bonneville Dam (Columbia River) received surgically implanted Vemco V7-2L acoustic transmitters (7 × 20 mm; 1.6 g in air) and PIT tags (a detailed description of the tagging methods can be found in Rechisky et al. 2014). To analyze the impact of exposure to TDG levels above 120% (the Oregon and Washington tailrace water quality standard) on TR and IR smolts, we assigned each smolt to one of four groups: transport low exposure (TR-LOW), transport high exposure (TR-HIGH), in-river low exposure (IR-LOW), or in-river high exposure (IR-HIGH; Table 1). In-river smolts were assigned to the high-exposure group if they were released after May 13, when daily TDG levels exceeded 120% at the Cascade Island TDG monitoring site; otherwise, IR smolts were assigned to the low-exposure group (Figures 1, 2). Transported smolts were assigned to the high-exposure group if they were released after May 17, when daily TDG levels exceeded 120% at the Warrendale TDG monitoring site; otherwise, the TR smolts were assigned to the low-exposure group (Figures 1, 2). We conducted comparisons within the TR and IR groups but not between the two groups because they were not similarly handled (Figure 3). Therefore, the TR-LOW group served as the control for the TR-HIGH group, and likewise the IR-LOW group acted as the control for the IR-HIGH group.

In-river migrants (n = 580) were collected at Bonneville Dam and were held in 1-m-deep flow-through tanks that were flushed with river water drawn from the upper dam face. The IR smolts were tagged either on the day of capture or the next day, and they were released on the fourth day at the smolt monitoring facility below the dam (river kilometer [rkm] 234 on the Columbia River; Figures 2, 3). Of the IR smolts, 300 were released in late April or early May, and 280 were released in late May (Table 1). Transported smolts (n = 200) were collected at Lower Granite Dam; they were tagged on the day after collection, were transported downstream in barges (with gas-stripping equipment) 3 d after capture, and were released 10–13 km below Bonneville Dam on day 4 (rkm 222–225 on the Columbia River; Figures 2, 3). Half of the TR smolts were released in early May, and half were released in late May (Table 1). Smolts that were assigned to the same group but released on different days were pooled because TDG levels were similar and we did not expect the small difference in release dates to affect survival (Table 1).

The IR-HIGH smolts were released at an average TDG of 132%, and IR-LOW smolts were released when average TDG was 118%. The river water above Bonneville Dam was also supersaturated; TDG averaged across the five U.S. Geological Survey (USGS) monitoring sites above Bonneville Dam from April 1 to May 25 (from the start of the fish migration season and voluntary spill at the Columbia River dams through the last capture date) was 113% (Tanner et al. 2011; USGS 2013). Based on laboratory studies (e.g., Mesa et al. 2000) and field studies (Cramer 1996), we hypothesized that potential exposure prior to tagging of fish followed by their release at TDG levels exceeding 130% would result in chronic effects, acute effects, or a combination of effects that would be evident in the reduced survival of the IR-HIGH group relative to the IR-LOW group.

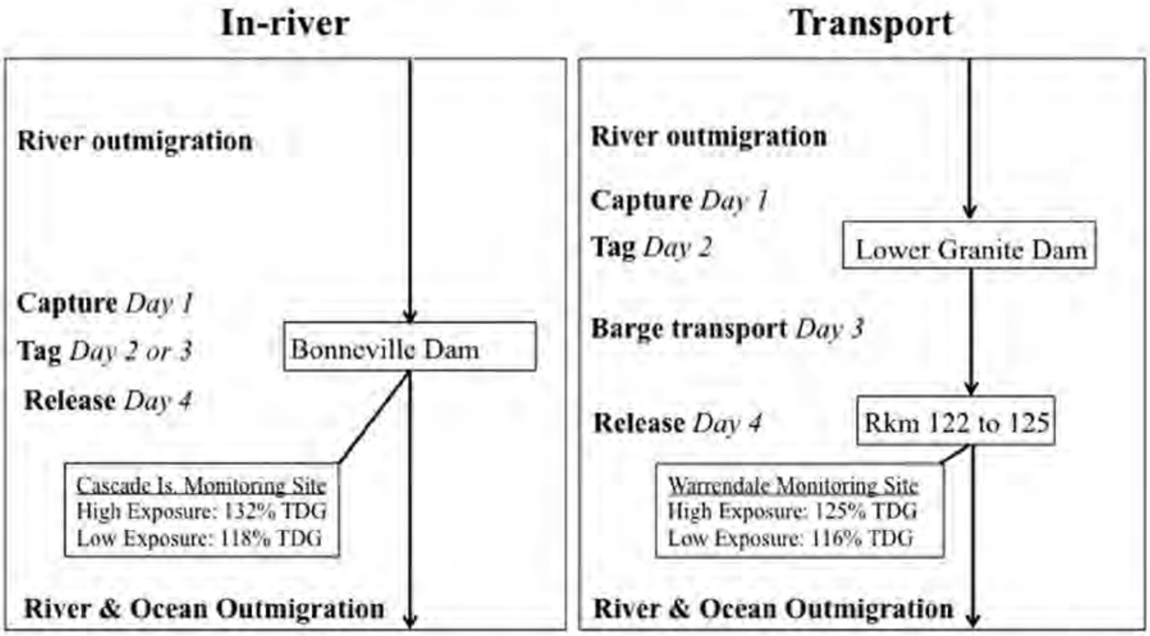

FIGURE 3. Treatment of the in-river-migrating and transported groups of Chinook Salmon smolts, indicating the timing of tagging events at Bonneville Dam (Columbia River) and Lower Granite Dam (Snake River). Total dissolved gas (TDG) levels presented for the high- and low-exposure groups were averaged over the release dates shown in Table 1. Panels are not to scale with regard to distance between locations.

The TR-HIGH smolts were released when average TDG was 125%, and the TR-LOW smolts were released at an average TDG of 116%. The river above Lower Granite Dam was also supersaturated; average TDG during April 1–May 25 at the two monitoring sites above Lower Granite Dam was 107%. Since the TR-HIGH group experienced an average TDG of 125%, we did not expect their acute mortality to be greater than that of the TR-LOW group (Weitkamp and Katz 1980; Cramer 1996), but we hypothesized that chronic effects would be evident.

Tagged smolts were tracked downriver and then north in the coastal ocean to Lippy Point, British Columbia, with listening lines ("subarrays") of acoustic receivers (Figure 1). We assumed that smolts swam northward shortly after entering the ocean and that the cross-shelf extent of the ocean subarrays was sufficient to bound the early marine migratory path

TABLE 1. Release groups, tagging sites (with release sites in parentheses), release dates, and numbers of Chinook Salmon smolts that were tagged in the Columbia River system (rkm = river kilometer) during 2011 (total dissolved gas [TDG] monitoring sites: CCIW = Cascade Island; WRNO = Warrendale; SYSTDG = SYSTDG model estimates of TDG).

Tagging site (release site)	Group	TDG treatment	Release date	Number released	TDG (%) at release (TDG monitoring site)
Lower Granite Dam (rkm 111–115)	Transported	Low exposure	May 3	47	115.1 (WRNO)
			May 5	53	116.1 (WRNO)
		High exposure	May 21	50	125.8 (WRNO)
			May 22	50	124.8 (WRNO)
Bonneville Dam (Bonneville Dam)	In-river	Low exposure	Apr 23	100	118.8 (CCIW)
			Apr 24	100	118.5 (CCIW)
			May 3	50	118.0 (CCIW)
			May 5	50	118.5 (CCIW)
		High exposure	May 19	48	131.0 (SYSTDG)
			May 22	101	131.3 (SYSTDG)
			May 27	72	133.8 (SYSTDG)
			May 28	59	133.3 (SYSTDG)

of similar proportions of the compared groups. These assumptions are well-supported by decades of trawl and telemetry observations, which consistently demonstrated a shelf-confined, rapid northward migration of juvenile yearling Chinook Salmon beyond the near vicinity of the Columbia River mouth and its strong tidal currents (Miller et al. 1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010; Rechisky et al. 2014).

Although acoustic-tagged smolts have been detected on the southwest and western terminus of receiver arrays placed within approximately 15 km of the Columbia River mouth (McMichael et al. 2013), these detections occurred during outgoing tides and reflect the influence of the tidal plume, where currents can exceed smolt swimming speeds (Horner-Devine et al. 2009). We do not believe that these reflect coastal ocean migration patterns reported in previous trawl and telemetry studies (e.g., Miller et al. 1983; Fisher and Pearcy 1995; Bi et al. 2007; Trudel et al. 2009; Peterson et al. 2010), and they do not suggest a violation of our assumptions.

The median difference in the time of detection between the subarrays at Astoria and Sand Island was only 2.8 h (SE = 0.25); due to the limited information and statistical penalty involved in estimating four additional parameters for survival of IR-HIGH, IR-LOW, TR-HIGH, and TR-LOW smolts in this small region, the detections at Sand Island were combined with the Astoria subarray detections to estimate survival in the lower Columbia River and estuary region (Figure 1). Six IR-LOW smolts were detected on a subarray of receivers at Cascade Head, Oregon (Figure 1), and one of those smolts was subsequently detected as rapidly migrating northward across the Willapa Bay and Lippy Point (British Columbia) subarrays. We only used the detections of the five remaining smolts at Sand Island–Astoria in the survival model, thus apportioning their mortality to the plume region.

Survival (φ) in each migration segment for high- and low-exposure IR and TR fish and the detection probability (p) at each subarray were estimated by using the Cormack–Jolly–Seber (CJS) live-recapture modeling framework, which was implemented with the RMark package in R (Lebreton et al. 1992; White and Burnham 1999; R Development Core Team 2011; Laake 2012). We used Akaike's information criterion (AIC) corrected for overdispersion and small-sample bias ($QAIC_c$) to select from three hypothesized models of the parameter p, including (1) a model with a single common p at each subarray, (2) a model with a unique p for each group at each subarray, and (3) a model with a unique p for each group at Astoria (freshwater) and a common p at each ocean array (Rechisky et al. 2014).

We considered AIC difference (ΔAIC) values greater than 2 to be significant for selecting the top-ranked model (model 1), which was used for all subsequent analyses. The ΔAIC between models 1 and 2 was 9.30, and the ΔAIC between models 1 and 3 was 4.86. The parameter φ was estimated for all four groups in the lower river (from release to Astoria) and plume (from Astoria to Willapa Bay). Lippy Point was the final array along the migratory path, and the estimated φ was thus confounded with p on that array.

We used the median $\hat{c}$ method to evaluate the model for overdispersion, a condition where the sampling variance exceeds the expected theoretical variance due to a lack of model fit or due to violations of CJS assumptions, and we adjusted the parameter variances of the selected model to avoid overestimating the precision of the parameters (White and Burnham 1999; Burnham and Anderson 2002). We used data from an ancillary tag life study conducted in 2011 (see details in the Supplement available in the online version of this article) and program ATLAS methods to correct the φ estimates for possible tag failure during migration to Lippy Point (Lady et al. 2012); tag-life-corrected survival estimates are denoted S.

High river flows that elevate TDG also shorten the time interval (or residence time) over which survival is observed, and it is important to scale the measured survival values by the observational period as $S^{\frac{1}{T}}$, where S is the corrected φ estimate and T is the travel time. Calculating daily survival rates (S'_D) in the lower river ($S'_{D,River}$) and plume ($S'_{D,Plume}$) required the group travel times in the lower river (T_{River}) and plume (T_{Plume}). We defined T_{River} as the median of individual lower-river travel times (d), which were calculated by subtracting the release date from the time of entry into the plume, where entry time is taken as the final detection time of an individual at Astoria or Sand Island. The T_{Plume} was the median of individual plume travel times, which were calculated by subtracting the time of plume entry from the time of plume departure (the final detection of an individual at the Willapa Bay subarray).

In making this calculation, we assumed that survival rates per unit time were constant and that any effects on the measured travel times from the differential survival of slower- or faster-moving smolts were sufficiently small and similar between the compared groups such that the results were not affected. An alternative measure, survival per kilometer traveled, $S^{\frac{1}{km}}$, could also be used if individual travel distances between detection sites were known. However, the average distances between subarrays—particularly between Astoria and Willapa Bay—were likely not representative of distances traveled because the smolts' migration path between receivers was unknown.

We examined the effect of TDG exposure within groups by using the log odds ratio,

$$\log_e\left(\frac{S_{LOW}}{1 - S_{LOW}} \Big/ \frac{S_{HIGH}}{1 - S_{HIGH}}\right),$$

and z-scores for estimated S and S'_D, where S_{LOW} and S_{HIGH} denote survival or daily survival estimates for the low-exposure and high-exposure groups, respectively. The SE of the log odds was estimated using the delta method, and z-scores were evaluated at the 0.05 level. A log odds ratio greater than zero indicates that the odds of survival is greater for the low-exposure group than for the high-exposure group. Travel times were nonnormally distributed, so the variability of each group's travel time was evaluated by using the median absolute deviation (MAD). The variances of the estimated survival rates were determined by bootstrap resampling of the capture histories and travel times within each group; estimating the φ, S, and S'_D for the resampled groups; and then calculating the variance of the results. The incorporation of bootstrap resampling of travel times captured the variability in $S^{\frac{1}{T}}$ resulting from variability in travel time.

In estimating survival, we made the standard CJS assumptions that (1) every tagged individual has an equal probability of survival and detection after release, (2) sampling periods are instantaneous, (3) emigration is permanent, (4) tags are not lost, and (5) the fish that are detected have the same probability of future detection as tagged fish that are alive but undetected. Results from tag effects and tag retention studies supporting these assumptions are reported in the Supplement.

At high levels of gas supersaturation (TDG > 130%), acute mortality due to GBT may occur within hours (Mesa et al. 2000). We were unable to determine whether acute mortality occurred in the IR-HIGH group because we could not count the surviving smolts until they reached Astoria several days after exposure. If acute mortality occurred quickly and close to the point of release and if the subsequent mortality rate was constant, then the following formula can be used to estimate the acute mortality at release that would result in the estimated survival to Astoria for the high-exposure group, assuming that the estimated daily survival rate of the low-exposure group in the lower river represented a base rate that was common to both high- and low-exposure groups:

$$M_a = 1 - \left[\frac{S_{R(e)}}{{S'_{D(u)}}^{T_{R(e)}}}\right],$$

where M_a is acute mortality, $S_{R(e)}$ is the estimated net lower-river survival of the high-exposure group, $S'_{D(u)}$ is the estimated daily survival rate (denoted by a prime) of the low-exposure group, and $T_{R(e)}$ is the lower-river residence time of the high-exposure group. The time to 20% mortality (LT_{20}) at 130% TDG was 3–6 h in the laboratory (Mesa et al. 2000). The SE of M_a was obtained by using the bootstrap routine described above. If these smolts experienced acute mortality due to GBT within a few hours of exposure to supersaturated water, then we would expect a comparable M_a estimate, with differences being potentially attributable to chronic mortality. This estimate should be received with care, however. Exposures in the field and laboratory may be very different, and the mortality in smolt groups exposed to 130% or greater TDG levels in the laboratory was variable: mortality at 3 h ranged from approximately 0% to 20%, and mortality at 6 h was approximately 20–65% (Mesa et al. 2000).

Hourly TDG levels recorded by automated water quality monitoring stations were provided by the U.S. Geological Survey (USGS 2013). Monitoring stations were located at (1) Cascade Island, situated immediately below Bonneville Dam and 1 km from the IR release site; (2) Warrendale, Oregon, 9 km downstream of the dam at rkm 225 and 0–3 km from the TR release sites; (3) Camas–Washougal, 40 km downstream (Figure 1); and (4) five upriver stations. Monitoring site locations and quality assurance measures for the TDG data were described by Tanner et al. (2011). Levels of TDG at the Lower Granite Dam forebay and at the Dworshak Dam tailrace were obtained from the U.S. Army Corps of Engineers (USACE) via the Columbia Basin Research portal (CBR 2013). The TDG levels declined, on average, 0.5% per kilometer between Cascade Island and Warrendale, so we expected that the TDG values recorded at these monitoring sites would be comparable to the TDG occurring at the release sites.

High discharge through the Bonneville Dam spillway destroyed the Cascade Island monitoring site on May 18, 2011, just prior to the release of 280 acoustic-tagged fish at the Bonneville Dam smolt monitoring facility (Table 1; Tanner et al. 2011). In lieu of field observations, we obtained estimates of hourly TDG at Cascade Island from SYSTDG, a sophisticated model that is used by USACE to predict TDG levels and support spill management decisions in the Columbia River basin (Schneider and Hamilton 1999; L. Hamilton, USACE, personal communication). The SYSTDG output compared well with observed TDG at Cascade Island when the monitoring station was intact (Figure 1), indicating that the use of mixed-source TDG data was unlikely to affect our grouping of IR smolts and analysis of their survival.

RESULTS

Overall, 523 smolts were detected at the Astoria subarray, 480 were detected at the Sand Island subarray, 105 were detected at the Willapa Bay subarray, 31 were detected at the Lippy Point subarray, and 6 were detected at the Cascade Head subarray. In total, 608 smolts were detected at the combined Sand Island–Astoria subarray, with an estimated p of 0.96 (SE = 0.02). At the Willapa Bay subarray, 110 smolts were detected, with an estimated p of 0.71 (SE = 0.10; Table 2).

Seventy-two IR-LOW fish were detected at the Columbia River mouth and remained somewhere upriver of the Astoria and Sand Island subarrays after May 14, when TDG reached 120% in the Bonneville Dam tailrace. Of those 72 smolts, 68 fish subsequently crossed the river mouth by May 23, 3 fish crossed by May 28, and the single remaining fish crossed on June 13. The final two TR-LOW fish to be detected at the river mouth crossed on May 15. Applying a back-calculation of their individual average travel speeds and the rate of decline in TDG from Bonneville Dam to the Camas–Washougal TDG

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TABLE 2. Detection probabilities (p) at each subarray, survival estimates before (φ) and after (S) correction for tag life, daily survival (S'_D), travel time (T; d), and log odds ratios for Chinook Salmon smolts in the lower Columbia River and plume (IR = in-river-migrating smolts; TR = transported smolts; HIGH = high TDG exposure; LOW = low TDG exposure; MAD = median absolute deviation). Log odds ratios in bold italics denote z-tests that were significant at the 0.05 level.

Lower river	p	φ (SE)	S (SE)	Log odds (SE)	T (MAD)	S'_D (SE)	Log odds (SE)
				Lower River			
IR-HIGH	0.96 (0.02)	0.80 (0.03)	0.82 (0.03)	0.14 (0.25)	2.7 (0.05)	0.93 (0.01)	***1.90 (0.27)***
IR-LOW		0.82 (0.03)	0.84 (0.03)		15.4 (1.23)	0.99 (0.002)	
TR-HIGH		0.86 (0.04)	0.88 (0.04)	−0.63 (0.45)	3.3 (0.11)	0.96 (0.01)	−0.25 (0.47)
TR-LOW		0.78 (0.05)	0.80 (0.05)		4.6 (0.04)	0.95 (0.01)	
				Plume			
IR-HIGH	0.71 (0.10)	0.28 (0.05)	0.28 (0.05)	−0.10 (0.25)	4.2 (0.94)	0.74 (0.05)	***0.85 (0.26)***
IR-LOW		0.26 (0.04)	0.26 (0.04)		9.4 (1.26)	0.87 (0.02)	
TR-HIGH		0.19 (0.05)	0.19 (0.06)	−1.08 (0.60)	4.0 (3.25)	0.66 (0.20)	0.98 (1.04)
TR-LOW		0.07 (0.04)	0.07 (0.04)		14.9 (0.14)	0.84 (0.13)	

monitoring station (Figure 2), we estimated that only the single IR fish that crossed on June 13 was potentially exposed to TDG above 120%, and we made no adjustments to the group assignments. We believe that the use of average travel speeds—and therefore constant rates of travel—was reasonable; Carter et al. (2009) found that acoustic-tagged smolts were detected on their acoustic arrays in the lower Columbia River nearly equally during all hours of the day, indicating constant travel.

The median $\hat{c}$ of the survival model was 1.45 (SE = 0.32). Lebreton et al. (1992) and Burnham and Anderson (2002) suggested that $\hat{c}$-values should not exceed 3 or 4. A value of 1.45 was thus very weak evidence for overdispersion and indicated limited violations of our assumptions and a good structural fit of the model. Estimated φ, S, travel times, S'_D, and log odds ratios are presented in Table 2, along with the probability of detection (p) at each array.

In the lower Columbia River, estimated S was 0.82 (SE = 0.03) for the IR-HIGH group and 0.84 (SE = 0.03) for the IR-LOW group. The log odds ratio was 0.14 (SE = 0.25), which means that the odds of surviving to the Columbia River plume was 1.15 times greater for the IR-LOW group, calculated as $e^{0.14}$; these estimates are provided only for significant results hereafter. The log odds ratio was not significant at the 0.05 level (z = 0.57, P = 0.57). Median travel times were 2.7 d (MAD = 0.05) for the IR-HIGH group and 15.4 d (MAD = 1.23) for the IR-LOW group. Estimated $S'_{D,River}$ was 0.93 (SE = 0.01) for the IR-HIGH group and 0.99 (SE = 0.002) for the IR-LOW group. The log odds ratio of $S'_{D,River}$ estimates was 1.90 (SE = 0.27) and was significant at the 0.05 level (z = 7.12, $P = 1.06 \times 10^{-12}$). This means that the odds of surviving to the plume was 6.69 times greater for the IR-LOW group than for the IR-HIGH group.

The estimated S for the TR-HIGH smolts in the lower river was 0.88 (SE = 0.04), and the estimated S for the TR-LOW group was 0.80 (SE = 0.05). The log odds ratio was –0.63 (SE = 0.45) and was not significant at the 0.05 level (z = –1.39, P = 0.16). Median travel times were 3.3 d (MAD = 0.11) for the TR-HIGH group and 4.6 d (MAD = 0.04) for the TR-LOW group. Estimated $S'_{D,River}$ was 0.96 (SE = 0.01) for TR-HIGH smolts and 0.95 (SE = 0.01) for TR-LOW smolts. The log odds ratio of estimated $S'_{D,River}$ was –0.25 (SE = 0.47) and was not significant at the 0.05 level (z = –0.54, P = 0.59).

In the Columbia River plume, estimated S was 0.28 (SE = 0.05) for the IR-HIGH group and 0.26 (SE = 0.04) for the IR-LOW group. The log odds ratio was –0.10 (SE = 0.25) and was not significant at the 0.05 level (z = –0.04, P = 0.69). Median travel times were 4.2 d (MAD = 0.94) for the IR-HIGH group and 9.4 d (MAD = 1.26) for the IR-LOW smolts. The $S'_{D,Plume}$ was estimated at 0.74 (SE = 0.05) for the IR-HIGH group and 0.87 (SE = 0.02) for the IR-LOW group. The log odds ratio of estimated $S'_{D,Plume}$ was 0.85 (SE = 0.26) and was significant at the 0.05 level (z = 3.26, P = 0.001). This means that the odds of surviving through the plume was 2.34 times greater for IR-LOW fish than for IR-HIGH smolts.

For the TR-HIGH group, estimated S in the plume was 0.19 (SE = 0.06); for TR-LOW smolts, estimated S in the plume was 0.07 (SE = 0.04). The log odds ratio was –1.08 (SE = 0.60) and was not significant at the 0.05 level (z = –1.8, P = 0.07). Median travel times were 4.0 d (MAD = 3.25) and 14.9 d (MAD = 0.14), respectively, for TR-HIGH and TR-LOW smolts. The $S'_{D,Plume}$ was estimated at 0.66 (SE = 0.20) for the TR-HIGH group and 0.84 (SE = 0.13) for the TR-LOW group. The log odds ratio of estimated $S'_{D,Plume}$ was 0.98 (SE = 1.04) and was not significant at the 0.05 level (z = 0.95, P = 0.34).

We estimated M_a at 0.16 (SE = 0.03), meaning that 16% of the IR-HIGH group would have to succumb shortly after release to realize the observed $S_{R(e)}$ of 82% (SE = 0.03). This compares reasonably well with the LT_{20} of 3–6 h for fish that were held at 130% TDG in the laboratory (Mesa et al. 2000). An M_a of 20% would require $S_{R(e)}$ to equal 79%, which is within one SE of the observed $S_{R(e)}$. The estimate of M_a

suggests that direct mortality effects of high TDG are possible in this group, but it does not eliminate the possibility of chronic effects.

DISCUSSION

There is substantial prior evidence that exposure to elevated TDG levels can be harmful to aquatic organisms. Similar to divers suffering decompression sickness (Todnem et al. 1991), smolt mortality after TDG exposure may occur in (1) an acute phase of GBT that can produce blockages of the vascular system (emboli) and internal and external soft tissue damage, wherein mortality is relatively quick and is directly caused by embolism or emphysema blocking blood flow to critical organs; or (2) a chronic phase in which mortality may occur later and over much longer time periods and may indirectly result from predators targeting smolts with reduced fitness, reduced resistance to bacterial and fungal infections, or impairments in motor skills, brain function, or lateral line function that could increase susceptibility to predation (Bouck et al. 1976; Schiewe and Weber 1976; Bouck 1980; Mesa and Warren 1997; Weiland et al. 1999; Mesa et al. 2000; Huchzermeyer 2003). By definition, chronic effects on survival are much more difficult to quantify in laboratory settings. Our results are consistent with the known effects of TDG exposure, but they rest on assumptions (discussed in detail below) that are uncertain.

It is clear that elevated TDG levels affected the IR-HIGH group held at the Bonneville Dam smolt monitoring facility. Daily maximum TDG levels in the Bonneville Dam forebay reached 123% on May 27 and 122% on May 28 (USGS 2013). Exposure to the forebay-sourced water in the 1-m-deep holding tanks produced GBT in 17 smolts that were found dead in a tank on May 28 and were examined by the Lower Columbia River Fish Health Center (the 59 remaining smolts did not appear to be affected). This was the only large mortality event that was observed during tagging at Bonneville Dam, and it occurred as TDG levels peaked (Figure 2), demonstrating lethality.

Of the 75 smolts that were held prior to release, 3 individuals also perished on May 27, presumably due to GBT, but they were not examined. No additional mortalities attributable to elevated TDG were observed during tagging at Bonneville Dam or at Lower Granite Dam, where TDG levels in the forebay peaked at 107% (CBR 2013). There were no reported incidences of GBT in TR smolts, and the barges that were used for transporting the smolts from Lower Granite Dam for release below Bonneville Dam operated gas-stripping equipment to prevent GBT during transit. Thus, there was compelling evidence for the lethality of river water reaching the upstream face of Bonneville Dam, despite some opportunity for off-gassing as the water flowed downstream from John Day Dam just prior to spill, further increasing the TDG levels below Bonneville Dam.

Although we cannot demonstrate causality, the differences in estimated survival rates between the IR-HIGH and IR-LOW groups were consistent with the effects of GBT. The IR-HIGH group experienced multiple exposures to elevated TDG: potentially in the Columbia River upstream of Bonneville Dam; certainly in the holding tank at the dam; and then again upon release into the river below the dam, when TDG levels were further elevated (130–134% TDG; Table 1). The estimated survival rates of the IR-HIGH smolts in the lower river and plume were reduced relative to those of the IR-LOW group but not significantly so. However, when the residence time between successive acoustic subarrays was considered, the IR-HIGH group experienced a significantly reduced odds of survival in the lower river and the plume, which could potentially be explained by the direct and indirect effects of GBT on survival. Unfortunately, we could not distinguish whether acute effects, chronic effects, or both were operating on survival, so we presented both for purposes of completeness. Although our M_a estimate was strikingly consistent with expectations, this laboratory-to-field comparison should be interpreted with care because (1) LT_{20} values in the laboratory are variable at high levels of TDG and (2) exposures in a field setting will be more variable than those occurring in the laboratory and may include additional factors.

The TR-HIGH group did not experience the same repeated exposures to supersaturated water. Although they were potentially exposed while migrating to Lower Granite Dam, they subsequently traveled in barges with gas-stripping equipment and were released at a location with lower levels of gas supersaturation (maximum TDG = 126%). Their limited exposure and rapid movement downstream (median = 3.3 d) may explain the lack of a significant effect on estimated survival rates in the lower river: either TDG was too low or observation time was insufficient to permit the detection of any effect. However, the point estimate of the effect on plume survival for TR smolts was similar to that for IR smolts, which could indicate chronic impacts on fitness from otherwise nonlethal exposure. Unfortunately, because fewer than 100 smolts reached the Willapa Bay subarray, it was not possible to draw a statistically robust inference. Any GBT effect that is manifested in the plume would probably not be caused by stress related to seawater acclimation (Nebeker et al. 1979).

Although the differences were not statistically significant, it is interesting that the TR-HIGH smolts had higher estimated survival in the lower Columbia River and plume and a higher estimated $S'_{D\,River}$ than the TR-LOW smolts. Scaling by time nearly removed the effect in the lower river, but these results were contrary to the commonly held belief that smolt mortality increases over the migratory season; we have no clear explanation for this finding.

Other factors, such as temperature, turbidity, emigration timing, and diseases other than GBT, may also affect smolt survival in the Columbia River and plume, and such factors cannot be separated from the potential TDG effects in this study. However, it is unclear whether these factors would have affected survival during the study period. Water temperature measured at the Warrendale monitoring station (Figure 1) was between 8°C and 13°C when IR and TR smolts were released; these temperatures are well below lethal levels (22–25°C) or the levels that affect growth in juvenile Chinook Salmon (15°C; Richter and Kolmes 2005).

Turbidity increased between the release times of the low- and high-exposure groups, thereby reducing visibility (Secchi depth) from approximately 0.91 m (3 ft) to 0.61 m (2 ft) in the Bonneville Dam forebay (CBR 2013) and increasing the measured turbidity from approximately 6 NTU to 12 NTU at rkm 85 (CMOP 2016). Increasing turbidity is generally expected to improve rather than reduce smolt survival. For example, Gregory and Levings (1998) found that predation on juvenile salmonids by piscivorous fish was significantly reduced in the turbid Fraser River (26–106 NTU) relative to the clear Harrison River and Nicomen Slough (<6 NTU), although those authors examined a wider range of turbidity.

Other diseases also do not seem likely to have played a role. Differences in the proportion of smolts exhibiting signs of disease other than GBT on dates when IR-HIGH and IR-LOW smolts were collected for tagging were not significant at the 0.05 level (z-tests; Fish Passage Center 2013b). The proportion of diseased smolts recorded at Bonneville Dam was 0.011 when IR-LOW smolts were collected ($n = 145$ fish examined on April 20; $n = 100$ fish examined each day on April 21, 30, and May 2) and 0.015 when IR-HIGH smolts were collected ($n = 100$ fish examined each day on May 16 and 24; $z = -0.39$, $P = 0.69$). No disease data were recorded on May 19 or May 25. The proportion of diseased smolts recorded at Lower Granite Dam was 0.02 when TR-LOW smolts were collected ($n = 100$ fish examined each day on April 30 and May 2) and 0.00 when TR-HIGH smolts were collected ($n = 84$ fish examined on May 18; $n = 80$ fish examined on May 19; $z = 1.82$, $P = 0.069$).

The effect of emigration timing on plume survival is unclear. The timing of ocean entry has been linked to smolt-to-adult survival rates; Scheuerell et al. (2009) found that smolt-to-adult return rates improved among fish entering the ocean in early to mid-May relative to mid-June but not during the April–May period used here. However, their approach measured the effect of the entire marine life cycle on smolt-to-adult return rates, including a survival period encompassing the smolts' first winter at sea—not just the brief period of plume occupancy (Beamish and Mahnken 2001). Because survival was measured at adult return (2–3 years after ocean entry), it is unclear whether the timing of plume entry would have resulted in a reduced odds of daily survival. Brosnan et al. (2014) found that daily plume survival rates measured using acoustic telemetry varied little from 2008 to 2011.

The effect of emigration timing on river survival has been better studied, although the results differ. In the Columbia River basin, Smith et al. (2002) examined the effect of release date on juvenile Chinook Salmon survival in the lower Snake River (280 km upstream of Bonneville Dam) and found no significant correlation between release date and survival. Schreck et al. (2006) found that in 2 of 6 years, mortality of both the transported smolts and the combined (pooled) transported and in-river smolts increased in the lower Columbia River during the fish migration season. In contrast, however, McMichael et al. (2011) found that lower river survival of yearling Chinook Salmon smolts increased significantly from early May to late May, similar to our finding of improved (although nonsignificant) lower river survival in the later-arriving TR-HIGH group.

Columbia River basin smolts are observed to display GBT symptoms when in-river TDG levels are elevated (Fish Passage Center 2013a), and exposure to supersaturated water leading to sublethal GBT experiences may have secondary effects that impact survival rates (Weitkamp 1976; Lutz 1995; Cramer 1996; Mesa and Warren 1997; Huchzermeyer 2003). Although horizontal and vertical avoidance of supersaturated waters is potentially possible, it is clearly insufficient to completely protect smolts from GBT effects because they are routinely found with evidence of GBT when TDG levels reach 125%. The question of whether TDG levels can be raised above their current limits to 125% to allow increased spill in the Federal Columbia River Power System without affecting smolt survival (e.g., ISAB 2014) is challenging to answer due to (1) the complexity of exposure histories that are not easily replicated in the laboratory; and (2) consequently, poor characterization of the effects of such exposures in the field. Results from the TR smolts examined here can be interpreted as indicating that exposure at approximately 125% TDG when previous exposure is limited has little direct impact on smolt survival but may lead to chronic effects that are expressed later in the life history. However, similar to the observations made by Cramer (1996) and based on our analysis of IR smolts, we find that exposure to approximately 130% TDG, when accompanied by previous sublethal exposures to gas-supersaturated water, may reduce survival via acute effects, chronic effects, or a combination thereof.

Retrospective cohort studies are useful in evaluating survival effects when exposure to the causative agent is rare and difficult to replicate, as is the case here. However, it is the nature of such studies that the results are potentially confounded with other unidentified differences, which in our study would involve other uncontrolled mortality factors (e.g., predator abundance in the Columbia River plume) that may covary with the differing arrival times of the high- and low-exposure groups. Although mortality due to GBT is a parsimonious explanation for the observed differences in survival estimates, it is not possible to exclude other potential causes for the measured differences in survival rate.

Our conclusions also rest on several assumptions: (1) survival is a time-based process rather than being strictly distance based; (2) the survival rate is constant; and (3) any effect on the measured travel times from differential survival of slower-or faster-moving smolts is similar between the compared groups such that the results are not affected.

We measured statistically significant differences in daily survival rates, and in our view, the drivers of smolt mortality in the Columbia River region are predominantly time based: if smolts did not migrate, they would still be subject to predation and disease over time—and (likely) at a consistent rate—while physically remaining in a particular location. In this time-based case, the lack of significant differences in estimated aggregate plume survival measured between the Astoria and Willapa Bay subarrays might have resulted from the observation period being of insufficient duration (~1 week).

The question of whether survival estimates measured between different geographic subarrays should be normalized by the time required for the different smolt groups to reach the sub-arrays may be contentious. Because smolts that were exposed to high TDG levels also migrated between subarrays more quickly, likely due to the higher flow rates that occurred under high-flow conditions, their survival was measured over a shorter time period than was used for smolts that were exposed to lower TDG levels. It can be argued that measured survival may simply be related to the distance traveled rather than time, so scaling for observation time may be inappropriate. We do not have sufficient information to rule out purely distance-based mortality processes (e.g., strong spatial variability in predation pressure) operating in the lower Columbia River, estuary, and coastal plume.

Although our results are consistent with the known effects of TDG, the uncertainty in the underlying assumptions calls for a controlled experiment to clarify how survival in the lower freshwater reaches of the Columbia River and the coastal ocean is affected by TDG exposure. A formal experiment that uses simultaneous paired releases of smolts that are exposed to different levels of TDG along with control groups of unexposed smolts could easily be performed by using the same techniques described here and by Rechisky et al. (2012, 2013). Fixed-time sampling would address assumptions about survival rates and the difficulty presented by different observation periods. In the absence of fixed-time sampling, which poses a significant technical challenge, greater spatial sampling (i.e., more densely spaced arrays over a larger area) would improve inferences about survival rates. Extending the period of observation beyond 1 month would also help to elucidate survival differences that are not clearly distinguishable by the time the smolts reach Willapa Bay. Such an experiment seems especially warranted within the Columbia River basin given the potentially significant conservation and economic costs of transitioning to higher spill levels (National Marine Fisheries Service 2013) and could inform new lines of inquiry globally, as increasing numbers of hydropower projects are raising concerns about fish health (Huang and Yan 2009; Finer and Jenkins 2012; Wang et al. 2015).

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Supplement: Tag Effects, Tag Retention, and Tag Life Studies

Tag effects, tag retention, and tag life studies are fully described by Porter et al. (2012) and are briefly reviewed here.

Tag effects and tag retention study.—In 2011, the ancillary captive-tagging study was concluded after 35 d. At that time, survival, mean FLs, and mean weights of Chinook Salmon smolts that were implanted with Vemco V7-2L dummy acoustic tags (n = 101) were not significantly different from those of PIT-tagged controls (n = 99). Only one dummy acoustic tag was shed. Growth rates of the dummy-tagged smolts in 2011 were slower than the growth of PIT-tagged controls, but previous long-term captive studies conducted under the same research program suggested that this effect was short term (Rechisky et al. 2010). Survival, tag retention, and growth effects were evaluated during 2008, 2009, and 2010 studies, which yielded similar results.

Tag life span study.—The 44 Vemco V7-2L tags used in the tag life study were randomly drawn from among the tags that were available for the 2011 field study. The 44 tags were exposed to the same handling conditions during the tagging period and were subsequently stored and monitored in water between 18°C and 22°C. The manufacturer's estimate of tag life span was 51 d. Two tags failed prior to the rated life span: one tag failed on day 1, and a second tag failed on day 28. All tags expired by day 182. We used program ATLAS methods to correct our survival estimates (Lady et al. 2012). ATLAS can apply corrections directly to Cormack–Jolly–Seber (CJS) survival models but not to the modified CJS survival model used in this analysis (note also that the model used here differs from the model presented by Porter et al. 2012). We used equations B.14, B.15, and B.16 from Lady et al. (2012) to implement the Kaplan–Meier method of estimating a tag survivorship curve, and we used equations B.23–B.27 to correct each survival estimate.

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

Sent: Wed Jan 11 15:00:24 2017

To: David Welch; Erin Rechisky

Subject: RE: date change.

Importance: Normal

Okay, I will see if I can set something up. Some of this could focus on a potentail second paper, but if Jeff is available, he could express his priorities.

The spill proposal is a wildcard for this year. It has come up in the past (in regular managements forums, not before a judge) and John Skalski had a precision analysis showing the sample sizes that would be required. I don't understand if a monitoring design has been or included or raised in the proposal by State of Oregon, but the decision to go forward or not is supposed to be March 19 so it doesn't give a lot of time

Http://www.opb.org/news/article/snake-river-dam-removal-environmental-groups-washington/

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 1/11/17 1:50 PM (GMT-08:00)

To: Erin Rechisky <Erin.Rechisky@kintama.com>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: date change.

Hi Christine—Just to clarify Erin's last comment, we are not "fishing" for a contract at this late date this year, but in our recent TDG paper (attached) we made this comment ((p. 249):

"Although our results are consistent with the known

effects of TDG, the uncertainty in the underlying assumptions

calls for a controlled experiment to clarify how survival

in the lower freshwater reaches of the Columbia River

and the coastal ocean is affected by TDG exposure. A

formal experiment that uses simultaneous paired releases

of smolts that are exposed to different levels of TDG

along with control groups of unexposed smolts could easily

be performed by using the same techniques described here

and by Rechisky et al. (2012, 2013).".

BPA-2021-00513-F 0805

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

This is a big part of what I would like to outline in the conference call.

BPA-2021-00513-F 0807

Best, David

From: Erin Rechisky
Sent: Wednesday, January 11, 2017 12:09 PM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: date change.

Hi Christine,

We'd like to change the following end dates all within Work Element C:

- Milestone A: end on July 31
- Milestone B: end on June 30
- Milestone C: end on August 31
- Milestone E: end on August 31

Regarding the top paper priorities, David and I would like to discuss this with you and Ben, and perhaps Jeff as well. Could you set up a conference call? David and I are available for most of this Friday. We could meet anytime between 9 and 4. We are in the office tomorrow as well, but David has an appointment at 10:30 and I leave at about 2:00 on Thursdays.

Also, can you send a link to the news articles about the preliminary injunction you mentioned? Kintama could potentially submit a proposal to monitor smolts but we' d have to start this work ASAP in order to have the proposal reviewed, approved and then order transmitters prior to the outmigration- which might not be feasible at this late date.

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: January 11, 2017 11:04 AM
To: Erin Rechisky; David Welch
Subject: RE: date change.

Hi Erin,

Can you tell me which dates you would like to change?

I was just talking to the CO in our procurement group and they are still working through their backlog and there could be a possibility of doing last minute changes.

(b)(5)
[redacted]

In any case, we weren't sure if we would want to sudeny change our order of b priorit and ask you to do the second paper first in this contract. We could also just pass this mestage along to you (without intrudine on the intellectual freedom clause where we are implying what we specifically want to see included in each paper). In any case, Jeff sent the request to attempt to find technical support funds for a second paper.

Also of some interest for you or Ian Brosnan, there was a preliminary injunction asking the judge to require a spill to gas cap experiment this spring...there were some news articles about it yeaterday. It would be hard to design monitoring. Will this high snowpack result in high forced spill levels and high gas like in 2011 anyway?

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 1/11/17 9:49 AM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: date change.

Hi Christine,

I wanted to modify some of the milestones end dates in Pisces but I don't seem to have write permission. Can you give me access or should I tell you what we wanted to change.

Thanks,
Erin

From: David Welch

Sent: December 21, 2016 3:08 PM
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: date change.

Thanks, Christine—Sorry for the delay in responding—just back from my annual meeting with our IT service provider.

This sounds sensible—I will ask Erin to put it on her list to review the dates of the intermediate milestones held in PICES next, after she gets a manuscript off her desk and to our co-authors (by Friday, we are hoping).

I will wait for you to get some feedback on the broader issues of whether a pre-award is possible, and then we can more intelligently discuss the possibilities at that point.

If I don't hear from you before Friday noon, Merry Christmas to you and yours!

Regards, David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Wednesday, December 21, 2016 12:41 PM
To: Erin Rechisky; David Welch
Subject: date change.

Hello,

I changed the dates in the contract in a relatively simple way, moving the start and end dates one month forward. You might want to glance at the intermediate milestone dates describing goals like submitting the paper to a journal.

I will try to raise the question of whether it is in any way possible to do a pre-award agreement which would allow invoicing to the period before the final contract is issued, which is a practice we have for most of our regular Fish and Wildlife program contracts.

Talk to you soon,

Christine P.

From: David Welch

Sent: Thu Jan 12 12:08:22 2017

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

Subject: RE: date change.

Importance: Normal

Thanks, Christine—

I had a look at the story yesterday, before it disappeared.

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, January 12, 2017 10:56 AM
To: David Welch; Erin Rechisky
Subject: RE: date change.

Oops – that OPB article seems to have disappeared. Here is another news article about the preliminary injunction supporting the Oregon spill proposal: http://abcnews.go.com/US/wireStory/environmental-groups-work-halted-snake-river-dams-44678122

From: Petersen,Christine H (BPA) - EWP-4
Sent: Wednesday, January 11, 2017 3:00 PM
To: David Welch; Erin Rechisky
Subject: RE: date change.

Okay, I will see if I can set something up. Some of this could focus on a potentail second paper, but if Jeff is available, he could express his priorities.

The spill proposal is a wildcard for this year. It has come up in the past (in regular managements forums, not before a judge) and John Skalski had a precision analysis showing the sample sizes that would be required. I don't understand if a monitoring design has been or included or raised in the proposal by State of Oregon, but the decision to go forward or not is supposed to be March 19 so it doesn't give a lot of time

Http://www.opb.org/news/article/snake-river-dam-removal-environmental-groups-washington/

From: Salmon Ocean Ecology

Sent: Fri Jan 13 15:16:39 2017

To: alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; camfresh@uvic.ca; campblac@dfw.wa.gov; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chrys.Neville@dfo-mpo.gc.ca; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; david.huff@noaa.gov; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; dower@uvic.ca; dstormer@uvic.ca; ebeamer@skagitcoop.org; ed.farley@noaa.gov; elan.downey@cahs-bc.ca; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erik.Neatherlin@dfw.wa.gov; erin.rechisky@kintama.com; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; gruggerone@nrccorp.com; hans@pgst.nsn.us; Eric Hertz; Ian.Perry@dfo-mpo.gc.ca; ibeveridge@lgl.com; ikemp@lltk.org; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; Jackie.King@dfo-mpo.gc.ca; jamal.moss@noaa.gov; jclark@ak.net; Jeff Rutter; jeanette.gann@noaa.gov; jen.zamon@noaa.gov; jenkins@psc.org; jennifer.gosselin@noaa.gov; jessica.miller@oregonstate.edu; jgmusslewhite@fs.fed.us; jgw3@uw.edu; jim.murphy@noaa.gov; jjulin.holden@gmail.com; jkeister@u.washington.edu; joe.orsi@noaa.gov; Joshua.Chamberlin@noaa.gov; joshuarussell0407@gmail.com; journey@uw.edu; jpkarnezis@bpa.gov; juanes@uvic.ca; kathryn.sobocinski@noaa.gov; katrina.vcook@gmail.com; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; kym.jacobson@noaa.gov; Lance.Campbell@dfw.wa.gov; lapointe@psc.org; Laura Kennedy; laurie.weitkamp@noaa.gov; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org; mara.zimmerman@dfw.wa.gov; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; matt@ktoo.org; mckinnell@shaw.ca; mcrewson@tulaliptribes-nsn.gov; megan.moore@noaa.gov; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; meredith.journey@noaa.gov; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; moore.jed@nisqually-nsn.gov; mschmidt@lltk.org; Megan McPhee; ndavis@npafc.org; neala.kendall@dfw.wa.gov; nick.leone@dfo-mpo.gc.ca; pborrett@uvic.ca; pearsalli@psf.ca; peter.w.lawson@noaa.gov; Amy Teffer; rabeamish@shaw.ca; ralexander@lgl.com; raphael.girardin@noaa.gov; rick.brodeur@noaa.gov; rmflagg@uvic.ca; Sandra.ONeill@dfw.wa.gov; sarah.ballard@noaa.gov; scott.hinch@ubc.ca; sean.hayes@noaa.gov; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; sue.grant@dfo-mpo.gc.ca; thomas.wainwright@noaa.gov; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov;

whitney.friedman@noaa.gov; willduguid@hotmail.com; David Welch

Subject: Registration for the Salmon Ocean Ecology Meeting 2017 is now open

Importance: Normal

Greetings Salmon Ocean Ecologists;

Registration for the 18th Annual Salmon Ocean Ecology Meeting is now open! The meeting will be held March 22-23 at the Landing at Tyee on Lake Union in Seattle, Washington. A pre-meeting workshop will also occur on March 21st, for a focused, small-group discussion on salmon prey and competition. To register for the meeting and optional workshop, please visit http://salmonoceanecology2017.brownpapertickets.com/. Meeting registration will close Friday, March 10th.

For information about nearby hotels and submitting abstracts, please visit the meeting website at https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

The abstract deadline is February 17th. Also, please reserve your hotel room early to ensure you have a spot near the meeting location. No room blocks could be held for this meeting. Most of the hotels listed are within a short walking distance. They are listed in order of proximity to the meeting on the web site.

Happy New Year!

Your 2017 SOEM Organizing Committee

From: David Welch

Sent: Wed Jan 18 09:38:42 2017

To: Douglas,Jan M (BPA) - NSSP-4

Subject: RE: questions from Bonneville Power

Importance: Normal

Hello, Jan—Nice to make your acquaintance—if only by email!

Kintama's Duns # is [redacted] and, yes, we are considered a small business.

Sorry for the delay in responding—[redacted]

Sounds like I should hold off on calling you until you know what further questions to ask, but either call me or let me know a time and I can call you to clarify anything further you need to know.

Kind regards,

David

P.S. Glad to help any way we can, but Kintama did have an earlier contract with you folks (terminated in 2011). That was Contract No. 00035492, Project No. 2003-114-00, originally under the company name of "Kintama Research Corp.". (We subsequently changed the name (in 20010, I believe) to "Kintama Research Services Ltd."). Although this contract is a new one rather than a continuation of that old contract, that bit of history might be of help to you when it comes to populating fields in a form? Just a thought!

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [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: Douglas,Jan M (BPA) - NSSP-4 [mailto:jmdouglas@bpa.gov]
Sent: Wednesday, January 18, 2017 7:19 AM
To: David Welch
Subject: questions from Bonneville Power

Hello David, working on a contract for you

Do you have a duns number

Are you considered a small business

I will still have some other questions because of this being a Canadian Company, but I have to find out those questions still. I'm new to the Grants and Agreements area so more to follow...

THANK YOU FOR YOUR TIME....JD

Call Anytime I Will Do My Very Best To Assist!

Jan Douglas (J.D.)

Bonneville Power Administration

Contracting NSSF – 4

jmdouglas@bpa.gov

503 230 4164

From: David Welch

Sent: Wed Jan 18 09:43:53 2017

To: Douglas,Jan M (BPA) - NSSP-4

Subject: RE: Bonneville Power Few Questions David

Importance: Normal

There will be three of us:

David Warren Welch, Ph.D., President (Canadian)

Erin Leanne Rechisky, Ph.D., Research Manager (American)

Aswea Dawn Porter, M.Sc., Research Analyst (Canadian)

Hydropower is critical infrastructure, so I get the security concerns!

David

From: Douglas,Jan M (BPA) - NSSP-4 [mailto:jmdouglas@bpa.gov]
Sent: Wednesday, January 18, 2017 9:30 AM

To: David Welch
Subject: Bonneville Power Few Questions David

2nd message from BPA this morning, So David I may have a few more requests along the way bare with me…

I need the full names and citizenship of the folks that will be working on our project… I'm not sure why BPA has a sensitive need for fish information seems silly to me, "you might release critical fish information to terrorist" Probably Not!

1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

I should have this contract to you today or tomorrow…..

Thank You Jan

Call Anytime I Will Do My Very Best To Assist!

Jan Douglas (J.D.)

Bonneville Power Administration

Contracting NSSF – 4

jmdouglas@bpa.gov

503 230 4164

BPA-2021-00513-F 0824

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

Sent: Fri Jan 20 14:43:43 2017

To: david.welch@kintama.com

Subject: FW: FCRPS - Oregon's corrected Bowles Declaration

Importance: Normal

Attachments: 2123.pdf; JUSTICE-#7995304-v1-NWF_0640_Corr_Ltr_to_Court_011817.pdf

Hi,

FYI – this was the publicly filed declaration from state of Oregon supporting the requested injunction to do a spill test.

(b)(5) [redacted]

Christine Petersen

From: Eitel, Michael (ENRD) [mailto:Michael.Eitel@usdoj.gov]
Sent: Wednesday, January 18, 2017 4:23 PM
To: Lear, Gayle HQ @ NWD; Godwin, Mary E HQ @ NWD; Peters, Rock (Rock.D.Peters@usace.army.mil); Feil, Dan; Langeslay; Michael Tehan; Ritchie Graves (Ritchie.Graves@noaa.gov); Ryan Couch - NOAA Federal; Francis,Rose (BPA) - LN-7; Leary,Jill C (BPA) - LN-7; Grimm,Lydia T (BPA) - A-7; Jeremiah Williamson
Cc: Philpott, Romney (ENRD); Gelatt, Andrea (ENRD)
Subject: FCRPS - Oregon's corrected Bowles Declaration

Attached is a corrected Bowles declaration filed today. It looks like the only changes are to Tables 1 and 2 on page 20 (NOTE: highlights are my additions to flag the changes discussed in Oregon's letter). We should use this declaration moving forward, which shouldn't disrupt any work you have done (because only footnote numbers, not paragraph numbers, changed).

Thanks,
Mike

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Attorneys for State of Oregon

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF OREGON

PORTLAND DIVISION

NATIONAL WILDLIFE FEDERATION, *et al.*, Plaintiffs, v. NATIONAL MARINE FISHERIES SERVICE, *et al.*, Defendants, and NORTHWEST RIVERPARTNERS, *et al.*, Intervenor-Defendants.	Case No. 3:01-CV-00640-SI CORRECTED[1] DECLARATION OF EDWARD BOWLES IN SUPPORT OF STATE OF OREGON'S MOTION FOR INJUNCTION

[1] This Corrected Declaration of Edward Bowles in Support of Oregon's Motion for Injunction ("Corrected Bowles Declaration") replaces the Declaration of Edward Bowles in Support of Oregon's Motion for Injunction ("Bowles Declaration") (ECF No. 2115). The Corrected Bowles Declaration corrects typographical errors and omissions in Table 1 and Table 2 on page 20 of the Bowles Declaration.

I, Edward Bowles, declare:

1. I previously submitted four declarations in these proceedings, namely: Declaration of Edward Bowles in Support of the State of Oregon's Motion for Summary Judgment, filed September 19, 2008 (ECF No. 1510); Second Declaration of Edward Bowles in Support of Oregon's Motion for Summary Judgment, filed November 18, 2008 (ECF No. 1592); Amended Declaration of Edward Bowles in Support of the State of Oregon's Motion for Summary Judgment, filed December 1, 2008 (ECF No. 1633); and Declaration of Edward Bowles in Support of Plaintiffs' Motion for Injunctive Relief, filed November 25, 2008 (ECF No. 1630). My professional experience, education and qualifications are set forth in a previous filing but are restated and updated herein. *See* Declaration of Edward Bowles in Support of the State of Oregon's Motion for Summary Judgment, filed September 19, 2008 (ECF No. 1510).

2. I am in charge of the Fish Division of the Oregon Department of Fish and Wildlife (ODFW), and have been so employed for the past sixteen years. I am responsible for providing policy and program oversight for all fish-related programs within the agency, including Columbia River fish recovery planning and implementation, Columbia River fishery management, and Columbia River research, management and operations associated with the Federal Columbia River Power System ("FCRPS"). I have also worked on special assignment with the Governor's Office for several years on the FCRPS biological opinion remand process. This includes technical and policy representation for the State of Oregon on the Policy Working Group, as well as numerous technical working groups assessing mortality factors, off-site mitigation and research, monitoring and evaluation. Previously, I was the Anadromous Fish Manager for Idaho Department of Fish and Game ("IDFG"), overseeing conservation, recovery and management of Snake River salmon and steelhead, including related activities associated with the FCRPS. And before that, I was the Principal Fishery Research Biologist for IDFG overseeing all salmon and steelhead research for the agency. This included research evaluating hatchery programs and investigating the effects of hatchery supplementation as a conservation

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tool. During this period, I participated in the Regional Assessment of Supplementation Project, reviewing and providing guidance on conservation hatchery approaches throughout the Columbia Basin. My prior experience includes research on large lakes in northern Idaho and research on habitat restoration for salmon and steelhead in central Idaho. I have authored or co-authored numerous papers and reports on fish research and recovery as well as hatchery and habitat management. I have a M.S. in Fisheries from the University of Idaho (1985) and a B.S. in fish management and biology from the University of Wisconsin – Stevens Point (1981).

3. In this declaration, I address the State's motion for injunctive relief. The State seeks increased spill at eight mainstem Snake and Columbia River dams in order to reduce irreparable harm to threatened and endangered species during the remand of the 2014 FCRPS Biological Opinion ("2014 BiOp"). Specifically, and as outlined below, the State requests an order directing the Army Corps of Engineers ("Corps") to spill the maximum amount of water through the spillways without exceeding state water quality standards for total dissolved gas ("TDG") from April 3 to June 20 for the Lower Snake River dams and April 10 to June 15 for the Lower Columbia River dams for the duration of the remand period, currently scheduled for December 31, 2018. As used herein, the maximum amount of water that can be spilled without exceeding state TDG standards is referred to as the "spill cap." This definition of spill cap is consistent with the Corps definition of the term in the 2016 Fish Operation Plan ("FOP"). Providing spill at the spill cap is referred to herein as "spill cap operations." Oregon's request for spill cap operations increases spill over the spill levels contemplated by the 2014 BiOp. The 2014 BiOp specifies *minimum* levels for voluntary spill at each dam. These specified minimums are below, and in many cases well below, the spill caps. Although the Corps could theoretically provide more voluntary spill than the volumes set forth in the 2014 BiOp, that has not been its practice. Thus Oregon's request would require an increase in voluntary spill over the status quo for all projects.

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4. Oregon's request is limited to the spring spill period determined by Federal Defendants in the 2016 FOP (April 10 through June 15 at Bonneville Dam, The Dalles Dam, John Day Dam, McNary Dam; April 3 through June 20 at Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam and Lower Granite Dam). During this spring spill period, a large portion of each of the listed species passes through the FCRPS. The precise date when these listed species begin migrating through the FCRPS varies but generally is evident as early as mid-March. With some minor exceptions, juvenile outmigration generally tails off by July for all species except subyearling Chinook (generally fall Chinook), which continue outmigrating throughout the summer. There are indications that the spring spill period in the 2016 FOP may not start early enough to provide passage enhancement to the leading tail of the outmigration, (FPC Memo December 8 2015 page 8 and 9 slides 4 and 5; Chockley 2016 slide 4 and 5 http://www.nwd-wc.usace.army.mil/tmt/agendas/2016/1207_Agenda.html), which can represent important diversity components of the listed species (Waples 2007, McElhany et al. 2000). Additional spill before and after the spring spill period in the 2016 FOP would also likely benefit both tails of the spring outmigration, important for species diversity, as well as the majority of fall Chinook outmigrating during the summer period. However, for purposes of this injunction during the remand period, Oregon's spill request is limited to the spring spill season determined by Federal Defendants in the 2016 FOP. Oregon is not requesting injunctive relief related to summer spill based on its expectation that, during the remand period, the Corps will not curtail the level of summer spill currently in place under the 2014 BiOp, as modified by the 2016 FOP. In lieu of requesting earlier spring spill, Oregon is requesting the Corps operate juvenile bypass facilities and associated Passive Integrated Transponder (PIT) tag detection systems beginning March 1 to better inform future management decisions and the new BiOp on juvenile passage timing. Such monitoring, because it will involve operation of juvenile bypass systems earlier than normal, will also offer some limited survival benefit because it will afford an alternative to turbine passage prior to initiation of spring voluntary spill.

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5. The upper limit on the amount of water that can be voluntarily spilled is constrained by state water quality standards. Spilling water over a dam increases the level of total dissolved gas (TDG) in the river. Excessive levels of TDG can be deleterious to fish or other aquatic life. The States of Oregon and Washington have each adopted water quality standards which provide an upper limit on TDG levels. *See* OR. ADMIN. R. 340-041-0031; WASH. ADMIN. CODE § 173-201A-200(l)(f)(2003). Although the two states have different standards, as relevant to the FCRPS, Washington's standard (which is more restrictive) controls, and generally allows a TDG of 120% saturation in the tailrace and 115% saturation in the forebay of the next downstream dam. *See* WASH. ADMIN. CODE § 173-201A-200(l)(f)(ii)(2003). The Washington standard allows for a maximum TDG one hour average of 125% during spillage for fish passage. *Id.* These TDG standards are based on TDG resulting from voluntary spill; TDG resulting from involuntary spill conditions are not included as exceedances under these standards. Oregon's modification restricts TDG to 120% of saturation in the tailrace from April 1 to August 31. *See* http://www.deq.state.or.us/wq/tmdls/docs/columbiariver/tdg/EQCorder.pdf (last visited Jan. 7, 2017).

I. Background on Spill

A. Summary of FCRPS spill operations

6. The main passage routes available to downstream out-migrating salmon and steelhead approaching a hydroelectric project are (1) powerhouse passage or (2) spillway passage. There are two routes of powerhouse passage, namely: (1) turbine passage or (2) passage through the smolt bypass collection system. The spillway is the structure that allows for controlled release of water over a dam. As used herein, the term "spill" refers to the water that is passed over or through a spillway. When spill is occurring, out-migrating juvenile salmonids can pass over the spillway rather than through either of the powerhouse passage routes. Out-migrating fish generally follow flow; the higher proportion of total flow spilled

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through the spillway, the higher proportion of fish that will migrate through that passage route. (Tuomikoski et al. 2012 (2014 NOAA B410:041962); McCann et al 2015, at Appendix J, page J-7 and Figure J-6, J-7, and J-8)[2] Attached hereto as **Exhibit 1** is a demonstrative exhibit depicting these passage routes, which is reproduced from the Comparative Survival Study[3] (CSS) 2013 Annual Report (Tuomikoski et al. 2013 at F-26 (2014 NOAA B408:041137)).

7. "Voluntary spill" is the term used to describe water that is spilled for the sole purpose of fish passage through the spillway. "Involuntary spill" occurs when the Corps must adjust voluntary spill operations for reasons other than fish passage. Reasons for these adjustments are: (1) Low runoff conditions that may require reducing voluntary spill to provide enough flow through the turbines to meet minimum generation requirements; (2) High runoff conditions where flows exceed the powerhouse hydraulic capacity; (3) Navigation safety concerns; (4) Generation unit and/or transmission outages that reduce the powerhouse hydraulic capacity; (5) Power system or other emergencies that reduces powerhouse outflow; (6) Lack of power demand resulting in an increase in spill levels; (7) Fish emergency conditions; (8) Project maintenance or in-season changes needed to address short term operational guidance; or (9) Conditions that threaten human health or safety and/or pose imminent safety concerns. Oregon recognizes these constraints on the Corps' spill operations. Oregon's requested relief, described

[2] Citations to documents contained in the administrative record follow the convention used by Federal Defendants, described in their Motion for Summary Judgment at vii. (ECF No. 2001 at 8).

[3] This Declaration cites several findings by the Comparative Survival Study (CSS). The CSS began in 1996 with the objective of establishing a long term dataset of the survival rate of annual generations of salmon from their outmigration as smolts to their return to freshwater as adults to spawn (SAR). The CSS Oversight Committee is comprised of representatives from Fish Passage Center (FPC), U.S. Fish and Wildlife Service, Columbia River Inter-Tribal Fish Commission, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife. The FPC is the administrative lead of the CSS. The CSS works under the oversight and guidance of the Northwest Power and Conservation Council (NPCC). Each CSS analysis undergoes a rigorous and transparent review process that culminates in an Annual CSS Review meeting and, before it is finalized, undergoes review by the public and by the Independent Scientific Advisory Board (ISAB). The CSS then responds to the reviews, all of which are publicly available. *See* http://www.fpc.org/documents/CSS.html (last visited Jan. 7, 2017).

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more fully below, would not apply during periods when the Corps must provide involuntary spill or constrain spill involuntarily for one or more of the reasons set out above (e.g., low flow operations).

8. As used herein, the term "flow" refers to the volume of water that moves past a dam (through all passage routes) over a fixed period of time. Flow is measured as the cross sectional area of the river (square feet) multiplied by the velocity of the water (feet per second), and is labeled as a rate of flow (typically thousand cubic feet per second ("kcfs")). As noted above, increasing voluntary spill redirects a larger proportion of the total flow away from the turbines and over the spillway, thereby directing a larger proportion of out-migrating juvenile salmonids through the spillway route.

9. Spill is widely recognized as an important tool to benefit listed salmonids in the Columbia and Snake River systems. Some degree of voluntary spill to aid fish passage has been a component (albeit quite limited in some cases) of every Federal Columbia River Power System ("FCRPS") biological opinion and of every Northwest Power and Conservation Council ("NPCC") Fish and Wildlife Program.

10. The court in this case has often been involved in overseeing spill at the FCRPS. A comprehensive historical summary of spill, including court-ordered spill, is set forth in a memorandum prepared by the Fish Passage Center (FPC), a copy of which is attached hereto as **Exhibit 2**. (FPC Memo, Nov. 2, 2016). The Corps is often required to make in-season adjustments to spill levels for reasons outside of the Corps' control. For example, when flow is unusually high, the Corps is forced to provide involuntary spill because flows exceed turbine capacities or energy demand. When flow is unusually low, the Corps cannot achieve the spill target while maintaining minimum operational levels at each project. During those low flow conditions, the Corps maintains the minimum flow necessary for station service and spills all remaining flow through the spillway in an attempt to meet spill targets to the extent possible.

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11. As noted above, the Corps describes the specific amount of voluntary spill that it intends to provide in a given year at the FCRPS in the FOP. The FOP is an appendix to the annual Fish Passage Plan (the plan developed annually by the Corps describing fish passage actions). In the past, the annual FOPs have been submitted to the Court in this proceeding, although that has not occurred in more recent years. The annual FOP is reviewed and finalized in a process that includes a review by the Regional Implementation Oversight Group ("RIOG") before the start of the relevant spill for fish passage season. As of the date of this declaration, the 2017 FOP has not been released. Based on its longstanding involvement in this case, Oregon expects that planned spill operations in the 2017 FOP will mirror spill operations for 2016, and in any event, that spring spill will remain below the spill operations requested in this motion. Oregon has historically and repeatedly advocated for increased spill in the RIOG process and other technical forums, but Oregon's efforts have met with extremely limited success. Changes to the voluntary spill for fish passage have primarily been small incremental changes in individual project spill levels or nonexistent.

B. Spill is a proven tool for improving juvenile survival and adult returns.

12. Increasing spillway passage is consistent with hydrosystem strategies and recommendations of the NPCC (NPCC 1982; NPCC 2003; NPCC 2009; NPCC 2014), Independent Scientific Advisory Board ("ISAB" ";ISAB 1997-2; ISAB 1999-4; ISAB 1999-6; ISAB 2001-2; ISAB 2006-3; ISAB-ISRP 2007-6; ISAB 2008-5; ISAB 2010-1; ISAB 2013-9; ISAB 2014-2; ISAB 2015), NOAA Fisheries (NMFS 2000 at 9-82; Hydro Strategy 3: RPA 29), and Oregon (ODFW 2008) as part of efforts to significantly improve mainstem survival rates and promote survival and recovery of anadromous fish. The benefits of spill at dams on the lower Snake and Columbia rivers are well established. Recent research findings corroborate the value of spill for juvenile fish passage and demonstrate that higher spill levels throughout the FCRPS are likely to contribute significantly to increases in survival during the smolt-to-adult life stage.

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(Petrosky and Schaller 2010 (2104 NOAA B334:035947); Haeseker et al. 2012 (2014 NOAA B146:012444); Schaller et al. 2014 (2014 NOAA B365:037791); Tuomikoski et al. 2011 (2014 NOAA B409:041367); Tuomikoski et al. 2012 (2014 NOAA B410:041914); Tuomikoski et al. 2013 (2014 NOAA B408:040796)). Given the existing impounded system, higher spill is associated with better fish survival for in-river juvenile out-migration, higher smolt-to-adult returns, and increased overall life-cycle productivity. Although flow and spill appear to work in concert to improve reservoir and dam passage affecting juvenile migration success and subsequent adult returns, the benefits of spill have also been observed independent of flow.

i. Spillway passage improves juvenile survival.

13. It has long been recognized that survival of juveniles migrating in river (i.e., not transported) is highest through spillway passage routes. (2000 BiOp § 9.6.1.4; 2004 BiOp § 6.2.1.3; FPC 2006 Annual Report at 21; FPC 2015 Annual Report at 27-29). In 2015, findings of the Comparative Survival Study (CSS) found that survival of in-river migrants is negatively affected by powerhouse passage and that powerhouse passage continues to negatively affect in-river migrants once they reach the ocean. (McCann et al 2015 at 53).

14. As noted above, powerhouse passage results in juvenile fish passing through turbines or bypass-collection systems. Turbine passage is the highest risk passage route and has been associated with direct and delayed mortality of downstream migrants. (Budy et al. 2002 (2008 NOAA B0052)). Turbine passage requires fish to sound and navigate through channels accompanied by high flow and pressure created by confining water into a tight corridor. Water is delivered to the turbine unit through a series of automated gates that wrap around the turbine unit such that they can regulate near equal distribution of the available water. Fish that pass under or through the gaps of the fish guidance screen and through the turbine intake are subjected to life threatening pressure changes (e.g., nadir pressure changes; barotrauma) that can strain internal organs. In addition, the sheer force of high velocity water jets can damage, strain or sever a fish's body.

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15. Juvenile bypass collection system passage—a second powerhouse passage route that, at some dams, is also used to collect juvenile fish for transportation —has also been shown to result in injury and delayed mortality. The bypass system is a staged dewatering system that reduces water volume. The process of dewatering separates fish from the original volume of water they entered the powerhouse in. The separation occurs through a system of channels, orifices and dewatering screens. This system presents a high potential for injury and disorientation which, in turn, are likely to result in vulnerability to tailrace predation and lower survival in later life stages from physiological stress. (Budy et al 2002 Schaller et al 2007, Schaller et al 2014, Tuomikoski et al 2010, Tuomikoski et al 2011, McCann et al. 2016). Powerhouse bypass-collection system passage is associated with a decrease in life-cycle survival. (Tuomikoski et al 2010; McCann et al. 2016).

16. Spillway passage is recognized as the safest route of in-river passage by hydroelectric projects under managed spill for fish passage (NOAA 2000 BiOp at § 9.6.1.4.1, Ferguson et al. 2003, Ferguson et al. 2004, Ferguson et al. 2005; NOAA 2004 BiOp at § 6.2.1.3; Whitney et al. 1997). Long term life cycle monitoring has shown that the proportion of fish passing through powerhouse routes can be reduced by increasing the proportion of river flow spilled through the spillway (Tuomikoski et al 2012; McCann et al 2015). The spillway route involves less circuitous complexity than the powerhouse route. However, passing over the dam via a spillway is subject to some risk. As described in paragraphs 5 and 34 through 36 of this declaration, spill can elevate total dissolved gas (TDG) in the tailrace and downstream reservoir. Excessive TDG levels can adversely impact aquatic life through gas-bubble trauma (GBT). Although all passage routes carry some risk of delay, injury or death during passage, the spill route is the least stressful and most representative of the natural migration experience, and as such was described by the ISAB as the baseline by which juvenile survival should be judged. The ISAB has recommended continuing spill as the default operation for juvenile dam passage

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and that all alternative dam passage measures be evaluated against the biological benefits of spill. (ISAB 2008).

17. The benefits of spill for juveniles include:

a. "Spill can be used to control the fraction of juvenile migrants that come into contact with the powerhouse, thereby reducing overall mortality associated with juvenile bypass and turbine routes of passage." (McCann et al. 2015 at 23). Spillway passage has been shown to provide the highest survival of any passage route at mainstem Snake and Columbia River dams (Whitney et al. 1997 (NOAA C3985:72541); Muir et al. 2001; Ferguson et al. 2005 (NOAA B119:9505); FPC 2015 Annual Report at A-107; 2014 BiOp at 345 Section 3.3.1).

b. Spill has been shown to reduce forebay delay because juvenile migrants follow the flow of spill through the spillway. With powerhouse passage (turbine or bypass system), juveniles are stalled in the forebay as they navigate or search for unfamiliar turbine or bypass system pathways. (FPC 2006 Annual Report; Schaller et al. 2007; 2014 BiOp at 345 § 3.3.1). Reduced forebay delay improves fish travel time. System-wide passage monitoring and analysis consistently show that reach survival (i.e., juvenile fish survival through sections of the impounded river) increases and fish travel time decreases as spill increases (Fish Passage Center (FPC) annual reports of the Smolt Monitoring Program, 1986-2007; Schaller et al. 2007).

c. Higher water velocity and spill decrease predation on downstream migrants by dispersing predators and decreasing the amount of time juvenile out-migrants are exposed to predators. (Faler et al. 1988; Mesa and Olson 1993; Shively et al. 1996; Zimmerman and Ward 1999).

d. Increasing spill reduces the number of fish that are exposed to risks associated with fish transportation operations. Compared to spillway passage, transportation and powerhouse passage have been associated with higher delayed mortality. (Budy et al 2002 (2008 NOAA B52); Williams et al. 2005; Muir 2006; Schaller and Petrosky 2007; Zabel et al. 2008; Clemens et al. 2009, Petrosky and Schaller 2010; Hall and Marmorek 2013; Schaller et al 2014;

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McCann et al 2015)). Even in low flow years (e.g., 2001 and 2015), fish travel time, instantaneous mortality rates, and cohort survival probability were better with more spill and less transportation (2015) than with less spill and more transportation (2001). (FPC Memo Dec. 8, 2015, at slide 23). Juvenile fish transportation is also associated with increased straying of adult fish (Keefer et al. 2008c).

ii. Increased spill during outmigration is associated with improved adult returns.

18. In addition to aiding downstream juvenile migrants, data show that higher juvenile fish survival associated with spill is also associated with higher rates of adult returns. This pattern has been shown across various years and species. For example:

a. Spring/Summer Chinook: Analysis of Snake River spring/summer Chinook Recruits/Spawner (R/S) suggests that population productivity is associated with flow and spill conditions during juvenile migration. *See* Declaration of Tony Nigro in Support of Oregon's Motion for Summary Judgment, Figure 6 (ECF No. 1986). Population growth was more likely to be positive (evidenced by a positive *ln* R/S) in years of highest flow and spill. Conversely, populations were more likely to be in decline (evidenced by negative *ln* R/S) in those years of lowest flow and spill.

b. Steelhead: Due to limited historical Recruits per Spawner (R/S) data, analyses of long term patterns of Snake River steelhead survival are less extensive compared to Snake River spring/summer Chinook salmon. However, results of ongoing monitoring studies of PIT-tagged Snake River steelhead indicate that, similar to spring/summer Chinook salmon, improvements in life-stage-specific and overall smolt-to-adult survival may be achievable through increasing spill percentages and reducing water transit time during juvenile out-migration through the FCRPS (Haeseker et al. 2012; McCann et al. 2015).

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c. Sockeye:

i. There are also indications that the strong returns of adult Sockeye salmon to the mid-Columbia and Snake rivers in 2008 were associated with better in-river conditions in 2006 and 2007 from high spill (2006 and 2007) and flow (2006), resulting in shorter fish travel times and increased reach survivals. (FPC Memo, July 14, 2008; FPC Memo, Aug. 6, 2008). Counts of adult Sockeye at upper Columbia and Snake River dams showed returns of 192,217 fish at Priest Rapids dam (4 times above the 10-year average for mid-Columbia Sockeye) and 907 adult fish at Lower Granite Dam (27 times greater than the 10-year average for Snake River Sockeye) (Fish Passage Center season total dam counts, November 22, 2008). Due to the high spill (2006 and 2007) and flow (2006), the proportion of Snake River Sockeye transported in 2006 and 2007 was lower (0.592 and 0.532, respectively) than the average for the previous eight years (0.772) (FPC Memo, July 14, 2008).

ii. High adult returns associated with low proportions transported and better in-river survival indicate that Snake River Sockeye likely respond more favorably to spill than to transportation. For example, monitoring from the summer of 2015 revealed that Snake River Sockeye adults that were transported as juveniles had lower adult survival rates through the FCRPS than the Sockeye adults that had migrated in-river as juveniles (FPC Memo October 28, 2015 http://www.fpc.org/documents/memos/159-15.pdf). Consistent with this observation, the Action Agencies agreed to a request for a slight increase in spill at Lower Monumental Dam in 2016 with the objective of increasing juvenile Sockeye spillway passage at that dam, which resulted in a lower proportion collected and transported. (TMT SOR 2016-1A and 2016-1B at http://www.nwd-wc.usace.army.mil/tmt/sor/2016/).

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d. Fall Chinook:

i. There are indications that stronger adult returns of Snake River fall Chinook in 2008 were at least partially the consequence of improved in-river survival resulting from court ordered summer spill in 2005-07. In 2008, a strong return of over 16,000 adult fall Chinook returned to Lower Granite Dam in the Snake River. Most adults returning in 2008 migrated to the ocean as juveniles in 2005-07, the first three years of the court-ordered summer spill program.

ii. Recent data from CSS indicate that an improvement in travel time and survival for subyearling fall Chinook salmon occurred following the implementation of court-ordered summer spill. As the CSS stated in its 2015 Annual Report, "[o]ne recent example of an adaptive management experiment is the implementation of court-ordered summer spill at the Snake River collector projects. The PIT-tag data revealed a dramatic improvement in travel time and survival for subyearling fall Chinook salmon following the implementation of court-ordered summer spill. Similar adaptive management experiments, such as reducing WTT [water travel time] in the MCN–BON reach or dissolved gas limit spill operations on a 24-hour basis, could reveal similarly dramatic improvements for yearling and subyearling Chinook, steelhead and Sockeye." (McCann et al 2015 at 75).

II. Oregon's Requested Relief will Reduce Irreparable Harm to Fish.

A. The 2015 water year and current listing status of protected species.

19. The EPA, along with the states of Oregon and Washington, has established 68°F (20°C) as a reference temperature considered the upper incipient lethal limit for salmon. In the summer of 2015, low flow and high water temperatures severely degraded fish passage conditions throughout the FCRPS. (FPC Memo, Oct. 28, 2015). Flow in 2015 was among the lowest seen since the 1995 BiOp, while water temperature was in excess of 68°F (20°C) earlier in the passage season than usual and for extended periods of time. System maintenance

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constraints added to a lack of flexibility within the FCRPS to address these low flows and hot water temperatures, even though cool water flow augmentation from Dworshak Reservoir and Columbia River Treaty and Non-treaty provisions were provided in an effort to partially address low flow and high temperature conditions. (FPC Memo Oct. 28, 2015 Appx. C).

20. Low flow and excessive temperatures are associated with negative effects on migration timing and survival. (Caudill et al 2013, Crossin et al 2008, Crozier et al 2014, Eliason et al 2011, Farrell et al 2008, Keefer et al 2008, McCullough et al 2001, Naughton et al 2005, Salinger et al 2006). In 2015, both spring and summer flow, as measured at Lower Granite Dam, were the second lowest observed since the 1995 BiOp, while spring and summer flow at McNary dam were the second and fifth lowest, respectively. (FPC Memo Oct. 28, 2015). In 2015, the mainstem FCRPS projects below Lower Granite Dam had surface water temperature in excess of 68°F between 35% and 46% of the days during the fish passage season (compared to between 4% to 39% in the previous ten years). The 2015 conditions resulted in an observed reduction in survival, and further emphasized a need to do more throughout the entire FCRPS to immediately address low flow and excessive water temperature (FPC Memo Oct. 28, 2015 Appendix C).

21. Most revealing of the negative impacts of 2015 flow and temperature conditions was the near complete loss of Snake River Sockeye (FPC Memo Oct. 28, 2015; NOAA Fisheries (2016)). Adult Sockeye survival from Bonneville to Lower Granite dam was a devastating 4% (95% CI 2%–5%) during 2015, a significant departure from the previous six years estimates of 44% (95% CI 36%–51%) to 77% (95% CI 64%–91%) (FPC Memo Oct. 28, 2015, Table 1 at 15). The 2015 adult Sockeye returns that had migrated in river as juveniles survived better than their transported counterparts who had zero survivors detected at any Snake River dam in 2015. (FPC Memo Oct. 28, 2015). The 2015 Snake River Sockeye Salmon adult returns were projected to be higher than the recent past (Idaho Fish and Game estimates). Although these projections were observed at Bonneville Dam during 2015 (NOAA Fisheries 2016, FPC Memo Oct. 28, 2015), subsequent survival plummeted such that roughly 96% (95% CI 95%–98%) of the Snake

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River Sockeye were lost before they reached Lower Granite Dam (FPC, RIOG, NOAA Fisheries (2016)). Losses increased even further as fish moved toward Redfish Lake in the Sawtooth Valley where only 1% (95% CI 0%–3%) survived as compared to the previous six years low and high survival of 14% (95% CI 9%–19%) to 60% (95% CI 44%–76%). (FPC Memo Oct. 28, 2015, Table 1 at 15).

22. There is an increased risk of 2015 water quality conditions occurring in the future. The Corps' own 2009 Water Quality Plan projects more frequent high water temperatures and low water years. (Corps 4160:0142821-822). For context, global land and ocean temperatures are available since 1880. In this 136 year period, the hottest 18 years have occurred in the last 20 years (NOAA NCEI 2016a). Regional temperatures are available since 1895 for the Pacific Northwest; 2015 was the hottest on record (NOAA NCEI 2016b). The presence of the FCRPS modifies and exacerbates natural temperature regimes by altering water travel time and heat exchange characteristics. (Yearsley 1999; Yearsley et al. 2001). These alterations created stratification such that warmer water temperatures reside above cooler water temperatures at depth (Spence et al 1996). In addition, FCRPS impoundments have increased the surface area exposed to solar radiation which has resulted in increased surface water temperatures which, when slowed by the dams, serve to retain heat in the reservoir longer (Yearsley et al. 2001, Yearsley et al. 2003, FPC Memo June 24, 2016).

23. Since the first listing of the three Snake River salmon ESUs and Snake River steelhead DPS, the populations are still at risk and are not viable. In its recent 5-year status review under the ESA, NOAA Fisheries concluded that no changes in the ESA-listing status of any of these species are warranted at this time. (NOAA 2016; Endangered and Threatened Species; 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead and Eulachon, 81 Fed. Reg. 33468, 33469 (May 26, 2016)). Specifically NOAA Fisheries found that:

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a. The Endangered Snake River Sockeye Salmon ESU remains at extremely high risk and there is currently no basis to change their ESU rating assigned in prior reviews. (NMFS 5-year Review at 29).

b. The Snake River spring/summer Chinook salmon ESU remains at high overall risk. (NMFS 5-year Review at 30).

c. While natural origin Snake River fall Chinook salmon abundance has increased significantly, the biological risk category for productivity and diversity has not changed enough since the last status review to reach the desired viability status and support delisting. (NMFS 5-year Review at 32).

d. For Snake River steelhead, the information analyzed does not indicate a change in biological risk status to achieve the desired viability status of highly viable and support delisting. (NMFS 5-year Review at 33).

B. Spill cap operations will help reduce risk and buffer environmental uncertainty during remand.

24. For a salmonid population to grow, it is necessary that more adult progeny (recruits) return to spawn than the number of parents that produced them consistently over time. Production of recruits depends on: (1) the number of eggs that survive to become out-migrating juveniles ("smolts") per spawner, which generally occurs in natal freshwater tributaries prior to entry into the FCRPS; and (2) the survival of those smolts to adulthood (smolt-to-adult return ratio or SAR). The SAR includes survival during the life stage when juveniles migrate through the FCRPS to the ocean and when adults migrate through the FCRPS as they return to the spawning grounds to spawn.

25. Unlike other strategies to increase survival, spill is a tool that can have a virtually immediate effect. Spill levels can generally be adjusted on a short timeline and yield immediate benefits. (McCann et al. 2015 at 52-53). As the CSS has put it, "[t]he immediate and dependable increases in survival obtainable from thoughtful implementation of hydrosystem operations can

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serve as an immediate benefit to populations undergoing restoration activities designed to bring about increases in productivity and capacity." (McCann et al. 2015 at 53). Furthermore, the CSS has found that "it is more certain that gains can be achieved from spilling, whereas you will still have some low recruitment years after productivity and capacity increase." (McCann et al. 2015 at 53).

Increased SARs are associated with improved productivity (R/S).

26. Smolt-to-Adult Returns (SARs) are an important measure of the effects of hydrosystem operations and configuration on life-cycle survival of salmon and steelhead populations. Across populations, SAR is a common currency that can be used to evaluate population survival trends. (McCann et al. 2015 at 24). As the CSS notes, "[t]he NPCC (2009) Fish and Wildlife Program objectives for unlisted populations or listed populations downstream of the Snake River and upper Columbia River basins are to 'significantly improve the smolt-to-adult return rates (SARs) for Columbia River Basin salmon and steelhead, resulting in productivity well into the range of positive population replacement.' The NPCC (2009 and 2014) also adopted a strategy to identify the effects of ocean conditions on anadromous fish survival and use this information to evaluate and adjust inland actions. The NPCC noted that while we cannot control the ocean, we can monitor ocean conditions and related salmon survival and take actions to improve the likelihood that Columbia River salmon can survive varying ocean conditions." (McCann et al. 2015 at 77).

27. In general, an increase in SARs indicates a reduction in harm to listed species adversely affected by the FCRPS. Recognizing this, the NPCC has set a regional goal of consistently achieving SARs in the 2% to 6% range. An SAR of 2% means that, for every 100 fish that migrate through the FCRPS as juveniles, two adult fish return. For the populations in these listed groups, an overall SAR is the SAR that includes the survival of all outmigrating smolts weighted across their different in-river and transport route experiences. (McCann et al. 2015 at 77). The probability of achieving the mid-range regional SAR goal of average 4% is one

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important aspect of evaluating how changes to FCRPS spill operations can affect survival (and, as relevant to the present injunction motion, reduce irreparable harm) of federal ESA-listed salmon and steelhead populations.

28. Results from CSS analyses are consistent with the NPCC goals. Updated annually, these analyses show that, for Snake River wild spring/summer Chinook and steelhead, SARs less than 1% are associated with population decline, whereas SARs above 2% are associated with population stability or growth (McCann et. al 2014, Fig. 4.18; McCann et. al 2015, Fig. 4.18; McCann et. al 2016, Fig. 5.2).

Increased spill reduces the risk of low SARs.

29. As described in Paragraph 12, above, spill is a critical management tool that is associated with improved in-river juvenile survival and migration travel time during outmigration and improved SARs. Retrospective analyses have provided strong evidence that the proportion of flow spilled is an important factor in explaining variability in SARs.

30. Prospective analyses by the CSS show that increasing spill to the spill cap will increase probability of achieving minimum desired SARs and reduce the risk of experiencing undesirable SARS. Specifically, using empirical data, the CSS assessed the probabilities of (a) achieving >2% SAR or (b) experiencing <1% SARs under 2014 BiOp spill operations versus spill cap operations under current state TDG standards. The analysis shows that increasing spill from the levels set out in the 2014 BiOp to spill cap operations will increase the probability of achieving the minimum desired SARs in more years. (Hall and Marmorek 2013 at I-98 to I-99 (NOAA C32696:273441-42)). Tables 1 and 2, below, summarize the CCS findings.

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Table 1. Observed SARs since 1998 and model predicted probabilities of achieving SARs <1% and >2% at high, medium and low levels of flow for Snake River spring/summer Chinook under 2014 BiOp spill operations and "Spill Cap" operations requested by Oregon. Flow levels are based on conditions (i.e., hourly flow) in 2009 (medium), 2010 (low), and 2011 (high).[4] All values are approximated.

Snake River Spring/Summer Chinook		
	<1% SAR	**>2% SAR**
Observed* since 1998	Occurred >60% of the time	Occurred 10% of the time
Probabilities under 2014 BiOp	47% (high flow) 60% (med. flow) 61% (low flow)	21% (high flow) 12% (med. flow) 12% (low flow)
Probabilities under Spill Cap operations requested by OR	30% (high flow) 35% (med. flow) 28% (low flow)	32% (high flow) 30% (med. flow) 32% (low flow)

*Note that the observed SARs since 1998 include several years (1998 to 2004) where there was no court-ordered spill.

Table 2. Observed SARs since 1998 and model predicted probabilities of achieving SARs <1% and >2% at high, medium and low levels of flow for steelhead under 2014 BiOp spill operations and "Spill Cap" operations requested by Oregon. Flow levels are based on conditions (i.e., hourly flow) in 2009 (medium), 2010 (low), and 2011 (high). All values are approximated.

Steelhead		
	<1% SAR	**>2% SAR**
Observed* since 1998	Occurred >60% of the time	Occurred 15% of the time
Probabilities Under 2014 BiOp	32% (high flow) 45% (med. flow) 42% (low flow)	27% (high flow) 26% (med. flow) 15% (low flow)
Probabilities Under Spill Cap operations requested by OR	27% (high flow) 27% (med. flow) 12% (low flow)	48% (high flow) 51% (med. flow) 48% (low flow)

*Note that the observed SARs since 1998 include several years (1998 to 2004) where there was no court-ordered spill.

31. The increased probabilities shown in Tables 1 and 2 are substantial. While spill cap operations would not consistently achieve SARs >2% for either of these populations—let alone SARs of 4% or more—they are likely to yield a substantial improvement to SARs as compared to 2014 BiOp spill operations.

[4] The CSS Report determined the best representative water years to be 2009 (medium flow), 2010 (low flow) and 2011 (high flow). (Hall and Marmorek 2013) (NOAA C32696:273359).

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a. For listed Snake River Spring/Summer Chinook:

i. The risk of falling below 1% SAR (and experiencing population decline) is reduced from between approximately 47–61% likelihood (under 2014 BiOp operations) to approximately 28–35% likelihood (under spill cap operations). This is at least a 36% reduction of the risk of falling below 1% SAR.

ii. The probability of exceeding 2% SAR (and experiencing population stability or growth) increases from between approximately a 12–21% likelihood (under 2014 BiOp operations) to approximately a 30-32% likelihood (under spill cap operations), which is at least a 52% improvement in the likelihood of achieving at least 2% SAR.

b. This pattern is also evident for steelhead.

i. The risk of falling below 1% SAR is reduced by at least 16% under spill cap operations compared to spill operations under the 2014 BiOp;

ii. The likelihood of exceeding 2% SAR is improved by at least 78% under spill cap operations compared to spill operations under the 2014 BiOp.

32. Spill cap operations provide a benefit at all flows levels. As depicted in Tables 1 and 2, the predicted SARs vary somewhat at different flow levels. The proportion of powerhouse encounters—or alternatively the proportion of fish passing via spillway routes—is an important factor in explaining this variation in model-predicted SARs, and consequently the probability of achieving a certain SAR level. In general, the greatest proportion of fish pass through spillway routes at low flow levels, particularly when constrained by TDG. Thus, at low flow, one would expect (and the model predicts) the greatest reduction in the probability of falling below 1% SAR and the largest increase in the probability of exceeding 2% SAR when spill is increased

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from BiOp to spill cap levels. Although the benefits of spill cap operations will be evident at all flows, the reduction of risk or the increase in benefit is greatest when environmental conditions are otherwise poor, i.e. when there is low flow during juvenile fish outmigration.

33. The projected benefits of increased spill represent an improvement over the recent past. SARs of Snake River wild Spring/Summer Chinook have had a geometric mean of 0.89% (well below the minimum regional goal of >2% SAR) during the period 1994 to 2013 and have exceeded 2% in only two migration years (1999 and 2008) (McCann et al. 2015). SARs of Snake River wild steelhead had a geometric mean SAR of 1.6% (also below this minimum regional goal) during the period 1997 to 2012 and have exceeded 2% in eight of sixteen migration years (McCann et al. 2015). As noted above, these low SARs have been associated with low population productivity.

34. Analyses conducted in 2010 as part of the CSS (Tuomikoski et al. 2010) showed that each powerhouse encounter experienced by juvenile migrating spring/summer Chinook and steelhead resulted in a relative 10% *per project encountered* reduction in adult returns when compared to juvenile migrants that experienced spillway passage. Many modifications in hydroelectric project passage have occurred since these analyses were conducted. To capture potential effects of more recent modifications to powerhouse passage systems, including surface passage weirs and other structural modifications, the powerhouse passage analyses first conducted in 2010 were updated in 2016 (McCann et al. 2016). These 2016 analyses include complete juvenile migration data from 2006 through 2013 and indicate that for Chinook, *each powerhouse encounter* through the FCRPS reduces the probability of adult return to Bonneville Dam by 11–12%. For steelhead, *each powerhouse encounter* reduces the probability of adult return to Bonneville Dam by 8–12%. These probabilities are multiplicative, meaning multiple powerhouse passages result in an increasing reduction in adult return. The analyses show juvenile migrants that encounter powerhouse passage have lower life cycle survival and further

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indicates the 2014 BiOp's dam specific performance standards can underestimates the adverse impacts of powerhouse encounters on life-cycle survival.

C. The biological benefits of spill to gas caps outweigh the risks.

35. The major adverse impact on actively migrating salmonids from exposure to excessive TDG levels is gas bubble trauma (GBT). The State of Oregon has recognized the risk of GBT. The State's Order modifying the state's TDG standard to 120% during juvenile migration provides that the spill program shall be halted if either 15 percent of the fish monitored show signs of GBT in their non-paired fins, or five percent show signs of GBT in their non-paired fins where more than 25 percent of the surface area of the fin is occluded by gas bubbles. *See* http://www.deq.state.or.us/wq/tmdls/docs/columbiariver/tdg/EQCorder.pdf (last visited Jan. 7, 2017). However, mainstem Snake and Columbia river research shows that reaching this GBT trigger level is not a significant concern with spill to the current gas caps at the eight mainstem dams, and even to levels that exceed current gas caps. Although maximum managed spill should be constrained by TDG limits or other legitimate biological constraints identified by the salmon managers, even years exceeding those constraints from uncontrolled spill are often associated with subsequent high adult returns. Analyses of years of higher involuntary spill and associated adult returns indicate that even higher SARs may be achieved at spill levels exceeding current state water quality standards. CSS analysis shows that potential survival benefits of spill could be maximized by conducting operations at the maximum project spill level that meets, but does not exceed, a TDG cap of 125%.

36. Over the past 20 years of GBT monitoring in the FCRPS—conducted through a cooperative effort between Oregon, Washington and federal Environmental Protection Agency—GBT early warning indicators in salmonids have rarely been manifested at TDG levels lower than 120%. In fact, indications of potential harm to migrating juvenile salmonids in the mainstem Snake and Columbia rivers begin to appear most at TDG levels greater than 125% (FPC 2016 at 66. This is consistent with an extensive body of *in situ* research finding low levels

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of GBT in a wide variety of species even when TDG rose above 120%. (Toner and Dawley (1995); Ryan et al. (2000); Weitkamp et al. (2003a); Weitkamp et al. (2003b)).

37. A recent Fish Passage Center summary of GBT from 1995–2016 that included over 300,000 examined fish showed less than 1% occurrence of GBT for all groupings below 120% (FPC Nov. 16, 2016 at Figure J-10). Observed incidence of GBT increased marginally for three groupings between 120% TDG and 130% TDG, but all remained well below the water quality threshold (15% of fish show signs of GBT in their non-paired fins, or five percent show signs of GBT in their non-paired fins where more than 25 percent of the surface area of the fin is occluded by gas bubbles). The report concluded that GBT early warning indicators have rarely been manifested at TDG levels lower than 120%, and when indications of potential harm begin to appear most are at TDG levels greater than 125% (FPC Nov. 16, 2016) for juvenile salmonids migrating through the mainstem Snake and Columbia rivers.

III. Oregon's Requested Relief.

A. Spill

38. Table 3, below, compares the presumed status quo spill operations under the 2014 BiOp to the increased spill that Oregon is requesting in this motion. More specifically, Table 3 compares (1) spill operations anticipated by the 2014 BiOp as modified by the 2016 FOP ("2014 BiOp/2016 FOP"), which Oregon anticipates will occur again in 2017 absent an injunction, with (2) the spill levels that Oregon is requesting in this motion. It is difficult to present a simple direct comparison between the status quo spill levels and spill requested by Oregon in this motion because the 2014 BiOp/2016 FOP presents spill levels in various forms, including total volume, percentage of flow, 12-hour spill level, 24-hour spill level and other formats. The bottom line, however, is that the spill cap operations requested by Oregon will yield more overall spill than would otherwise be provided by the Corps.

39. For each season, the Corps sets out its estimate of the spill cap for each project in its "Spill Priority List," publicly available on the Corps website at http://www.nwd-

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wc.usace.army.mil/tmt/documents/spill-priority. The Spill Cap Estimates provided in Table 3 below are the same as those provided in the Corps Spill Priority List for spring/summer 2016 (attached hereto for the Court's convenience as **Exhibit 3**), with the exception of John Day Dam. For John Day, Oregon's estimated spill cap is 146 kcfs compared to 90 kcfs estimated in the Corps Spill Priority List for spring/summer 2016. CSS modeling indicates that 146 kcfs can be spilled at John Day without exceeding existing TDG water quality standards. (Hall and Marmorek 2013 at 18). The Corps calculated the spill cap for John Day Dam as 146 kcfs (under the current TDG standards) in its 2013 Spill Priority List, attached hereto as **Exhibit 4**. Therefore, Oregon's estimate of 146 kcfs is consistent with the weight of evidence and earlier spill priority lists.

TABLE 3: OREGON'S PROPOSAL COMPARED TO 2014 BIOP OPERATIONS

Project	**2014 BiOp Spring Spill Operations as modified by 2016 FOP (consistent with 2011 Court-ordered Spill Operations) (24 hours per day operation unless specified otherwise)**	**Oregon's Spill Request: Provide spill at the spill cap 24 hours per day**		
		TDG cap	**Spill Cap Estimate (kcfs)**	**Dates**
Lower Granite	20 kcfs (Apr. 3 to June 20)	120% LGR tailrace/115% LGS forebay	41	Apr. 3 to June 20
Little Goose Dam	30% spill (Apr 3 to Jun 20)	120% LGS tailrace/115% LMN forebay	40	Apr. 3 to June 20
Lower Monumental Dam	Gas Cap 120/115% TDGL using bulk spill pattern (Apr 3-Jun 20)	120% LMN tailrace/115% IHR forebay	36 (using uniform spill)	Apr. 3 to June 20
Ice Harbor Dam	45 kcfs day/75–95 kcfs at night Apr 3 to Apr 28 & alternating 2-day blocks 45 day /75–95 night and 30% Apr 28 to Jun 20	120% IHR tailrace/115% MCN forebay	75 day/95 night	Apr. 3 to June 20

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McNary Dam	40% spill (Apr 10 to Jun 15)	120% MCN tailrace/115% JDA forebay	146	Apr. 10 to June 15
John Day Dam	30% spill (Apr 10 to Apr 27) & alternating two treatment operations 30% spill and 40% spill (Apr 27 to Jun 15)	120% JDA tailrace/115% TDA forebay	146	Apr. 10 to June 15
The Dalles Dam	40% spill (Apr 10 to Jun 15)	120% TDA tailrace/115% BON forebay	135	Apr. 10 to June 15
Bonneville Dam	100 kcfs (Apr 10 to Jun 15)	120% BON tailrace	130	Apr. 10 to June 15

40. TDG levels are monitored hourly to allow the Corps to adjust spill levels as necessary to meet the spill cap, without exceeding them. I agree with the Corps that "spill caps may vary daily depending on flow, spill operation, spill pattern, temperature, and other environmental concerns." 2016 FOP at 2. For this reason, Table 3 refers to a spill cap "estimate." Oregon also recognizes that the Corps may need to deviate from the spill cap estimates set forth in Table 3 during periods where involuntary spill is required (i.e., exceed the spill cap) or when spill is curtailed involuntarily due to inadequate flow to meet project minimum generation requirements, or other constraints identified in Paragraph 7.

41. Oregon's motion requests that defendants utilize a uniform spill pattern where possible. Spill pattern volume influences the amount of water that can be spilled without exceeding the spill cap. Evenly distributing the volume of water earmarked for spill for juvenile fish passage across multiple spill bays is considered a uniform spill pattern. Taking that same volume of water and spilling it through one spill bay (or, when volume exceeds the capacity of one spill bay, through more than one spillway) is referred to as a bulk spill pattern. Bulk spill typically results in higher total dissolved gas (TDG) levels than uniform spill (Pickett and

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Harding 2002). A bulk spill pattern more rapidly elevates TDG above water quality standards and forces reductions in spill earlier than would be achieved using a uniform spill pattern (Pickett and Harding 2002; FPC Memo Feb.14, 2014 at 1, 3). Using a bulk spill pattern also promotes the development of eddies in the tailrace which is commonly considered to impede tailrace egress of juvenile fish that have passed the dam (FPC Memo Oct. 7, 2013 at 9).

42. As used in Table 3, "TDG cap" means the applicable state Total Dissolved Gas water quality standard, including any waiver to the applicable TDG cap, under current state law at the time of the spill.

43. Oregon's proposed injunctive relief also allows the Corps to reduce voluntary spill levels below spill cap levels due to biological constraints if there is no objection from state, federal or tribal salmon managers represented on the Fish Passage Advisory Committee (FPAC). The FPAC is comprised of federal, tribal, and state agencies or entities with various management authorities over fish and other aquatic species, including NOAA, U.S. Fish and Wildlife Service, the Columbia River Inter-Tribal Fish Commission, Nez Perce Tribe, the Colville Tribe, the Fish Passage Center, and the states of Idaho, Washington, Montana and Oregon. These salmon managers provide technical recommendations and guidance for in-season management of FCRPS operations. These fish managers have worked together for many years and I am confident that if they are exercising their independent scientific judgment in these matters, decisions about spill will be made for biological reasons that will produce the best overall benefit for salmon and steelhead. In the event that spill levels must be adjusted, adjustments should be made in a manner that minimizes large fluctuations of water volumes or TDG levels. Moreover, if spill volumes need to be modified because they exceed state gas standards, they should be changed in the smallest possible increments to meet the spill cap volumes at each project. This proposed FPAC process would pertain only to adjustments in voluntary spill levels; as noted above in paragraph 7, Oregon's motion contemplates unilateral adjustments by the Federal Defendants in involuntary spill situations.

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B. Earlier initiation of Pit Tag Detection in the bypasses.

44. Historically, voluntary spring spill has begun in early April. It is my understanding that this was based at least in part on the understood run timing of outmigrating smolts. There are indications, however, that (1) this timing fails to provide spill for the leading tail of the run, which is key for species diversity, and (2) the overall run timing may be moving earlier, consistent with climate change, increasing the proportion of fish that must pass the dams without the benefit of voluntary spill.

45. Migration data collected for the Federal Defendants through a contract administered by the Pacific States Marine Fisheries Commission at the FCRPS show that the leading tails of the spring/summer Chinook and steelhead runs pass Lower Granite Dam before the current spring spill season begins. As part of its smolt monitoring program, Federal Defendants monitor movement of outmigrating juveniles through the dams. There are two types of smolt monitoring that go on at the dams: first, PIT tag detection, and second the Smolt Monitoring Program. With PIT tag detection, PIT tagged fish (a subset of all out-migrating fish) are detected as fish move through the bypass by instrumentation that activates and electronically catalogues a signal from the tag when it passes in range. With manual smolt monitoring, a sample of smolts are manually examined for various parameters by people working at sampling tanks within the bypass systems at the dams.

46. Tables 4 and 5 below are from PIT-tag detection data compiled by the Fish Passage Center at the request of ODFW. This data show the estimated proportion of the total number of PIT-tagged spring/summer Chinook and steelhead detected at Lower Granite Dam *before* the spill season began on April 3 of each year from 2012 to 2016. These tables also show the date of initiation of monitoring at Lower Granite Dam in each of those years. During these years, monitoring at Lower Granite began between March 17 and 22. Monitoring indicates wide variability in these earlier detections. But of concern is the data indicating that in some years, detections can exceed 10% of the outmigration for some listed populations. Thus, existing data

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show that some portion of the earlier outmigrating juveniles is migrating without the benefit of spill. And the proportion *detected* passing in early spring without the benefit of voluntary spill does not take into account any fish that pass before the monitoring begins. Furthermore, any fish migrating prior to watering up of the juvenile bypass facilities and before spill begins are forced to pass via turbines (passage route with highest mortality rate).

Table 4: Estimated proportion of PIT-tagged spring/summer Chinook detected at LGR that were detected prior to the April 3rd initiation of spill, from various locations.

Rear Type	Migration Year	LGR Detection Start Date	Proportion Detected Prior to April 3rd				
			Clearwater	Grande Ronde	Salmon	Imnaha	Total†
Wild	2012	22-Mar	0.079	0.060	0.033	0.191	0.058
	2013	18-Mar	0.020	0.010	0.001	0.026	0.008
	2014	20-Mar	0.096	0.028	0.004	0.055	0.023
	2015	17-Mar	0.115	0.041	0.027	0.117	0.059
	2016	21-Mar	0.042	0.015	0.004	0.038	0.011
Hatchery	2012	22-Mar	0.070	0.001	0.002	0.000	0.030
	2013	18-Mar	0.020	0.004	0.000	0.000	0.008
	2014	20-Mar	0.014	0.000	0.000	0.000	0.005
	2015	17-Mar	0.181	0.002	0.000	0.000	0.083
	2016	21-Mar	0.072	0.000	0.000	0.000	0.024

† Includes additional fish tagged and released from Snake River trap, which would include wild and hatchery Chinook originating from the Grande Ronde, Salmon, and/or Imnaha Rivers.

Table 5: Estimated proportion of PIT-tagged steelhead detected at LGR that were detected prior to the April 3rd initiation of spill, from various locations.

Rear Type	Migration Year	LGR Detection Start Date	Proportion Detected Prior to April 3rd						
			Clearwater	Asotin	Grande Ronde	Salmon	Imnaha	Hells Canyon Dam	Total†
Wild	2012	22-Mar	0.009	0.017	0.008	0.016	0.006	---	0.011
	2013	18-Mar	0.003	0.005	0.001	0.002	0.001	---	0.002
	2014	20-Mar	0.009	0.039	0.011	0.008	0.005	---	0.014
	2015	17-Mar	0.063	0.061	0.095	0.064	0.005	---	0.047
	2016	21-Mar	0.006	0.024	0.001	0.002	0.010	---	0.009
Hatchery	2012	22-Mar	0.000	---	0.001	0.000	0.023	0.113	0.008
	2013	18-Mar	0.000	---	0.000	0.000	0.000	0.033	0.002
	2014	20-Mar	0.000	---	0.000	0.000	0.023	0.097	0.009
	2015	17-Mar	0.000	---	0.088	0.000	0.000	0.282	0.029
	2016	21-Mar	0.000	---	0.000	0.000	0.000	0.063	0.003

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† Includes additional fish tagged and released from Snake River trap, which would include wild and hatchery steelhead originating from the Grande Ronde, Salmon, and/or Imnaha Rivers, as well hatchery steelhead released at Hells Canyon Dam.

These Pit Tag detection data are consistent with the data collected by the smolt monitoring program, which also shows fish passing prior to the initiation of spill. *See* FPC Memo December 8, 2015.

47. There are some recent indications that the overall outmigration timing for spring/summer Chinook and steelhead is shifting earlier. The Corps monitoring data show that the date when 10% of the detected outmigration has moved past Lower Granite Dam was earlier—more than two weeks earlier—in 2015 (FPC Memo December 8, 2015) and 2016 (Chockley 2016) than the ten year average for both steelhead and spring/summer Chinook. The same was true for the 50% and 90% passage dates. Earlier run timing is consistent with what might be expected from changing climate conditions such as unseasonably warm temperatures (both atmospheric and water) and earlier runoff (freshets) that are predicted in connection with climate change (Edmonds et al. 2003; Mote et al. 2003; Barnett et al. 2005; Palmer et al. 2009). This can affect both hatchery and wild fish because elevated water temperature can accelerate growth in both the hatchery and river environments. Earlier run timing would mean at least two things: first, that increasing numbers of fish are passing the dams before the juvenile bypass facilities and associated monitoring starts operating in mid- to late March, and second, that increasingly large portions of the run may be passing the dams before the spring spill period begins in early April.

48. The early and late tails of the runs are particularly important for species diversity. The "tails" of the run refers to the beginning and end portions of the run; those portions appear as the left and righthand ends of the bell curve (the "tails") when the run is displayed graphically. Diversity is one of the recognized Viable Salmonid Population ("VSP") benchmarks for assessing the status of salmon and steelhead, together with population abundance, population growth or productivity, and spatial structure (McElhany et al 2000). Diversity refers to the

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distribution of traits within and among populations that contribute to species persistence and adaptability. Because salmon and steelhead exhibit unique traits within their population and among other populations, sustaining variation (diversity) is important to a population's viability. Diversity provides a means for addressing highly variable environmental conditions. Similarly, diversity protects species from short term changes to their physical environment (spatial) and timing or phases of their life cycle (temporal). Additionally, diversity helps maintain the raw materials needed to survive long-term environmental change. For these reasons conserving adaptive diversity has been at the center of NOAA Fisheries' VSP management strategy. (Waples 2007; McElhany et al. 2000). Diversity in migration timing, in this case the leading tail of outmigrants, can improve salmon and steelhead populations' resilience to adverse or changing conditions later in the migration season (e.g., warm and low flows). Such adverse and changing conditions have been observed in recent years, and are expected to continue in future climate change scenarios. In other words, because of their importance to species diversity, failure to protect the early tail of the run (e.g. via spill) may have a disproportionate impact on ultimate species viability and resilience.

49. Taken together, the evidence regarding run timing, potential changes in run timing, and diversity consideration suggest that failure to provide spill during the month of March is a concern. If validated with additional monitoring and further years of data, these concerns may support management changes such as an earlier initiation of spring spill in order to provide protection across key portions of the run.

50. At this time, because juvenile bypass operations and associated monitoring does not begin until mid to late March, we do not have data on fish that move passed FCRPS dams earlier than that. However, two different datasets suggest that by the time monitoring begins in mid to latter March, the fish are already migrating past Lower Granite Dam. Currently we can summarize juvenile arrival times at FCRPS dams using Smolt Monitoring Program data (generally staffed by March 26 in most years) and the automated PIT tag detection system data

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that is capable of operating immediately upon initiation of the bypass system (since 2012 between March 17 and March 22). With both of these programs, fish are generally detected immediately, or detected within one day of the initiation of monitoring or detection—suggesting that they may have begun moving earlier than that. Thus, although we do not know precisely when out-migrating juveniles first arrive at FCRPS dams, the available evidence suggests that it may begin to occur before either monitoring effort is initiated. Collecting data to determine when the runs in fact begin moving passed the dams are needed for a robust evaluation of whether the current spring spill season dates remain appropriate. Oregon seeks an order requiring an expansion of the juvenile bypass facility operations period in order to inform future management decisions and the new biological opinion, and to prevent future management decisions being made without the benefit of information about when the important leading tail of the run begins moving past the dam. In particular, Oregon requests that the federal defendants be enjoined to initiate juvenile bypass operations with automated PIT tag monitoring at all instrumented Snake River dams starting on March 1 of each year (or, for 2017, as early as practicable following the Court's ruling) using established smolt monitoring protocols, subject to necessary safety (e.g. freezing risk) constraints.

51. In addition to providing important data, earlier initiation of PIT tag detection may also have a biological benefit during the remand period. Beginning juvenile monitoring earlier will require the Action Agencies to water up (open and begin operating) the juvenile bypass systems earlier, as the PIT-tag detection system detects fish moving through the bypass system. Currently, the bypass systems are not opened until monitoring begins in mid to latter March. Opening them at the beginning of March will provide the early tails of the run with an alternative

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to turbine passage. While spillway passage is preferable to both turbine and bypass routes, as explained at length above, bypass passage is more advantageous than turbine passage.

I declare under penalty of perjury that the foregoing is true and correct.

EXECUTED on January 18, 2017.

(b)(6) [redacted]

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In-river Passage Routes

Non-powerhouse = Spill (traditional or surface spillway weirs)

Powerhouse = Turbine or juvenile collection/bypass

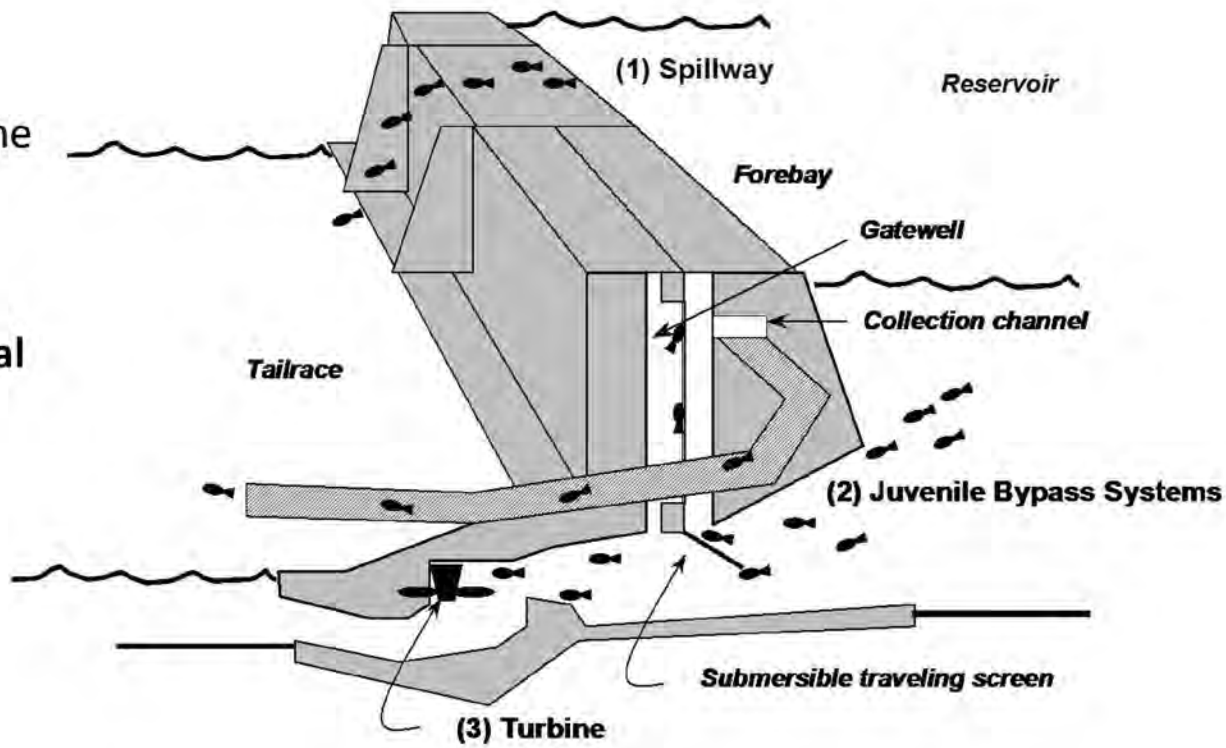
Direct survival:

spill ≥ bypass > turbine

Direct & indirect survival (delayed mortality):

spill > bypass

spill > turbine



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Declaration of Edward Bowles
Case No. 3:01-CV-00640-SI

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MEMORANDUM

TO: State, Tribal and Federal Fishery Agencies

(b)(6) [redacted]

FROM: Michele DeHart

DATE: November 2, 2016

RE: Historical Spill Summary 1981 to 2016

Attached you will find an updated document that was developed by the Fish Passage Center summarizing spill in the Columbia and Snake River hydrosystem from the completion of the present hydrosystem in1981through the 2016 spill season. The document was developed by the Fish Passage Center for our own use in understanding and interpreting long term trends in fish survival and abundance. Please replace all existing copies with this newest updated version.

There is no one source where the information regarding spill can be derived. In order to develop the document historic documents from several sources were reviewed, summarized and consolidated. We believe that this document may be of some utility to you and, therefore, we have decided to distribute it to the regional fishery agencies.

The History of Spill and Planned Spill Programs in the Federal Columbia River Power System, 1981 to 2016

I. Introduction

This compendium was developed by the Fish Passage Center and addresses the development and evolution of the planned spill program in the Federal Columbia River Power System (FCRPS). This memo is an update that includes the spill that has occurred over the last five years, since the original memo was developed in 2012.

The present hydrosystem configuration that is in place today was completed in 1981, when the last three units were brought on line at Lower Monumental Dam. The Lower Snake River dams that are part of the FCRPS include: Lower Granite; Little Goose; Lower Monumental; and, Ice Harbor. Those dams that are considered to comprise the Middle Columbia dams of the FCRPS are: McNary; John Day; The Dalles; and, Bonneville.

Spill has been traditionally provided as an alternate route of passage at hydroelectric projects to improve juvenile fish survival by avoiding the mortality associated with turbine passage. The provision of a spill program has evolved from providing spill only when excess energy was present in the hydrosystem, to a planned spill program at each of the FCRPS projects under any conditions. The time period during which spill has been provided has also evolved from a few hours during daily peak juvenile passage at a project, to a set hourly spill amount for the entire twenty-four hour period. Seasonal spill is now provided throughout the spring and summer migration period, whereas, in the early days of the spill program it was limited to peak juvenile passage days.

II. Spill for Fish Passage after completion of current hydrosystem configuration, 1981-1982

This first section addresses spill in the hydrosystem in 1981 and 1982, prior to the first Fish and Wildlife Program under the Northwest Power Act. Spill during this early period was provided only when flows exceeded the energy requirements of the system.

1981 – Planned spill at Lower Monumental, Ice Harbor and John Day dams was to be 10% of daily average flow when monitoring indicated that significant numbers of juveniles were passing the projects. Transportation at Lower Granite and Little Goose dams was expected to decrease the fish numbers at Lower Monumental and Ice Harbor dams, decreasing the need for spill. In addition, the use of the ice trash sluiceway was expected to further decrease spill at Ice Harbor. The vast majority of the volume of spill that occurred in 1981 was involuntary spill that occurred during the latter part of May and early June.

1982 – Planned spring spill was provided for Lower Monumental and John Day dams. The provision of planned spill was dependent on hydroacoustic monitoring showing the presence of fish, with spill occurring at Lower Monumental when sufficient numbers of fish were present, and at John Day Dam, when the daily passage was estimated to be greater than 30,000 fish. The sluiceway had been modified at Ice Harbor Dam and spill would only occur if the sluiceway did not effectively pass juveniles. The 1982 flow year was characterized as having very high runoff. Consequently, spill objectives were generally met, or exceeded, during the spring migration period. Most of the spill provided was involuntary, either as spill in excess of energy needs, or as excess of generation capacity. Involuntary spill extended into the summer period at several projects.

III. Spill for Fish Passage during the Water Budget Years, 1983 – 1992

The following is a summary description of the spill program over the ten years, 1983 -1992. The first Fish and Wildlife Program (Program) was published in November of 1982 as directed by the Northwest Power Act of 1980. The Program recognized the impact of juvenile passage through hydroelectric plants and called for the development of adequate bypass systems at projects and, until those bypass systems were operational, the Program called for the provision of spill to provide safe passage for juveniles. Consequently, spill was provided as mitigation at hydroelectric projects to enhance juvenile project survival. It was deemed the safest and most benign mode of passage for fish past a hydroelectric project. Historically, spill occurred operationally when project capacities, or system generation needs, were exceeded. As the hydrosystem was developed it became more efficient through such actions as the construction of the DC and AC Intertie transmission lines. As a consequence the occurrence of spill declined, accelerating the disagreements between the operators and regulators and the agencies and tribes regarding spill. Up until 1986, the provision of spill was tied to the availability of non-firm energy in the hydrosystem. Subsequent negotiations between the operators and regulators and the state, federal and tribal fishery agencies resulted in a 10 year package for a spill program (Fish Spill Memorandum of Agreement, December 1988) that was to be provided at projects that were not equipped with adequate bypass systems. The development of juvenile fish bypass systems by the operators and regulators was an attempt to provide an alternate route of passage past a hydroelectric project, avoiding spill.

As fish stocks declined and the Endangered Species listings occurred, it became clear that the negotiated contracts were not aggressive enough to recover endangered stocks. The state tribal and federal fishery agencies re-established the goals originally recommended in the Bypass Performance Standards developed in 1986, and continued pursuing those goals. The continued decline of fish stocks under the spill and passage programs in place over the ten years demonstrated the need for more aggressive protection. The following is a summary description of the spill program over the ten years, 1983 -1992.

1983 – Spill was used as a bypass at John Day and Lower Monumental dams. It was also used as a partial bypass at Bonneville, The Dalles, Ice Harbor, Little Goose and Lower Granite dams. At transportation collector projects spill was used to bypass spring Chinook, while transportation was maximized for steelhead by eliminating spill during peak steelhead passage. High flows in the spring and the summer resulted in large amounts of uncontrolled spill.

1984 - High flows and low loads resulted in large amounts of forced spill in the Snake River and at McNary Dam. Spill was requested at all projects, except McNary, during the spring Chinook migration to maximize bypass. Subsequently, spill requests called for spill to be minimized to allow maximum transport for steelhead. However, high flows resulted in forced spill after the steelhead were migrating, and continued through much of the spring migration period at each project. The COE developed the 1984 Spill Plan, which was not endorsed by the fishery agencies and tribes.

1985 - An executive committee process was initiated by the COE since they believed that problems had arisen with spill planning in 1984 due to a lack of policy level involvement. However, the lack of common objectives precluded the possibility of the group having any impact. Flow in 1985 was considerably lower than had occurred in 1984. The COE implemented a spill plan that they developed to meet the Northwest Power Planning Council's 90% survival objective, with the exception of Bonneville Dam where the objective was 85% fish passage efficiency (FPE). Fish passage efficiency (FPE) is a measurement of the proportion of fish that pass a project via a non-turbine route. Based on the assumptions made by the COE in calculating project survival relative to the 90% objective, the COE's plan offered no protection above bypass passage at most projects. Spill was provided at Lower Monumental and Ice Harbor Dam, and was managed on a daily basis using hydroacoustic monitoring of fish abundance.

1986 - High levels of spill occurred during the spring migration due to high river flows from the end of May to June. Requests for spill at the collector projects were denied on the basis of maximizing transportation. Spill at these projects only occurred as excess hydraulic capacity or excess generation spill. Spill was managed in-season based on trigger numbers developed by the COE and coupled with hydroacoustic monitoring. Spill during the summer migration was limited and was only implemented at The Dalles and John Day dams. The agencies and tribes developed bypass performance standards that were based on fish passage efficiencies at a project.

1987 - The agencies and tribes began meeting with the COE in December of 1986 to develop a joint 1987 Juvenile Fish Passage Plan, but the parties could not come to agreement. In February of 1987 the Northwest Power Planning Council amended the Program to require the COE to develop a Fish Passage Plan that incorporated a sliding scale that would provide spill to achieve better than 90% survival, exclusive of transportation, for 80% of the spring and summer migrants at each project in better than critical water years. Efforts were hampered by the inability to agree on the slope of the sliding scale and the flow level used to trigger the start of the slide. Efforts resulted in a separate COE Fish Passage Plan and an agency and tribal Detailed Fishery Operating Plan. Spring spill was only provided at Lower Monumental Dam.

In this extremely low flow year efforts were concentrated on developing a summer spill program for Lower Monumental Dam, which was not equipped with a bypass system. An agreement was reached between the resource agencies and the COE, where the COE would agree to 15 days of spill over a 45 day migration period. In addition, the summer spill agreement was to provide spill at John Day Dam according to a sliding scale whenever BPA was marketing non-firm energy in the system. A similar agreement was established for The Dalles. However, since no non-firm energy was sold during the summer period, no sliding scale spill occurred at either dam. Spill did occur to achieve the NPPC 90% survival, whenever passage indices exceeded 30,000 fish as determined by hydroacoustic monitoring.

1988 – Several processes were initiated prior to the 1988 migration season to facilitate agreement between the hydropower operators and regulators and the agencies and tribes. This included the establishment of the Mainstem Executive Committee, which was to address major policy controversies that precluded agreement on the 1987 Juvenile Fish Passage Plan. Technical and policy staff tried to reach agreement on a 1988, and long term, spill and passage program and Intertie settlement. The agencies and tribes presented a spill proposal based upon the interim 70/50 FPE bypass standards. Discussions continued through the fall and winter on three parallel tracks with policy staff, technical staff and legal staff meeting to address long term spill issues associated with the Intertie expansion development, and settlement of annual spill controversies. Several proposals were exchanged, including a sliding scale proposal by the agencies and tribes, which were based on flow year and the concept of equitable treatment. However, the COE developed their own Fish Passage Plan and spill during 1988 was limited to Lower Monumental Dam during the spring and to Lower Monumental and John Day dams during the summer. The COE again used hydroacoustic monitoring to limit spill to high fish passage days. Spill at Lower Monumental Dam was provided for 39 days during the spring migration, and 5 days during the summer migration. Spill was provided for 57 days at John Day Dam during the summer period.

1989 – The Mainstem Executive Committee, which was established in 1987, conducted negotiations from November of 1987 through the fall of 1988 regarding spill for fish passage at federal Snake and Columbia River hydroelectric projects that were not equipped with, or had inadequate fish bypass facilities. The culmination of these negotiations was a ten year Fish Spill Memorandum of Agreement (MOA) that commenced on December 31, 1988. The Spill MOA was implemented in 1989. More planned spill for fish occurred in the hydrosystem than had occurred in any previous year. The MOA broadened the spill program to include Lower Monumental, Ice Harbor and The Dalles dams during the spring, as well as John Day Dam during the summer. Spill was also provided at Bonneville Dam, but not as part of the MOA.

While the MOA provided more planned spill than ever before, it was a negotiated agreement that did not achieve the interim 70/50 FPE goal of the agencies and tribes.

1990 – The MOA was successfully implemented in 1990. More water was spilled in 1990 than in 1989, and most of that spill came in the form of excess generation spill. The agencies and tribes submitted a recommended operational plan for Bonneville Dam that was based on an interim objective of a 70% FPE during the spring migration and a 50% FPE during the summer migration. The proposal recommended that the second powerhouse not be operated and called for spill equal to 49% of flow for the spring and 44% of average daily flow for the summer. The COE rejected the plan and approximately 24% of average daily flow was spilled during the spill season.

1991 – The MOA was successfully implemented in 1991. In general, spill levels were either at, or above, the levels specified in the MOA due to high flows and excess generation spill. The COE again rejected the agencies and tribes recommended plan for Bonneville Dam and spill averaged 34% of daily average flow over the spill season.

1992 – In 1992 spill was implemented as defined in the NMFS Biological Opinion. Spill amounts were increased at the Snake non-collector projects, while in the Middle Columbia spill was designated a conservation measure and occurred according to the Spill MOA. In addition to increasing spill levels the NMFS Biological Opinion lengthened the spill seasons. Spill levels determined for the Snake projects were based on the interim 70/50 FPE bypass standard. The 70/50 FPE standard was also applied to spill at Bonneville Dam. The agencies and tribes recommendation was for spill to achieve the 80/70 FPE standard. The agencies and tribes maintained that increasing spill in the drought year presented a means of increasing fish survival without increasing flow. The agencies and tribes regarded the NMFS Biological Opinion as establishing minimum spill mitigation for 1992. Requests for increasing spill were denied. Using the same assumptions adopted by NMFS while developing the Biological Opinion, it was estimated that spring spill during 1992 yielded a seasonal 70% FPE at Lower Monumental Dam, a 59% FPE at Ice Harbor Dam, 58% FPE at The Dalles Dam and a 70% FPE at Bonneville Dam. No spring spill was provided at John Day Dam since NMFS assumed a 72% FPE from the bypass system alone. Summer spill in 1992 approximated the 50% FPE objective of the Biological Opinion at Lower Monumental, Ice Harbor, The Dalles and Bonneville dams, but at John Day the FPE was only about 40%. Under direction of NMFS, spill was not required at the collector projects.

IV. Spill for Fish Passage and the Biological Opinion, 1993 - 2004

As fish stocks continued to decline and were listed under the Endangered Species Act, it became clear that the negotiated contracts were not aggressive enough to recover endangered stocks. This lead to the modification of spill programs under the different versions of the Biological Opinion. At the same time that spill was identified as a key element in the recovery of listed stocks, the need to meet the objectives of the Clean Water Act were also identified. Spill causes high levels of total dissolved gas that could increase mortality and eliminate the benefits associated with the implementation of an aggressive spill program. Therefore, subsequent implementation of a spill program has been within the confines of the "risk" associated with increased levels of total dissolved gas. Consequently, spill is limited by the "gas cap" approved by the State water quality agencies as a way of managing risk.

In March of 1995, an ESA Section 7 Biological Opinion on the operation of the Federal Columbia River Power System was issued. The BIOP established a set of reasonable and prudent alternatives with the objective of improving the operation and configuration of the federal power system to meet a no jeopardy requirement of the Endangered Species Act (ESA), and to fulfill the United States commitment to uphold tribal treaty fishing rights. One of the RPAs established the Biological Opinion spill program for fish passage.

A Supplemental Biological Opinion was signed on March 2, 1995 in part to address the needs of the newly listed as threatened Snake River steelhead and the Middle Columbia River steelhead, as well as the endangered Upper Columbia River steelhead. The Supplemental Biological Opinion called for additional spill to the gas caps on a system-wide basis and modified the planning dates for the initiation and duration of the spill program. To the extent that the fish passage efficiency (FPE) at some projects exceeded 80%, the additional spill supplemented the 1995 BIOP RPA Measure 2 for an interim period pending decisions regarding biologically based performance standards for project passage.

NOAA Fisheries (then National Marine Fisheries Service) again modified spill in the 2000 Biological Opinion (BIOP) issued in December of 2000. In the 2000 BIOP spill at Lower Monumental Dam was increased from a 12-hour period to a 24-hour period. At The Dalles Dam the instantaneous spill level was decreased from 64% of instantaneous flow to 40% of instantaneous flow. Spill at John Day and Bonneville dams remained unchanged from the 1998 Supplemental Opinion, but called for the initiation of daytime spill test at John Day Dam and a test of increasing daytime spill volume at Bonneville Dam.

In June 2003, Judge James A Redden remanded the 2000 BIOP to NOAA Fisheries to resolve several deficiencies including: reliance on federal mitigation actions that have not undergone section 7 consultation under the ESA; and reliance on range-wide off-site non-federal mitigation actions that are not reasonably certain to occur. In a subsequent "minute order," the Judge denied plaintiffs' motion to vacate the Biological Opinion and the BIOP remains in place as deficiencies were addressed. Consequently, the system in 2004 was operated as called for by the 2000 BIOP.

The following is a yearly account of the program in place and the spill that occurred in the federal hydrosystem.

1993 - The NMFS Biological Opinion was issued on May 26, 1993. Prior to that date spill was in accordance with the COE Annual Fish Passage Plan, which prohibited spill at the collector projects and only called for spill at the non-collector projects to achieve a 70/50 fish passage efficiency. The Fish Passage Plan criteria applied to Ice Harbor and Bonneville dams. Spill according to the 1989 Fish Spill MOA was implemented at The Dalles and John Day dams. The 1993 Opinion superseded the earlier implementation scheme and prohibited planned spill at the collector projects, limited spill at Ice Harbor Dam, called for the removal of fish screens at Ice Harbor and Bonneville dams during the summer migration and implemented spill according to the 1989 MOA at John Day and The Dalles dams. The 1989 Spill MOA called for spill at John Day during the spring for 10 hours a day at a level equal to 20% of instantaneous flow, and spill at The Dalles Dam at a level equal to 10% of the daily average flow during the spring and 5% of daily average flow during the summer.

No planned spill occurred at the Snake River collector projects, but some excess generation spill did occur during the spring season. The spill MOA was implemented at John Day and The Dalles dams. During the period of peak runoff spill exceeded the levels of the MOA, but whenever possible they were managed down to those levels.

1994 - Spill was initially provided according to the 1994 –1998 BIOP, which required 70% spring and 50% summer FPE at non-collector projects. Operations changes on May 11 and implementation was requested to the 80% FPE. Spill was adjusted and varied up to the TDG waivers until May 27, when NMFS requested a one-third reduction in spill levels. Summer spill was limited at John Day and The Dalles Dams.

1995 - Spill was provided according to the 1995 Biological Opinion. This included spring spill at the Snake and Lower River projects and summer spill at Ice Harbor, John Day, The Dalles and Bonneville dams. Spill was up to the 80% FPE objective, or as limited by the gas cap. Ice Harbor Dam's hydraulic capacity was limited to 66 Kcfs; consequently, significant excess hydraulic capacity spill occurred at this project. John Day Dam did not have spillway deflectors installed and spill was limited

1996 - Spill was provided according to the 1995 Biological Opinion. Extremely high natural runoff conditions resulted in spill levels in excess of those that would have occurred under a spill program managed for total dissolved gas levels.

1997 - Spill was provided according to the 1995 Biological Opinion. Extremely high natural runoff conditions again this year resulted in spill levels in excess of those that would have occurred under a spill program managed for total dissolved gas levels. Full use of the John Day Dam spillway was delayed until after May 5 because of delays in spillway deflector installation due to contested contracts. The Ice Harbor project operated with spillway deflectors. The addition of spillway deflectors at both Ice Harbor and John Day resulted in lower levels of total dissolved gas compared to the previous high flow year values.

1998 – The 1998 Supplemental BIOP called for additional spill to the gas caps on a system-wide basis, even if the project met the 80% FPE at lower spill amounts. The Supplemental BIOP also modified the planning dates for spill allowing earlier initiation of the program and keying the duration to fish passage movement.

1999 – Spill was provided according to the 1998 Supplemental BIOP and was primarily involuntary, resulting from flows in excess of hydraulic capacity and power needs. Spill at most projects met or exceeded the 80% fish passage efficiency objective. The notable exception was The Dalles Dam, where spill alternated between 64% of average daily flow and 30% of average daily flow as part of a spill test. The spill levels for this test resulted in less spill than called for in the BIOP.

2000 – In April of 2000 NMFS released a Spill Plan agreement that modified the 1998 Supplemental BIOP spill levels, and was to be the basis for the 2000 BIOP spill program. Spill at Lower Monumental Dam was increased from a 12 hour to a 24-hour period. At The Dalles Dam, spill was reduced from the 64% of daily average flow, to 40% of daily average flow. In addition, while spill remained the same at John Day and Bonneville dams, spill tests were called for at both the projects. In general, the BIOP was implemented up to the spill gas caps.

2001 – The low flows and the declaration of a power system emergency resulted in no spill occurring in the Snake River during either the spring or the summer migration. A limited spill program equal to 600 MW months of energy was implemented after mid-May at Bonneville and The Dalles dams, and on May 25th at McNary and John Day dams that extended to June 15th. A limited summer spill program was implemented beginning in mid-July at The Dalles and Bonneville dams.

2002 - Spring and summer spill were provided according to the NMFS 2000 BIOP, as constrained by the total dissolved gas caps. The only exception occurred at Lower Monumental Dam where spill was not implemented because of repair work that was being conducted in the stilling basin.

2003 - Spring and summer spill were provided according to the NMFS 2000 BIOP, with modifications and, as constrained by the total dissolved gas caps. The BIOP was remanded in June, but left in place as deficiencies were addressed. The runoff volume was close to the BIOP cut-off for maximizing transportation in the Snake River, but the decision was made to continue spill through the spring migration. Spill was variable at Lower Granite Dam due to RSW testing. Spill at Lower Monumental Dam was 50% of flow to address tailrace egress issues, based on physical modeling, resulting in about a 10 Kcfs daily reduction from BIOP levels. At Ice Harbor Dam research studies were conducted and NOAA made in-season management decisions to curtail spill based on very preliminary findings suggesting survival through the spillway was lower than survival through the turbine units. The final results did not substantiate the earlier findings, but modification was not made to return the spill program to BIOP levels. Gas cap spill levels increased at McNary Dam due to new spillway deflectors. Spring spill tests were conducted at John Day and Bonneville dams, and a summer spill test was conducted at John Day Dam.

2004 - Spill was provided in accordance with the NMFS 2000 BIOP. Several issues with the implementation of the BIOP spill program were addressed this year. The Action Agencies proposed to terminate spill for Spring Creek National Fish Hatchery (NFH) fish and only operate the untested corner collector. The Bonneville Dam corner collector was tested against spill for Spring Creek NFH release prior to the BIOP spill season. It was a low flow year and, according to the 2000 BIOP, spill would be terminated and maximum transportation implemented. However, the salmon manager's wanted to invoke the adaptive management provisions in the BIOP since research was showing that early season transportation was not beneficial for spring Chinook (however, among the salmon managers there was not an agreement as to when to transition to transport operation. NMFS recommended an April 23 start date, while the others recommended a May 1 start date). The regional process was not able to reach a decision regarding implementation, and the decision regarding spill in 2004 stating, "Based on the discussions at IT (Implementation Team), the COE has decided to provide spill at Lower Granite and Little Goose until 23 April to provide in-river passage for yearling Chinook prior to the steelhead juvenile migration". Also this year, the Bonneville Power Administration implemented a requirement for revenue neutral decisions regarding the provision of spill at Lower Granite Dam to reduce the number of fish collected and offsetting this spill by a reduction of spill at Bonneville Dam. The Implementation Team considered the issue and recommended that in the future, revenue-neutrality should not be a constraint. The Action Agencies proposed a modified summer spill program that was less than included in the BIOP. On July 28, Judge Redden in the District Court of Oregon ruled in favor of plaintiffs' motion for a preliminary injunction to stop implementation of a modified summer spill proposal. The Department of Justice on August 4 filed a request with the Ninth Circuit Court to stay the district court's preliminary injunction on or before August 9, 2004, pending appeal of the decision. The request was denied and spill was implemented as described in the 2000 Biological Opinion until August 31, 2004. An incorrect calibration at Bonneville Lock and Dam caused less water to be released than reported. Because of this calibration error the daytime spill quantity reported at Bonneville Dam was increased to approximately 85 Kcfs, while the actual spill quantity was about 75 Kcfs. The discrepancy in flow between Bonneville and The Dalles was first noted in December 2003 and appears related to the new spill pattern and flow deflectors that came online at Bonneville in 2002. Historically there have been two types of gates at Bonneville: 50-foot-high gates and 60-foot-high gates. The last time the Bonneville rating curves were recalibrated was 1967. This discrepancy may have been occurring since 1972, when the gates were modified at Bonneville, although the most serious discrepancies have most likely occurred since 2002, when the flow deflectors were installed and the flow pattern was modified. In essence, much more limited fish protection has occurred historically at Bonneville Dam than previously estimated.

V. Spill for Fish Passage under Court Ordered Operations, 2005 – present.

Spill during this period has been guided by the Court Ordered Operations after the 2004 Biological Opinion and the 2008 Biological Opinions were remanded to the courts. In December of 2004 the Biological Opinion was released and in a May 2005 court opinion, it was found that the 2004 BIOP violated the ESA and it was remanded. The provisions contained in the 2004 BIOP remained in place for the 2005 migration, with the exception of the requirements for additional summer spill. Judge Redden's June 10, 2005 opinion in NWF v. NMFS granted the spill portion of the National Wildlife Federation's requested injunctive relief. For the first time, a planned summer spill program at Lower Granite, Little Goose, Lower Monumental (since 1993) and McNary dams to the gas cap limits was implemented in the hydrosystem.

In May of 2008 a new Biological Opinion was issued. On February 19, 2010 the Federal Court granted a limited, voluntary remand to the defendants of the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BIOP). The remand was granted for a three month period and was granted for the purpose of integrating the Adaptive Management Implementation Plan into the 2008 BIOP.

2005 - In December of 2004 a new Biological Opinion was released. In a May 2005 decision it was found that the 2004 BIOP violated the ESA, and it was remanded. The provisions contained in the 2004 BIOP remained in place for the 2005 migration, with the exception of the requirements for additional summer spill. Fish from Spring Creek NFH were passed with the operation of the Bonneville corner collector and no spill. Spring spill operations were terminated at the transport collector projects due to projected flows below 85 Kcfs. Spill at The Dalles Dam was restricted in 2005 due to the inability to operate spill gates at all but two spillbays because of gate hoist problems and the project only had the ability to pass a fixed volume of spill. At times, this resulted in spill less than the 40% called for in the BIOP. Although a volume trade-off was requested throughout the period for spill at John Day to be increased to mitigate the loss, the Action Agencies only implemented it for 7 days. Judge Redden's June 10, 2005 opinion in NWF v. NMFS granted the summer spill portion of the National Wildlife Federation's requested injunctive relief to provide spill at Lower Granite, Little Goose, Lower Monumental and McNary dams to gas cap limits.

2006 - Although the 2004 BIOP was remanded in October of 2005, the provisions remained in place for 2006. On December 29, 2005 the court granted the plaintiffs a preliminary injunction which provided for spill operations in 2006 that were, in part, different than the 2004 BIOP. The changes to the spring spill program from the 2004 Biological Opinion provided 24-hour spill at 30% of river flow at Little Goose Dam and a flat spill of 100 Kcfs at Bonneville Dam. In addition, spill was to be provided at all projects during the summer period at the same levels that occurred in 2005. This year (2006) was the last year of the USFWS agreement with the Action Agencies and spill was not provided for the March release from Spring Creek NFH. Spill that occurred in the spring of 2006 offered less mitigation to migrating salmonids than what could have occurred if spill only met the 120% TDG tailrace objective, after excess hydraulic capacity and excess market spill were removed from the equation. The bias towards a higher TDG reading at the forebay monitors results in an unnecessary limitation of protection measures for fish passage. John Day Dam's T-1 bank of transformers suffered a fault to ground that damaged bushings. The result of this mishap was that turbine units 1 through 4 were out of service throughout the spring and summer juvenile and adult fish migration season, reducing the hydraulic capacity of John Day and affecting fish passage conditions and spill at the project. Spill for fish passage provided at The Dalles Dam was less than the BIOP established level of 40% throughout most of April and early May due to either the limited operational bays at The Dalles Dam due to spillway cable repairs or the 115% forebay dissolved gas limitations at the Bonneville forebay.

2007 - Spill occurred according to the 2007 FCRPS Operations Agreement. The 2007 migration year was unique in that spill occurred throughout the spring period in a low flow year. The 2007 FCRPS Operations Agreement states that in water years when the projected seasonal average flow is greater than 70 Kcfs, transportation is initiated between April 20 and May1 at Lower Granite Dam, and at staggered dates at the downstream transport collector projects. In years where projected flows are less than 70 Kcfs, transport is initiated on April 20. The early projections were for spring flows to exceed 70 Kcfs and therefore transport operations were not initiated until May 1 at Lower Granite Dam. The 2007 FCRPS Operations Agreement specifies spill levels that exceed those contained in the 2004 Biological Opinion. Spring spill at Lower Granite Dam was expanded from 12 to 24 hours daily to accommodate the continuous operation of the removable spillway weir. Spill hours at Little Goose and McNary Dams increased from twelve to twenty-four hours daily.

The 2007 FCRPS Operations Agreement also incorporated a summer spill program at the Snake River Transport collector projects (Lower Granite, Little Goose and Lower Monumental Dams) as well as at McNary Dam. In general spill during 2007 met the objectives of the 2007 FCRPS Operations Agreement, with the caveats that a) no spill was provided for the March Spring Creek NFH release and high mortality was observed for this release, b) there was a failure to meet 2007 FCRPS Operations Agreement spill levels at the beginning of the season that resulted in the changing of the 2007 FCRPS Operations Agreement into a Court Order; and, c) spill volumes were again constrained by forebay total dissolved gas readings.

2008 – The Court ordered operations from 2007 were continued into 2008. Spill according to the 2008 Operations Agreement was to occur under all flow years. The 2008 runoff volume was above average and, consequently, spill in excess of the Court Order occurred in the system as excess hydraulic capacity or generation throughout most of the spring and into the beginning of the summer. Spill during 2008 generally met the objectives of the 2008 Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project. A little more than 3 days of spill at 35 Kcfs was provided for the March Spring Creek NFH release and turbine units were operated at the low end of the 1%

efficiency range to minimize fish mortality. A negotiated total of 14 days of nighttime gas cap spill at Little Goose Dam were provided in early May.

2009 - A new NOAA FCRPS Biological Opinion was released in May of 2008. Court-ordered spill operations for spring and summer 2009 were implemented, subject to modifications necessary to accommodate new structures and perform essential research. The 2009 Fish Operations Plan was signed on April 10, 2009 as an order directing 2009 FCRPS hydro operations for spring migrating fish and on June 2, 2009 for summer migrating fish. The Fish Operations Plans continued the 2008 operations into 2009, subject to modifications necessary to accommodate new structures and research at specific dams. The 14 days of gas cap spill at Little Goose, which had been provided in 2008, was eliminated from the "roll over" operations in 2009 to accommodate the testing of the newly installed temporary spillway weir (TSW).

On October 23, 2008 an agreement was signed by the U. S. Fish and Wildlife Service, U. S. Army Corps of Engineers, NOAA Fisheries and the Bonneville Power Administration to reprogram fish production at Spring Creek National Fish Hatchery in Washington. The agreement moved a portion of Spring Creek's production to other facilities so the hatchery could raise the remaining juvenile salmon until they were larger. These larger fish were released later and passed Bonneville Dam during the Biological Opinion spring spill period, thus eliminating the March hatchery release and the need for spill at Bonneville Dam outside of the spring spill period.

2010 - On February 19, 2010 the Federal Court granted a limited, voluntary remand to the defendants of the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BIOP). The remand was granted for a three month period and was granted for the purpose of integrating the Adaptive Management Implementation Plan into the 2008 BIOP. On March 31, 2010 a Spring Fishery Implementation Plan was introduced to the Court that included a strategy for the upcoming low water year that terminated spring spill and maximized transportation for Snake River migrants. According to NOAA the maximum transport plan for expected flows less than or equal to a season average regulated flow of 65 Kcfs was based on new scientific information, and "*the Corps and NOAA, in coordination with the regional sovereigns, will consider the best available science, including the ISAB input*", to make a determination on the transportation operations. The transportation operations were submitted to the Independent Scientific Advisory Board for an independent scientific review. After reviewing the information, the ISAB concluded that "a mixed strategy of spill and transport during the critical spring migration period allows learning from spill conditions and supports potential advances in knowledge to improve decision-making in the future." The ISAB's conclusions looked at broader ecosystem considerations than the NOAA proposal's focus on the protection of ESA-listed Snake River Chinook salmon and steelhead stocks during a low-flow year.

While NOAA stated that they had "reservations about leaving juvenile fish in-river during these low flow conditions, implementation of a mixed strategy of spill and transport for 2010 will allow us to gather additional information." The 2009 spring and summer operations were continued into 2010, subject to modifications necessary to accommodate new structures and research at specific dams.

2011 – The runoff volume this year was significantly above average (the January to July runoff volume was 133% of average above The Dalles Dam and 139% of average above Lower Granite Dam). Spill prior to the onset of the Court ordered spill program occurred due to high flows early in the season as projects drafted to flood control elevations. In general, the 2010 Court Ordered spill operations were extended to 2011, subject to modifications necessary to accommodate new structures and perform essential research. Spill during the spring season met or exceeded the court ordered amounts due to high flows in excess of hydraulic capacity, or due to limited market availability. During the early part of the summer season, flow was still high and court ordered operations were often exceeded. In addition, several of the FCRPS projects (particularly Lower Granite, McNary and Bonneville dams) were operating with limited hydraulic capacity. At Little Goose Dam there was a complete powerhouse outage between May 24 and June 1, during which time the entire river flow (less 5 Kcfs for station power service) was passed in spill.

2012 - Runoff (January-July) in 2012 was 100% of average (1971-2000) above Lower Granite and 121% of average above The Dalles Dam. There were turbine units out of service limiting the hydraulic capacities of the projects at several hydro projects in the FCRPS. River flows were extremely high during March, April, May, June, and into July. Above average precipitation in late spring, snowmelt, and the drafting of storage reservoirs for flood control resulted in the high flow and consequently, high spill and total dissolved gas levels. Uncontrolled spill (spill in excess of hydraulic capacity or power needs) occurred regularly during this period. Spill during 2012 generally exceeded the objectives of the 2012 Fish Operations Plan due to the uncontrolled spill. However, whenever possible, spill was managed within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and meeting the requirements for minimum turbine operations at each project.

2013 - The runoff (January–July) volume for the 2013 water year was near average in the Middle Columbia River but below average in the Lower Snake River. Runoff (January–July) was 96% of average (1981–2010) at The Dalles Dam and 69% of average at Lower Granite Dam. In the Snake River, this resulted in mostly lower than average flows throughout the spring and summer seasons, with peak flows in May. In the Middle Columbia, the 2013 runoff resulted in near average flows in both the spring and summer 2013. The peak flow conditions in the Snake River and Middle Columbia rivers in mid-May resulted in some uncontrolled spill for a few days at the Snake and Columbia River sites. Spill during 2013 generally met the objectives of the 2013 Fish Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and meeting the requirements for minimum turbine operations at each project.

2014 - The runoff (January–July) volume for the 2014 water year was above average in the Middle Columbia River and near average in the Lower Snake River. Runoff (January–July) was 107% of average (1981–2010) at The Dalles Dam and 98% of average at Lower Granite Dam. In the Snake River, this resulted in near average flows throughout the spring and summer seasons, with peak flows in May. In the Middle Columbia, the 2014 runoff resulted in above average flows in both the spring and summer periods. The peak flow conditions in the Snake River and Middle Columbia rivers in mid-May resulted in uncontrolled spill for periods of time at the Snake and Columbia River sites. The spill in excess of the planned amount generally occurred at McNary Dam, which has a more limited hydraulic capacity that the other Middle Columbia River projects. Outside of the peak flow period, spill during 2014 generally met the objectives of the 2014 FOP, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project.

2015 - The runoff volume (January–July) for the 2015 water year was considerably below average in both the Middle Columbia and Lower Snake rivers. Runoff (January–July) was 83% of average (1981–2010) at The Dalles Dam and 69% of average at Lower Granite Dam. To put the low runoff volumes into perspective, the 2015 January–July runoff volumes at The Dalles and Lower Granite were ranked 68th and 74th, respectively, over the 87 year record (1929–2015). In the Snake River, this resulted in below average flows throughout the spring and summer seasons, with peak flows of only about 71 Kcfs in mid-May. In the Middle Columbia, the 2015 runoff resulted in below average flows in both the spring and summer periods. Flows in the Snake and Middle Columbia rivers were sufficiently low throughout the entire spring and summer seasons that uncontrolled spill events were extremely rare. Summer flow operation at Bonneville Dam continued the "test operations" of alternating every two days between 85 Kcfs/121 Kcfs and 95 Kcfs instantaneously, rather than reverting to the 75 Kcfs/gas cap spill operations on July 21.

2016 - The runoff (January–July) volume for the 2016 water year was near average for both the Middle Columbia River and the Lower Snake River. Runoff (January–July) was 96% of average (1981–2010) at The Dalles Dam and 88% of average at Lower Granite Dam. In the Snake River, this resulted in near average flows throughout the spring and summer seasons. To put the 2016 runoff volumes into perspective, the 2016 January–July runoff volumes at The Dalles and Lower Granite were ranked 54th and 52nd, respectively, over the 88 year record (1929–2016). Almost no uncontrolled spill occurred in 2016. Spill was provided according to the Fish Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project.

VI. Planned Spill Operations

Each year throughout the history of the spill program, there has been a planned operation for spill at each of the federal hydroelectric projects. Actual spill levels may have been greater than the planned spill levels as a result of high river flows that exceeded powerhouse capacity, or river flow levels that exceeded the energy needs. Tables 1-7 (below) are based on the pre-season plans for each year and capture the essence of the planned operation of each project by the spring and summer season. Seasons have been of different lengths among years, and are defined for each year in Appendix A.

Table 1. Planned spill operations at FCRPS projects, 1983-1987.

Season/Project	1983	1984	1985	1986	1987
SPRING					
Lower Granite	No spill (unless surplus spill available and spring Chinook dominate)	No spill (unless surplus spill available and spring Chinook dominate)	No spill	No spill	No spill
Little Goose	Same as Lower Granite	Same as Lower Granite	No spill	No spill	No spill
Lower Monumental	Up to 50% of flow, for up to 5 hours When fish # > 15K	Up to 50% of flow, for up to 5 hours When fish # > 15K	50% of flow 2000 to 0600	50% of flow 2000 to 0600	55% of flow for 3 hours (or more if needed) beginning at 2000, when fish # > 15K
Ice Harbor	40% of flow, for up to 4 hours if sluiceway less effective than screened bypass at LGR & LGO	No spill	30% of flow 2000 to 0600	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	50% of river flow exceeding the capacity of screened units 2000 to 0600	No spill	No spill
The Dalles	No spill	No spill	24% of river flow 1000-2000 (if warranted and if non-firm energy)	5% of daily average flow	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17 & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	50% of flow 2000 to 0600 to July 15	50% of flow 1800 to 0600	100% for 8 hours, 15 days out of 45 day period
Ice Harbor	No spill	No spill	No spill	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	36% of river flow 1800 to 0600	36% of river flow 1800 to 0600	Spill 18% of flow for 3 hours (or more if necessary) when fish # >30K/d
The Dalles	No spill	No spill	5% of daily average flow	No spill	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17 & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

Table 2. Planned spill operations at FCRPS projects, 1988-1992.

Season/ Project	1988	1989	1990	1991	1992
SPRING					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	40% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	60% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	No spill	No spill	No spill	No spill
The Dalles	No spill	10% of daily average flow	10% of daily average flow	10% of daily average flow	10% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	43% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	30% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	5% of daily average flow	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600
The Dalles	No spill	5% of daily average flow	5% of daily average flow	5% of daily average flow	5% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

Table 3. Planned spill operations at FCRPS projects, 1993-1997.

Season/ Project	1993 (1993 BIOP)	1994 (1994-1998 BIOP)	1995 (1995 BIOP)	1996 (1995 BIOP)	1997 (1995 BIOP)
SPRING					
Lower Granite	No spill	No spill	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Little Goose	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)
Lower Monumental	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Ice Harbor	60% up to a max of 25 Kcfs (1800-0600)	60% up to max of 25 Kcfs (1800-0600)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)
McNary	No spill	No spill	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)
John Day	No spill	No spill	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)
The Dalles	10% day/night	10% (2000-0400)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)
Bonneville	70 % FPE - 75 Kcfs day/gas cap (110%) night	70 % FPE - 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	60% up to a max of 25 Kcfs (1800-0600)	30% up to max of 25 Kcfs (1800-0600)	70% of instantaneous flow day/night	70% of instantaneous flow day/night	70% of instantaneous flow day/night
McNary	No spill	No spill	No spill	No spill	No spill
John Day	20% (2000-0600)	20% (2000-0600)	86% (2000-0600)	86% (2000-0600)	86% (2000-0600)
The Dalles	5% day/night	5% (2000-0400)	64% of instantaneous flow day/night	64% of instantaneous flow day/night	64% of instantaneous flow day/night
Bonneville	50% FPE - 75 Kcfs Day/gas cap (110%) night	50% FPE - 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night	75 Kcfs day/100% night	75 Kcfs day/100% night

Table 4. Planned spill operations at FCRPS projects, 1998-2002.

Season/ Project	1998 (1998 Supplemental BIOP)	1999 (1998 Supplemental BIOP)	2000 (Spill Plan Agreement)	2001 (2000 BIOP)	2002 (2000 BIOP)
SPRING					
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)
Little Goose	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)
McNary	No spill	No spill	No spill	No spill	No spill
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)

Table 5. Planned spill operations at FCRPS projects, 2003-2007.

Season/ Project	2003 (2000 BIOP)	2004 (2000 BIOP)	2005 (2004 BIOP)	2006 (Court Order)	2007 (Court Order)
			SPRING		
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 45 Kcfs)	20 Kcfs day/night	20 Kcfs day/night
Little Goose	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 60 Kcfs)	30% day/night	30% day/night
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; 45-50% of outflow	40 Kcfs day/night	Gas Cap day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	40% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	60% of outflow until June 20 (1800-0600;1900-0600); Starting June 21; 30% of outflow	60% night (1800-0600 to May 15;1900-0600 after May 15)	0 day / 60% night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	100 Kcfs day/night	100 Kcfs day/night
			SUMMER (Court Order)		
Lower Granite	No spill	No spill	Spill in excess of the flow necessary for station service	18 Kcfs day/night	18 Kcfs day/night
Little Goose	No spill	No spill	Spill in excess of the flow necessary for station service	30% day/night	30% day/night
Lower Monumental	No spill	No spill	Spill in excess of the flow necessary for station service	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	Spill in excess of the flow necessary for station service	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	No spill	No spill	Spill in excess of 50 Kcfs flow	Alternate between 40% day/night and 60% day/night	40% day/night vs. 60% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	30% of outflow for 24 hrs	30% of outflow for 24 hrs	30% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day / gas cap night (approx 120 Kcfs)

Table 6. Planned spill operations at FCRPS projects, 2008-2011.

Season/ Project	2008 (Court Order)	2009 (Court Order)	2010 (Court Order)	2011 (Court Order)
SPRING				
Lower Granite	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night
Little Goose	30% day/night 14 nights of gas cap spill	30% day/night (To accommodate new spillway weir testing, 14 nights of gas cap spill used in 2008 will not occur)	30 % day/night	30 % day/night
Lower Monumental	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night
Ice Harbor	30% day/night vs. 45 Kcfs day/gas cap night	45 Kcfs / gas cap on non-test days; 30% day/night vs. 45 Kcfs day/gas cap night	April 3-April 28: 45 Kcfs/Gas Cap April 28-June 20: 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 27: 45 Kcfs/Gas Cap April 28- mid July 30%/30% vs. 45 Kcfs/Gas Cap
McNary	40% day/night	40% day/night	40% day/night	40% day/night
John Day	0 day / 60% night	30% day/night on pre-test days; 30% day/night vs.40 day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night
SUMMER				
Lower Granite	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night
Little Goose	30% day/night	30% day/night	30% day/night	30% day/night
Lower Monumental	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	30% day/night vs. 45 Kcfs day/gas cap night	45 Kcfs/gas cap on non-test days; 30% day/night vs. 45 Kcfs day/gas cap night	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap
McNary	40% day/night vs. 60% day/night	40% day/night vs. 60% day/night	50% day/night	50% day/night
John Day	30% day/night	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day / gas cap night	85 or 75 Kcfs day/gas cap night (85 Kcfs day through July 20, then 75 Kcfs day through August 31)	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap

Table 7. Planned spill operations at FCRPS projects, 2012-2016.

Season/ Project	2012 (Court Order)	2013 (Court Order)	2014 (Court Order)	2015 (Court Order)	2016 (Court Order)
SPRING					
Lower Granite	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night
Little Goose	30% day/night	30% day/night	30 % day/night	30 % day/night	30 % day/night
Lower Monumental	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night
Ice Harbor	April 3-April 28: 45 Kcfs/Gas Cap April 28- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 28- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap
McNary	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
John Day	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; 30% day/night vs.40 day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing (Apr 28-June 15) 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing (Apr 28-June 15) 30% day/night vs.40% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night
SUMMER					
Lower Granite	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night
Little Goose	30% day/night	30% day/night	30% day/night	30% day/night	30% day/night
Lower Monumental	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap
McNary	50% day/night	50% day/night	50% day/night	50% day/night	50% day/night
John Day	Testing (July 1-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (July 1-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (June 16-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (June 16-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	30% day/night on non-test days; 30% day/night or 40% day/night on test days
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	85 Kcfs/121 Kcfs and 95 Kcfs/95 Kcfs (alternating every two days)	85 Kcfs/121 Kcfs and 95 Kcfs/95 Kcfs (alternating every two days)

VII. Actual Spill Volumes Among Years

While spill has mostly been provided in accordance with the prevailing spill program in any specific year, there has been a considerable variation in spill among years for a variety of reasons (excess generation spill, excess hydraulic capacity spill, maintenance issues, and test schedules). To capture this variation, Tables 8 and 9 summarize the amount of spill that actually occurred in two different ways. The daily average spill (in Kcfs-days) that occurred is summed over the spring and summer period to give an estimate of the magnitude of water spilled (ΣKcfs-days). For comparison sake, all periods were standardized, that is to say, the spring period extends from April 3 to June 20 in the Snake River and April 10 to June 30 in the Middle Columbia River, while the summer period extends from June 21 to August 31 in the Snake and July 1 through August 31 in the Middle Columbia.

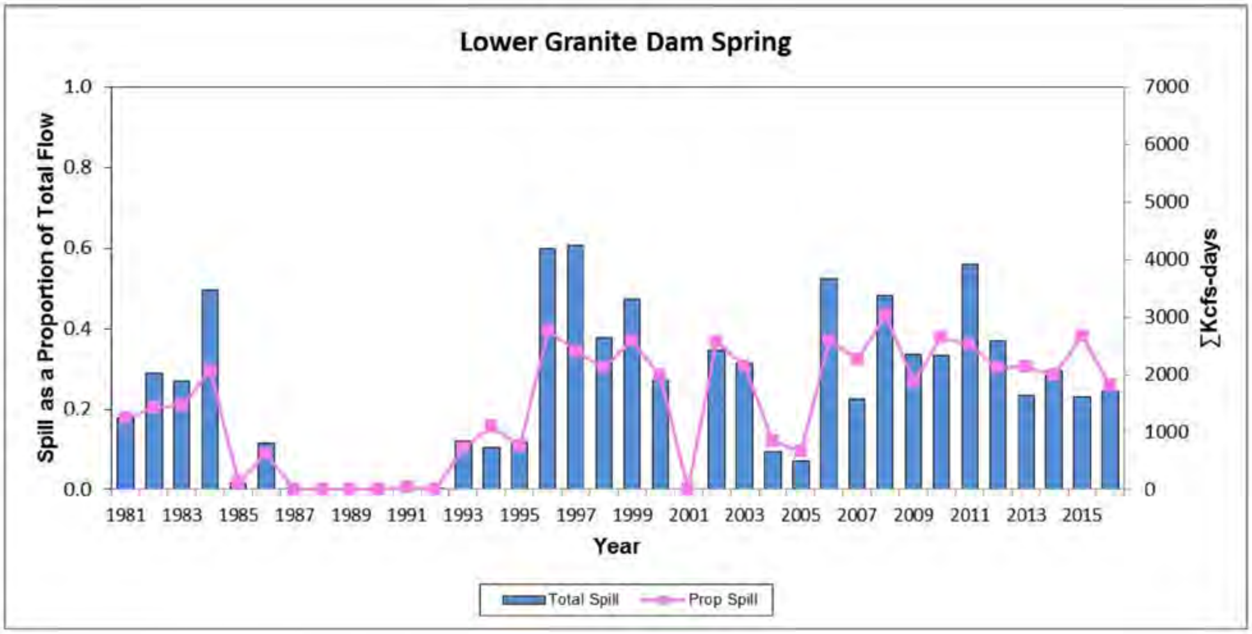
The second summary statistic on the graphs (Figures 1-8) averages the daily proportion of water spilled (relative to total flow) over the same time periods. Spill over the period has ranged from the lows observed during the power emergency in 2001 to the highs observed during the high flow years of 1996 and 1997. Tables 8 and 9 and Figures 1-8 depict this information in a standard format and provide the annual runoff volume as a way of illustrating the magnitude of the individual flow year.

Table 8. Total sum of Kcfs-days spill at each Lower Snake River dam by season for each year, as well as the runoff volume (MAF) provided as a relative measure of flow volume among years.

YEAR	Runoff Vol	Lower Granite				Little Goose				Lower Monumental				Ice Harbor			
	Snake	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	above LGR	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill
	(Jan -July)	∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days	
1981	**25.4**	1249	0.18	57	0.02	520	0.08	9	0.00	2906	0.41	809	0.32	2778	0.40	658	0.26
1982	**42.8**	2025	0.20	973	0.18	1965	0.20	895	0.17	5248	0.53	2318	0.44	4185	0.43	1596	0.31
1983	**37.8**	1886	0.21	0	0.00	2018	0.22	494	0.13	4288	0.48	469	0.12	3969	0.44	685	0.18
1984	**44.5**	3475	0.30	718	0.15	3187	0.27	655	0.14	4343	0.37	1099	0.23	4352	0.37	1178	0.25
1985	**25.6**	116	0.02	0	0.00	0	0.00	0	0.00	1246	0.17	0	0.00	680	0.10	0	0.00
1986	**38.0**	807	0.09	0	0.00	829	0.09	0	0.00	3637	0.40	143	0.06	3350	0.37	1	0.00
1987	**17.1**	0	0.00	0	0.00	0	0.00	0	0.00	403	0.10	63	0.04	33	0.01	0	0.00
1988	**17.3**	0	0.00	0	0.00	0	0.00	0	0.00	367	0.08	0	0.00	0	0.00	0	0.00
1989	**25.0**	0	0.00	0	0.00	0	0.00	0	0.00	1635	0.24	297	0.13	650	0.10	146	0.07
1990	**20.2**	0	0.00	0	0.00	112	0.02	2	0.00	1689	0.30	414	0.20	843	0.15	163	0.08
1991	**18.9**	39	0.01	7	0.00	24	0.00	0	0.00	1770	0.33	616	0.27	757	0.14	225	0.10
1992	**14.1**	0	0.00	0	0.00	0	0.00	0	0.00	719	0.19	341	0.25	1028	0.28	198	0.15
1993	**26.7**	848	0.10	0	0.00	1748	0.21	0	0.00	1382	0.17	0	0.00	2548	0.31	906	0.27
1994	**15.9**	736	0.16	13	0.01	1069	0.23	0	0.00	424	0.09	14	0.01	1611	0.34	342	0.18
1995	**29.4**	824	0.11	33	0.01	1491	0.20	96	0.02	1176	0.15	87	0.02	2768	0.36	1817	0.44
1996	**42.4**	4203	0.40	332	0.09	4015	0.39	407	0.11	3892	0.37	465	0.12	4506	0.44	1825	0.47
1997	**49.5**	4245	0.34	327	0.07	4386	0.37	254	0.05	4653	0.36	278	0.06	6854	0.56	2925	0.56
1998	**31.3**	2647	0.30	106	0.03	2813	0.33	14	0.00	2501	0.28	8	0.00	5151	0.57	2998	0.71
1999	**36.1**	3328	0.37	359	0.09	2136	0.25	84	0.02	1848	0.21	88	0.02	5567	0.60	3178	0.73
2000	**24.7**	1895	0.29	0	0.00	1654	0.26	19	0.01	2353	0.36	0	0.00	4907	0.70	2167	0.80
2001	**14.4**	0	0.00	15	0.01	0	0.00	1	0.00	0	0.00	9	0.00	10	0.00	0	0.00
2002	**24**	2432	0.37	383	0.13	2142	0.34	271	0.09	70	0.01	0	0.00	4463	0.66	2397	0.76
2003	**23.8**	2193	0.31	17	0.01	1770	0.26	0	0.00	2360	0.34	0	0.00	4106	0.57	1038	0.44
2004	**20.7**	663	0.12	0	0.00	356	0.06	0	0.00	559	0.10	41	0.02	3672	0.62	1873	0.75
2005	**18.1**	496	0.09	1367	0.57	141	0.03	1097	0.45	337	0.06	1213	0.52	3124	0.58	1467	0.62
2006	**32.2**	3675	0.37	1226	0.45	2820	0.29	837	0.31	2621	0.26	1091	0.41	4939	0.49	1602	0.59
2007	**18.9**	1571	0.32	1084	0.52	1430	0.30	664	0.32	1752	0.37	1000	0.49	2831	0.58	1178	0.58
2008	**27.5**	3384	0.43	1595	0.39	2752	0.36	1214	0.31	2581	0.34	1293	0.33	4656	0.58	2508	0.61
2009	**28.9**	2352	0.27	1339	0.39	2361	0.29	1021	0.30	2411	0.28	1219	0.37	4671	0.53	2126	0.63
2010	**22.5**	2330	0.38	1311	0.39	1897	0.32	1018	0.30	2374	0.39	1178	0.36	3452	0.56	2016	0.61
2011	**41.6**	3914	0.36	2228	0.38	5036	0.49	1820	0.32	3536	0.33	1883	0.33	6234	0.56	3671	0.61
2012	**29.9**	2584	0.30	1373	0.45	2753	0.34	1102	0.36	2588	0.30	1191	0.39	5194	0.60	2052	0.65
2013	**19**	1643	0.31	1058	0.49	1612	0.31	697	0.32	2115	0.39	1001	0.45	3307	0.60	1260	0.56
2014	**26.9**	2058	0.28	1225	0.42	2109	0.30	903	0.31	2284	0.32	1135	0.39	4288	0.58	1866	0.62
2015	**18.5**	1603	0.38	822	0.44	1219	0.30	596	0.33	1953	0.47	860	0.48	2628	0.62	976	0.54
2016	**24.1**	1711	0.26	1115	0.50	1903	0.30	699	0.33	2430	0.39	985	0.48	3914	0.59	1234	0.56
AVG 1981-2016	**27.0**	**1693**	**0.21**	**530**	**0.17**	**1619**	**0.21**	**413**	**0.13**	**2124**	**0.28**	**600**	**0.20**	**3278**	**0.43**	**1341**	**0.41**

Table 9. Total sum of Kcfs-days spill at each Middle Columbia River dam by season for each year, as well as the runoff volume (MAF) provided as a relative measure of flow volume among years.

YEAR	Runoff Vol	McNary				John Day				The Dalles				Bonneville			
	Columbia	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	above TDA	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill
	(Jan -July)	∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days	
1981	104.5	6230	0.30	266	0.02	4914	0.22	1022	0.08	4638	0.21	178	0.01	9187	0.42	2236	0.18
1982	134.9	11010	0.41	3096	0.23	9434	0.33	3001	0.22	8749	0.32	2703	0.20	11063	0.39	2207	0.16
1983	123.4	8700	0.37	48	0.00	8980	0.37	2558	0.22	4689	0.20	1338	0.12	6800	0.28	2374	0.20
1984	123.7	10762	0.42	1234	0.12	7978	0.29	2300	0.22	5012	0.19	578	0.06	10792	0.40	842	0.08
1985	90.5	575	0.03	0	0.00	970	0.05	0	0.00	1312	0.08	126	0.02	5271	0.29	82	0.01
1986	112.9	3759	0.18	0	0.00	5017	0.23	571	0.07	5040	0.24	189	0.02	8880	0.41	147	0.02
1987	79.2	1060	0.07	0	0.00	7	0.00	102	0.02	29	0.00	0	0.00	2797	0.19	0	0.00
1988	76.0	0	0.00	0	0.00	126	0.01	141	0.02	0	0.00	0	0.00	2080	0.15	1	0.00
1989	93.2	679	0.04	0	0.00	297	0.02	354	0.06	1087	0.06	292	0.05	5534	0.30	122	0.02
1990	99.7	2740	0.14	71	0.01	2785	0.14	602	0.06	2433	0.12	425	0.04	6832	0.33	996	0.10
1991	107.1	5303	0.25	847	0.08	2872	0.13	910	0.08	3176	0.15	818	0.07	7769	0.35	2610	0.23
1992	70.4	307	0.02	0	0.00	350	0.02	453	0.07	983	0.07	292	0.04	7300	0.48	2546	0.34
1993	88.1	4574	0.25	0	0.00	2645	0.14	609	0.07	4450	0.24	408	0.05	8289	0.43	3783	0.42
1994	75	1494	0.10	159	0.02	558	0.04	419	0.06	3341	0.22	397	0.05	6410	0.41	2780	0.36
1995	104	7611	0.38	423	0.04	693	0.03	319	0.03	10189	0.51	6138	0.60	6888	0.33	5403	0.50
1996	139.3	16650	0.57	4094	0.31	6758	0.22	2231	0.17	16859	0.58	7253	0.56	14296	0.48	5482	0.40
1997	159	21698	0.62	4829	0.33	11630	0.31	2839	0.19	21923	0.61	9102	0.64	18751	0.52	6220	0.42
1998	104.5	9389	0.43	1186	0.11	7116	0.31	2939	0.27	10342	0.46	4856	0.46	8373	0.36	5456	0.49
1999	124.1	10960	0.46	4867	0.34	6403	0.26	3938	0.28	10599	0.43	7871	0.56	8274	0.33	5350	0.37
2000	98	7760	0.39	365	0.04	6274	0.31	3311	0.35	7627	0.38	3688	0.39	7306	0.34	5653	0.57
2001	58.2	163.09	0.02	0	0.00	400	0.04	0	0.00	1263	0.12	1163	0.21	1482	0.13	1281	0.21
2002	103.8	9560	0.43	2015	0.17	6952	0.31	3426	0.29	8107	0.37	4507	0.39	9919	0.44	6724	0.55
2003	87.7	6188	0.33	1	0.00	4661	0.25	2016	0.24	6942	0.37	3159	0.38	9319	0.45	5617	0.57
2004	83	5548	0.33	20	0.00	4560	0.28	2464	0.30	6410	0.38	3227	0.39	7039	0.37	5139	0.52
2005	81.4	5801	0.36	6829	0.67	4465	0.28	2820	0.30	5363	0.34	3598	0.39	6507	0.40	5335	0.55
2006	114.7	13156	0.49	5122	0.50	10361	0.39	2878	0.30	10054	0.39	3713	0.40	9775	0.36	5335	0.53
2007	95.7	8047	0.41	5069	0.50	4880	0.26	2802	0.30	7422	0.40	3675	0.40	7942	0.40	5666	0.57
2008	99.2	11645	0.50	5345	0.50	8088	0.34	3140	0.32	9332	0.41	3944	0.40	11166	0.46	5415	0.50
2009	90.2	9698	0.44	4343	0.49	6794	0.31	2626	0.32	8034	0.38	3174	0.40	9054	0.40	5012	0.58
2010	84.7	8300	0.45	4781	0.50	6406	0.34	2992	0.33	6977	0.39	3484	0.40	8766	0.46	5259	0.55
2011	142.6	18658	0.60	9153	0.56	12763	0.40	5029	0.32	13695	0.44	5943	0.39	16103	0.50	7345	0.46
2012	129.4	15293	0.54	9042	0.55	10781	0.38	5385	0.33	10835	0.40	6035	0.40	11205	0.39	6783	0.42
2013	97.7	10056	0.47	5820	0.51	7550	0.35	3524	0.32	7852	0.39	4015	0.40	8327	0.38	5621	0.51
2014	108.1	11930	0.51	5896	0.50	8435	0.36	3623	0.32	8627	0.39	4198	0.40	9166	0.39	5945	0.52
2015	83.7	5908	0.42	4431	0.50	4656	0.34	2682	0.32	5082	0.40	3026	0.40	7985	0.57	5494	0.65
2016	97.6	8890	0.44	4625	0.50	6735	0.34	2786	0.32	5082	0.40	3026	0.40	8716	0.43	5506	0.62
AVG 1981-2016	101.8	7781	0.34	2610	0.23	5397	0.23	2134	0.20	6765	0.31	2959	0.28	8482	0.38	3938	0.37



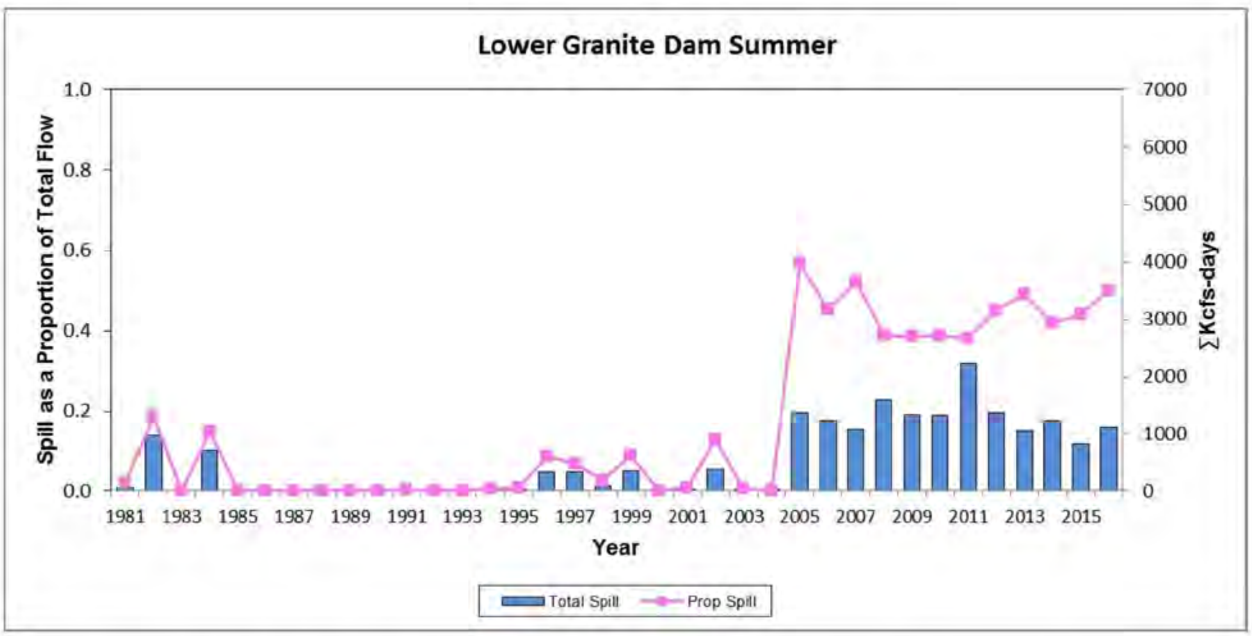
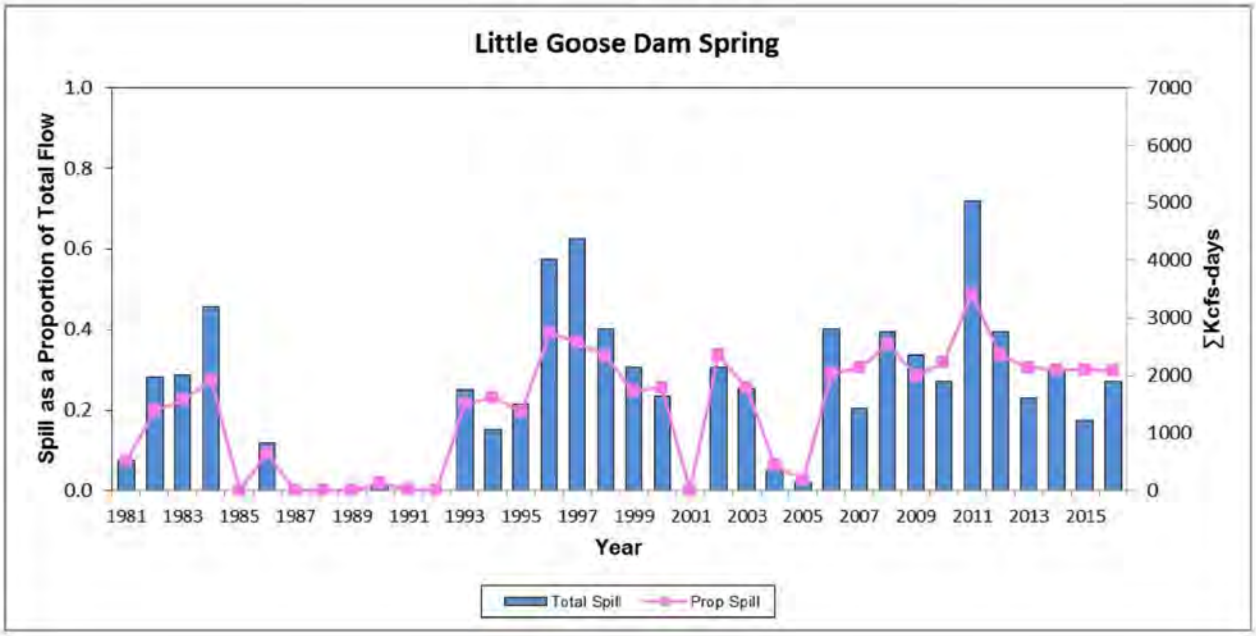


Figure 1. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Granite Dam, and spill as a proportion of total flow for the same time period.



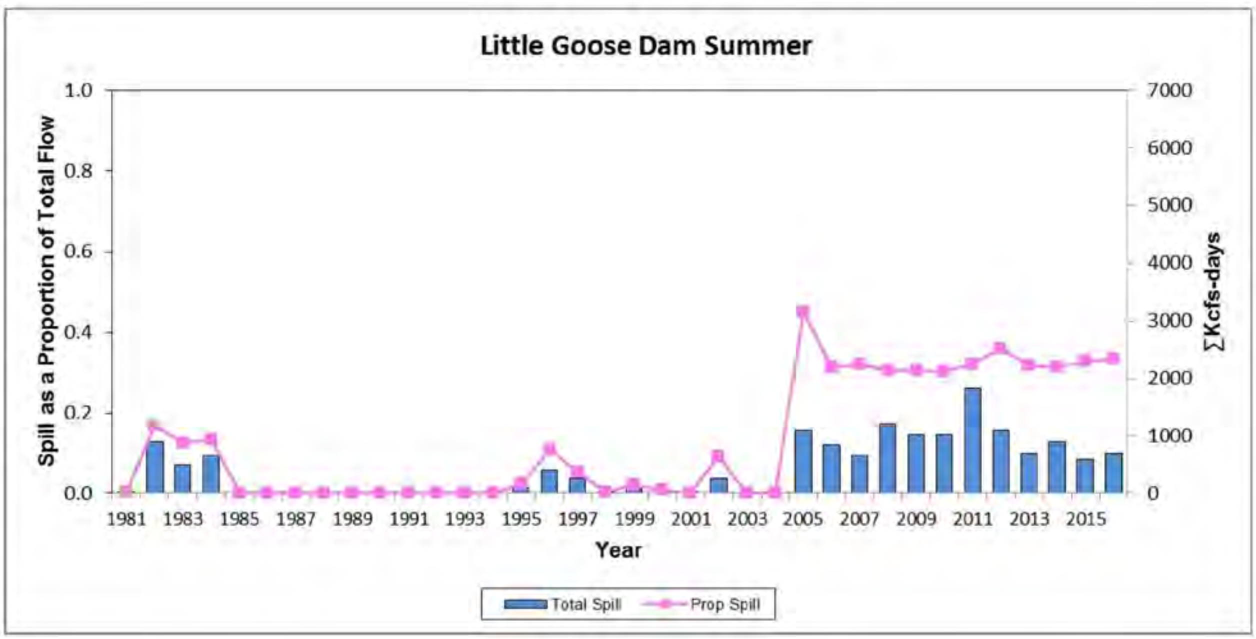
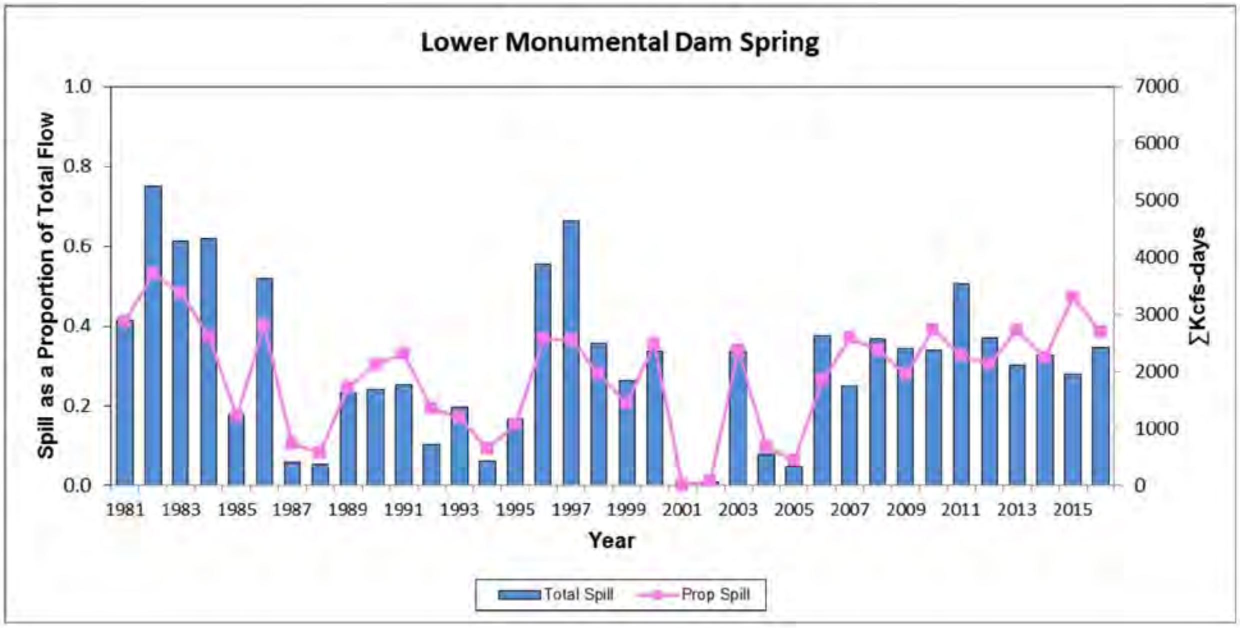


Figure 2. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Little Goose Dam, and spill as a proportion of total flow for the same time period.



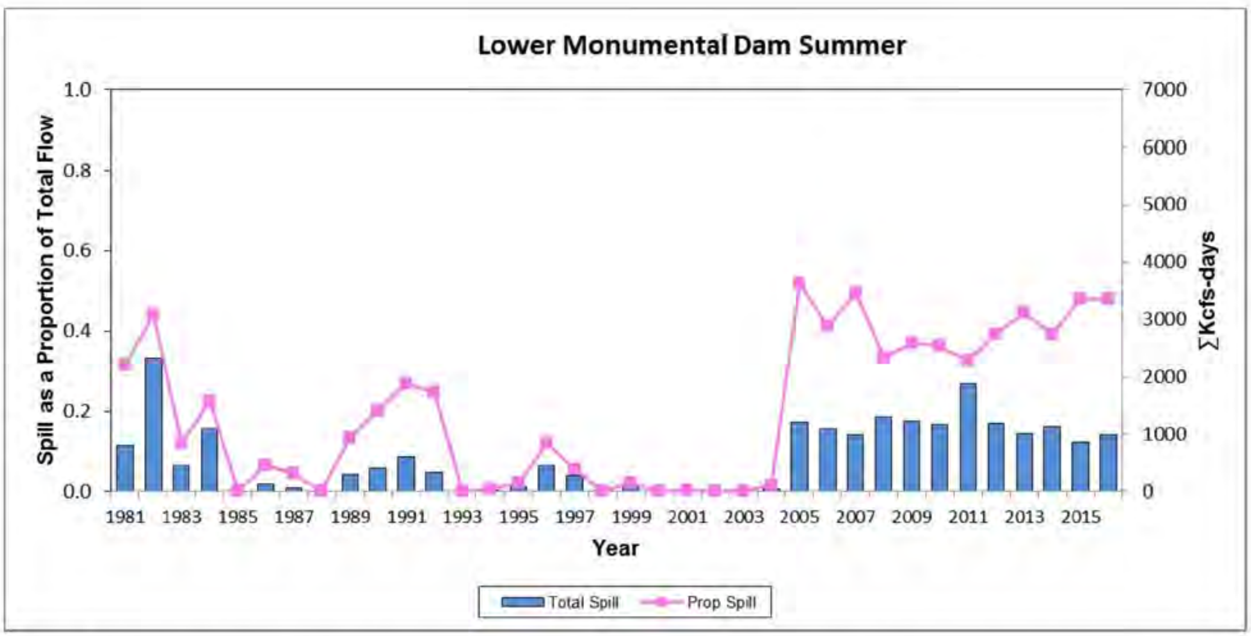
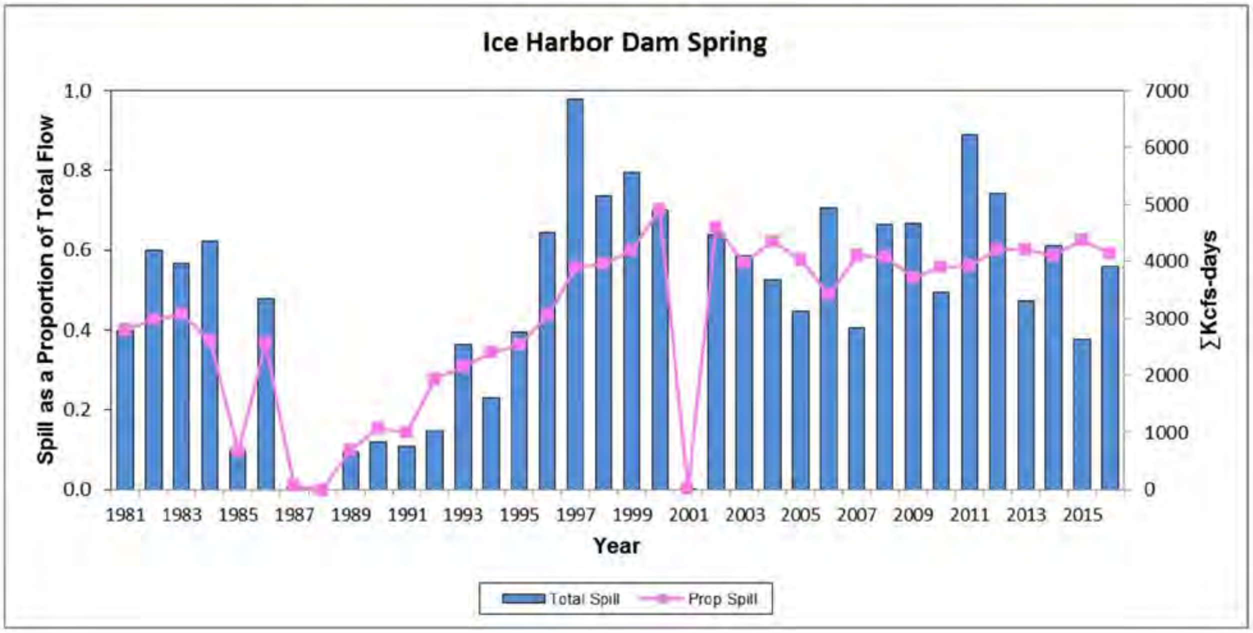


Figure 3. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Monumental Dam, and spill as a proportion of total flow for the same time period.



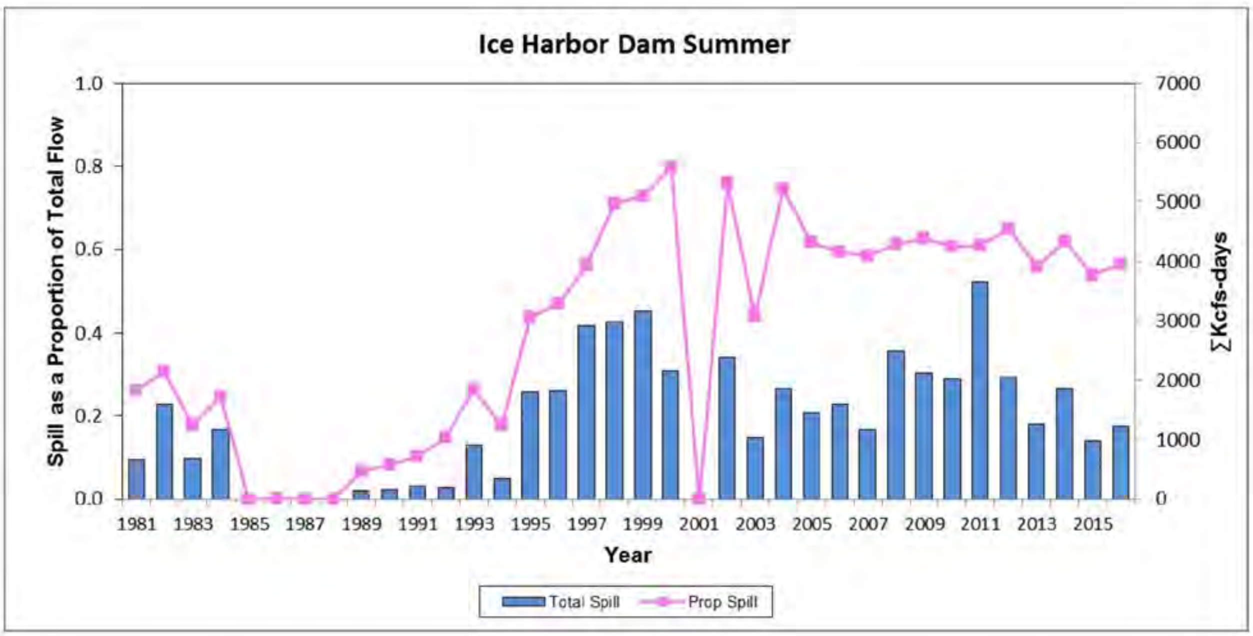
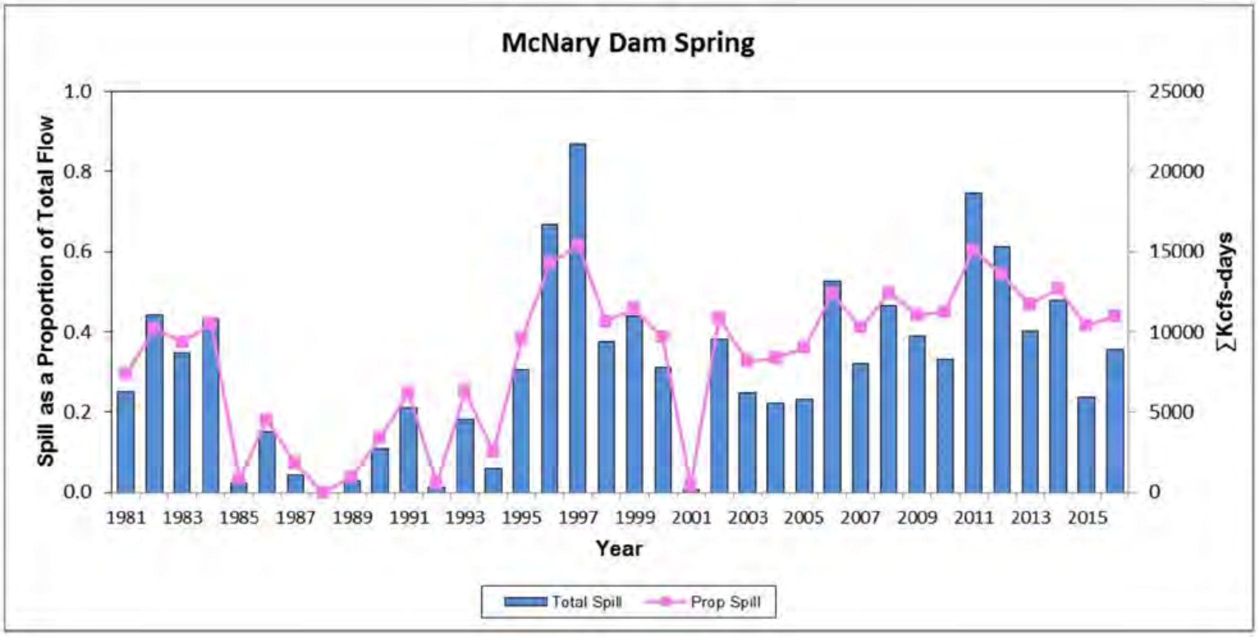


Figure 4. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Ice Harbor Dam, and spill as a proportion of total flow for the same time period.



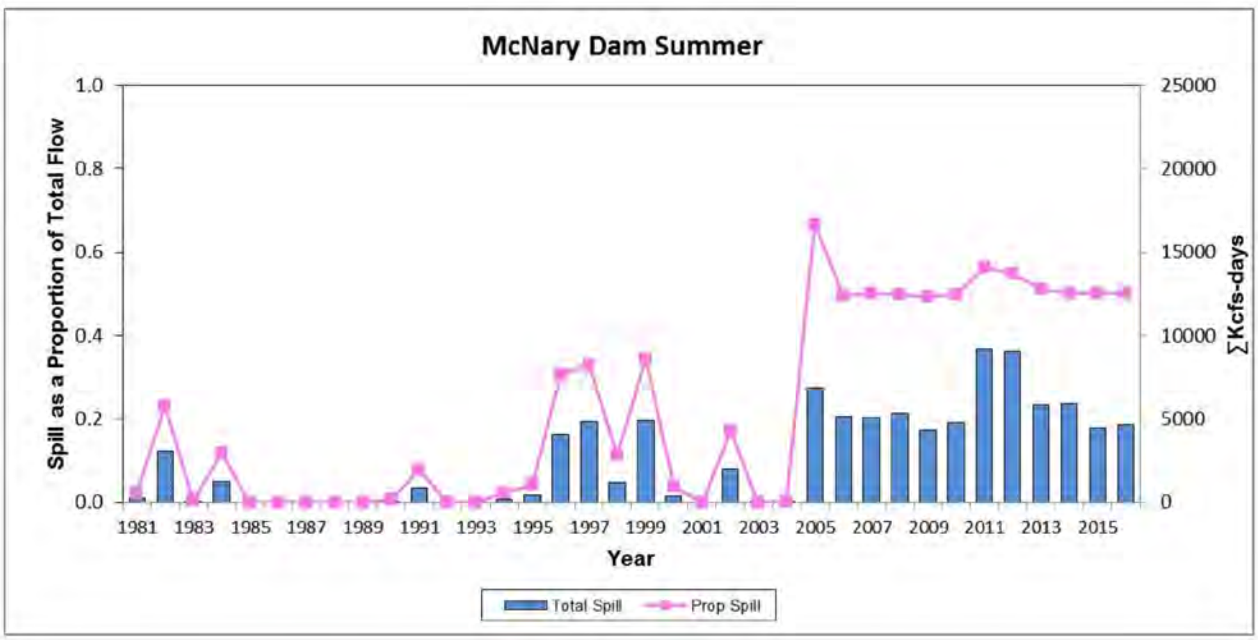
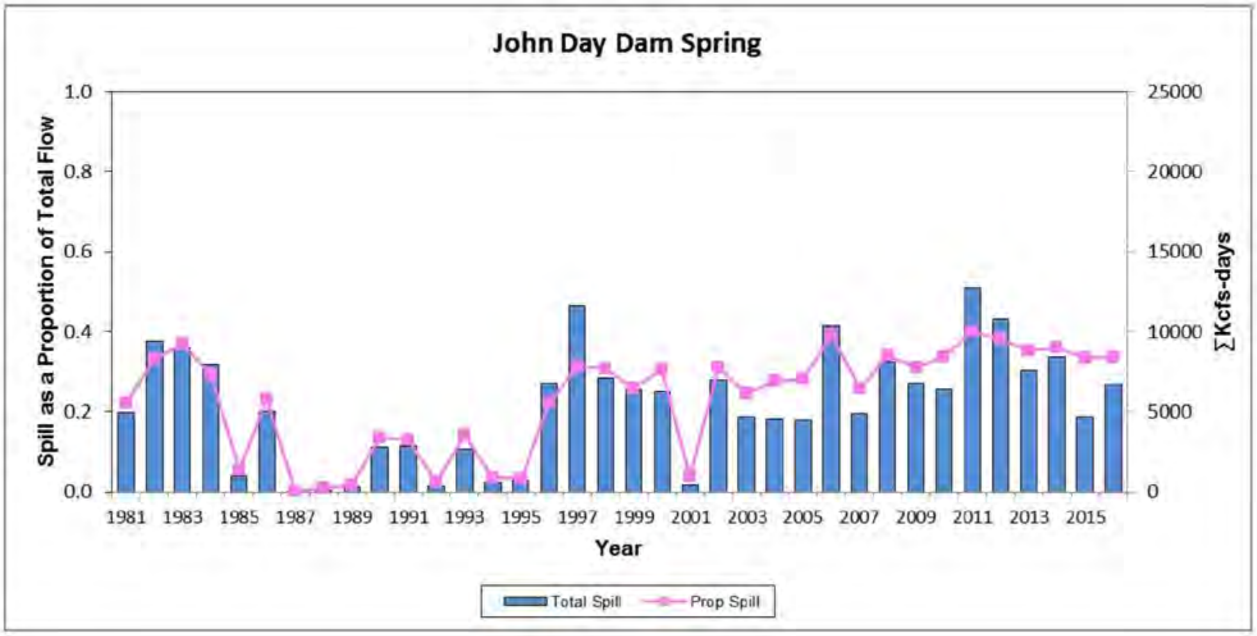


Figure 5. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at McNary Dam, and spill as a proportion of total flow for the same time period.



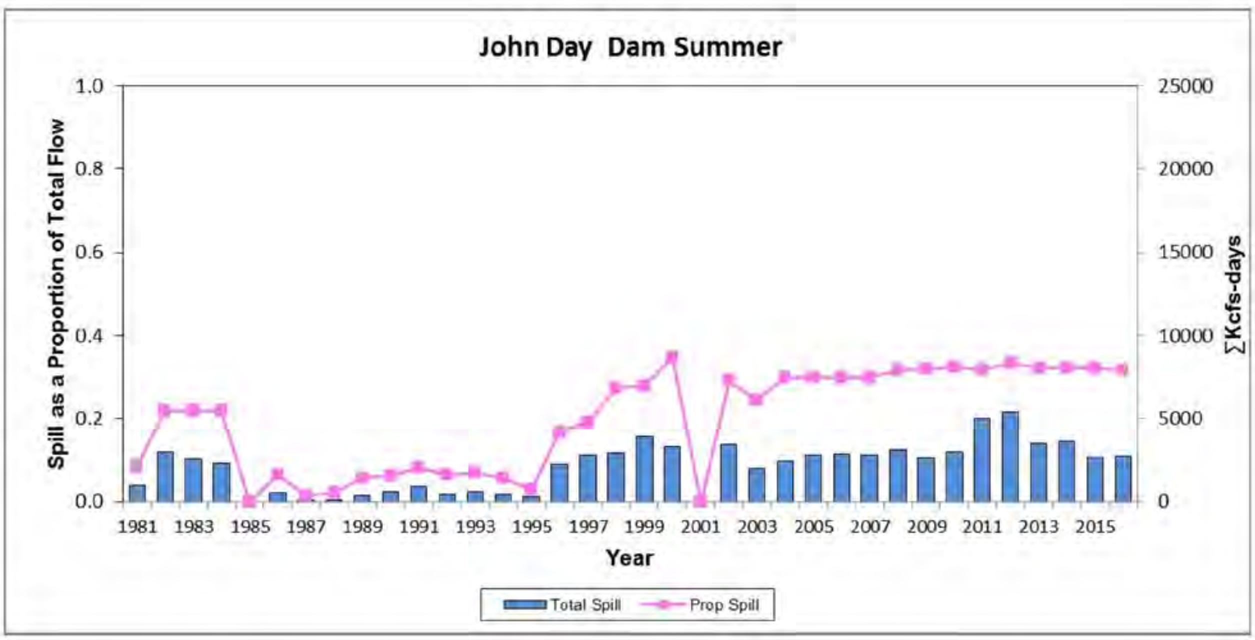
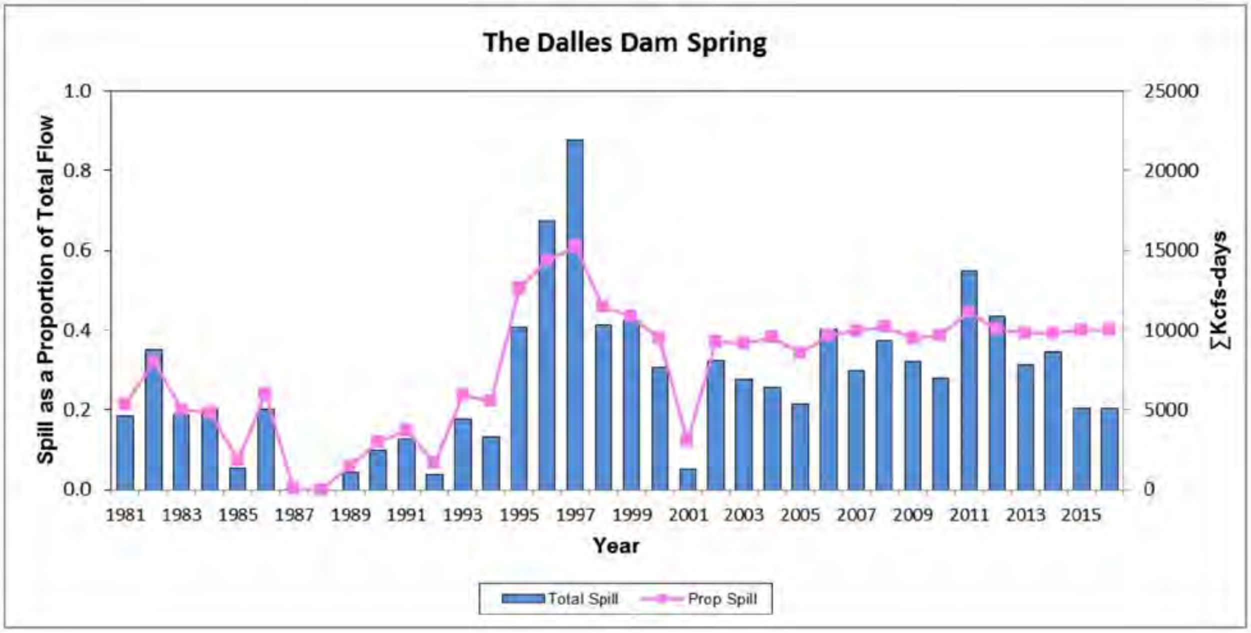


Figure 6. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at John Day Dam, and spill as a proportion of total flow for the same time period.



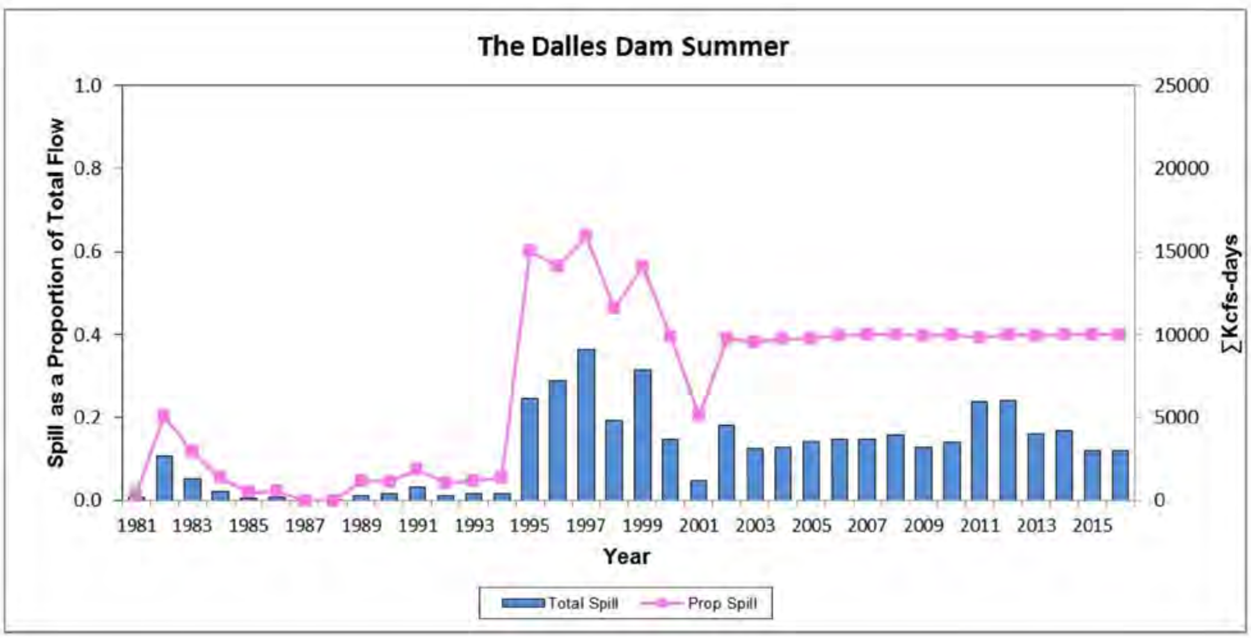
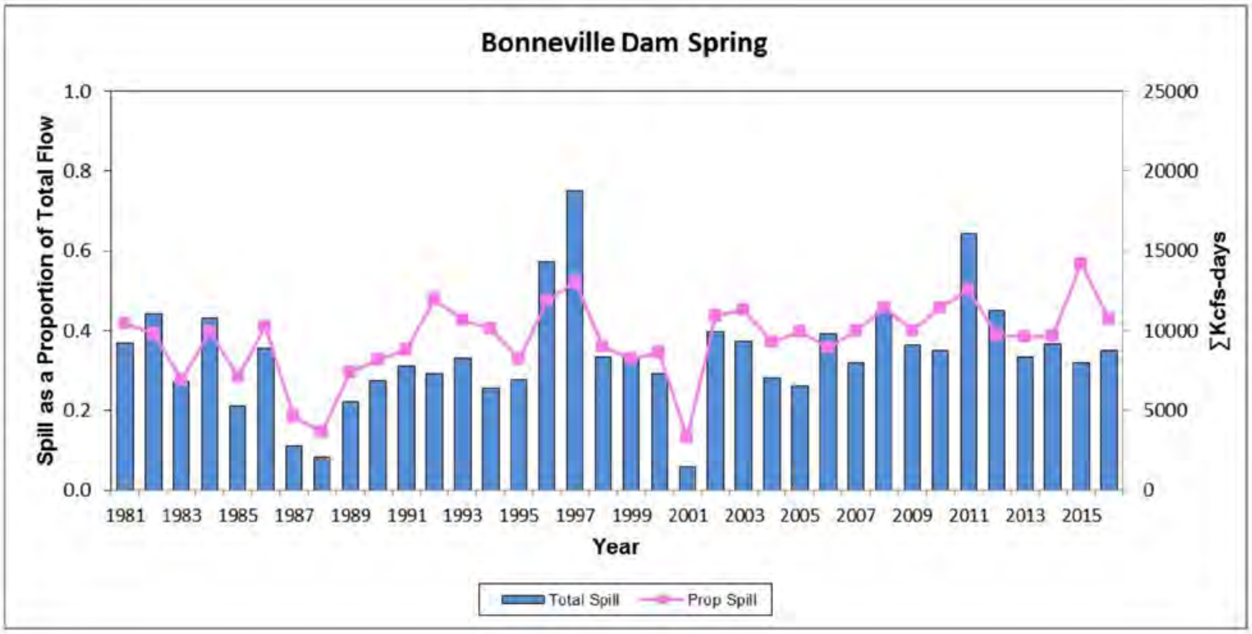


Figure 7. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at The Dalles Dam, and spill as a proportion of total flow for the same time period.



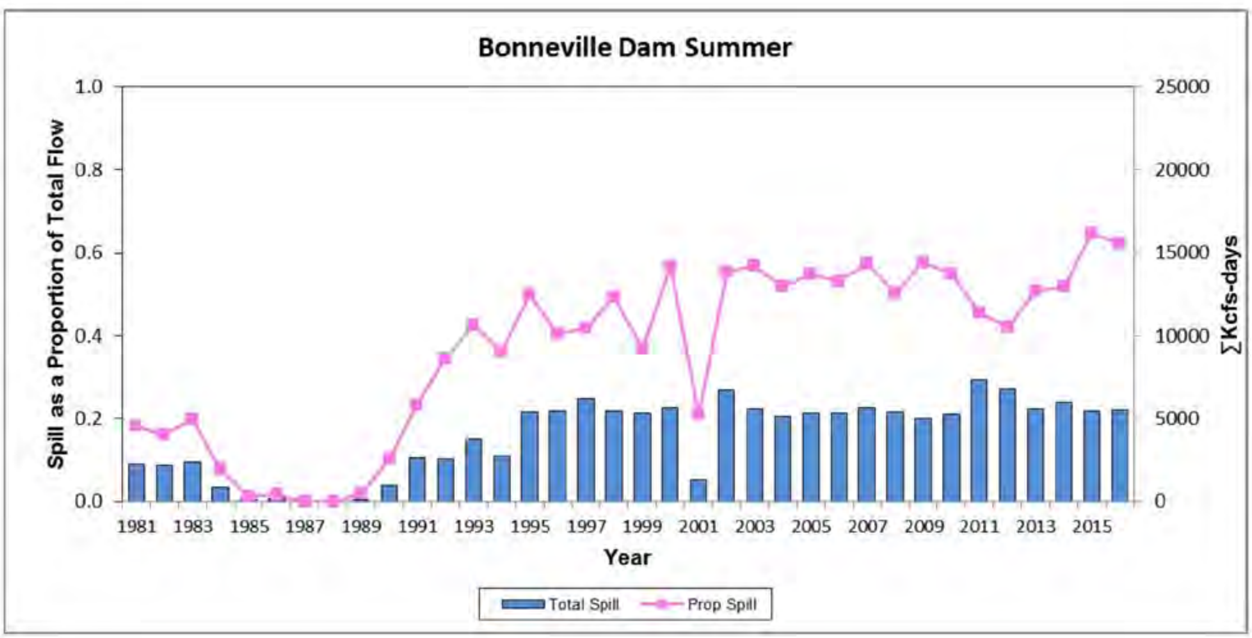


Figure 8. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at Bonneville Dam, and spill as a proportion of total flow for the same time period.

VIII. Summary

From the historic record it is evident that spill has become a more important tool in the recovery of listed stocks. Major modifications to spill over the time period addressed in this compendium include expanding spill to all hydroprojects in the FCRPS; implementing a "spread the risk" transportation policy at transport collector dams by providing spill simultaneously with transport operations; providing spill in low runoff volume years, and the provision of spill during the summer months.

The benefits of spill are outlined in several publications, including: Haeseker et al., 2012; Tuomikoski et al., 2009, 2010, 2011, 2012, 2013; McCann et al., 2014, 2015, 2016; Petrosky and Schaller, 2010; and, Schaller et al., 2014. Some of the recently recognized benefits of spill passage include the following:

- Increasing proportion of spill provided for fish passage at hydroelectric projects has resulted in higher juvenile spring/summer Chinook, fall Chinook, sockeye and steelhead survival and faster juvenile fish travel time through the FCRPS. The addition of the most recent data to the historic CSS time series continues to show the importance of spill and flow for in-river juvenile survival and SARs.

- Increasing spill proportion provides mitigation for low flows through the hydrosystem. In observations of years with similar flow and water travel time, juvenile fish survival and fish travel time are improved in years with higher average spill.

- Spill proportion and water travel time (i.e. flow) are correlated with smolt-to-adult return rate. Increasing spill proportion and faster water travel time (i.e. higher flow) result in higher smolt-to-adult return rate.

- Fresh water passage conditions affect early ocean survival. Spill proportion and water travel time affect ocean survival of Chinook and steelhead.

- Increasing spill proportion allows a higher proportion of downstream migrants to avoid power house passage. Powerhouse passage through juvenile bypass systems decreases smolt-to-adult return rates. The Comparative Survival Study (CSS) has conducted analyses comparing the survival of fish that pass a hydroelectric project undetected at a transportation collection site (C_0) in the Snake River versus fish that have passed through a bypass (C_1) at a collection site. The smolt-to-adult return rates (SARs) indicate that bypassed juvenile Chinook and steelhead appear to have a lower SAR than undetected in-river migrants that did not pass through the powerhouse juvenile bypass system, with the magnitude of those differences varying across years.

- Direct estimates of project survival do not capture the delayed mortality effect of project passage and therefore underestimate project impact on juvenile survival and adult return.

- Model simulations indicate that juvenile survival could be significantly increased and juvenile fish travel time could be decreased by increasing spill proportion in low flow periods.

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Appendix A. Spring and summer migration period spill seasons.

Year	Project	Spring	Summer
1981	LMN	Apr 20 – June 2	na
	IHR	Apr 22 - June 2	na
	JDA	Apr 21 – June 8	na
1982	LMN	Apr 19 – June 4	na
	IHR	Apr 12 - July 18	na
	JDA	May 1 – June 1	na
1983	LMN	Apr 15 – June 15	na
	IHR	Apr 15 – June 15	na
	JDA	May 1 – June 30	July 1 – Sept 1
1984	LMN	Apr 15 – June 15	na
	JDA	May 1 – June 30	July 1 – Aug 29
	BVL	May 1 – June 30	July 1 – July 11
1985	LMN	Apr 10 – June 12	na
	IHR	Apr 17 – June 12	na
	JDA	May 1 – June 14	na
	BVL	May 1 – June 29	July 2 – July 4
1986	LMN	Apr 15 – June 15	June 15 – July 7
	JDA	Apr 15 – June 15	na
	TDA	Apr 15 – June 11	June 15 – Aug 21
	BVL	Apr 15 – June 11	June 15 – Aug 21
1987	LMN	Apr 15 –May 26	June 22-July 7
	JDA	na	July 8 – Aug 14
	BVL	Apr 29 – June 11	na
1988	LMN	Apr 15 – May 29	June 5 – Jun 9
	JDA	na	June 8 – Aug 15
1989	LMN	Apr 15 – May 31	June 11 – July 23
	IHR	Apr 19 – May 31	June 13 – July 23
	JDA	na	June 13 – Aug 22
	TDA	May 9 – June 11	June 13 – Aug 23
	BVL	Apr 7 – Apr 24	June 5-June 22
1990	LMN	Apr 19 – May 31	June 1 – July 23
	IHR	Apr 22 – May 31	June 1 – July 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	Apr 23 – June 6	June 7 – Aug 23
1991	LMN	Apr 20 – May 31	June 1 – July 23
	IHR	Apr 23 – May 31	June 1 – July 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	Apr 15 – June 6	June 7 – Aug 20
1992	LMN	Apr 15 – May 31	June 1 – Aug 15
	IHR	Apr 15 – May 31	June 1 – Aug 22
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23

	BVL	May 1 – June 6	June 7 – Aug 23
1993	IHR	Apr 15 – May 31	June 1 – Aug 31
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	May 1 – June 6	June 7 – Aug 23
1994	IHR	Apr 15 – May 31	June 1 – Aug 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	May 1 – June 6	June 7 – Aug 23
1995	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1996	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1997	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1998	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1999	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
2000 to 2007	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30	July 1 – Aug 31
2008	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) Bonneville April 10 - June 20	July 1 – Aug 31 (except) Bonneville June 21 - Aug 31
2009	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) Bonneville April 10 - June 20	July 1 – Aug 31 (except) Bonneville June 21 - Aug 31
2010	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 10 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 21 - Aug 31
2011	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 10 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 21 - Aug 31
2012	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 15 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 16 - Aug 31
2013	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 15 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 16 - Aug 31
2014 to present	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 15	June 15 – Aug 31

SPILL PRIORITY LIST

Effective 1-APR-2016 until further notice (no later than 31-AUG-2016). [a]

The Spill Priority List defines the project priority order for lack-of-load spill in order to manage TDG on a system-wide basis.

If necessary to spill above FOP rates due to lack-of-load, spill will be allocated to projects in the following priority order.

Priority Order	Project	TDG Cap (%)	Example Spill Caps (kcfs)	
LEVEL 1 (State TDG Standards [a])				
1	LWG	120% / 115%	41	
2	LGS	120% / 115%	40	
3	LMN (bulk)	120% / 115%	28	
4	LMN (uniform)	120% / 115%	36	
5	IHR (night)	120% *	95 [b]	* No downstream forebay standard.
6	IHR (day)	120% *	75 [b]	* No downstream forebay standard.
7	MCN	120% / 115%	146	
8	JDA	120% / 115%	90	
9	TDA	120% / 115%	135	
10	BON	120% *	130	* No downstream forebay standard.
11	CHJ	110%	20	
12	GCL [c]	110%	OT=0; DG=5	
13	DWR	110%	30%	
LEVEL 2				
14	LWG	120%	45	
15	LGS	120%	52	
16	LMN (uniform)	120%	44	
17	MCN	120%	146	
18	JDA	120%	146	
19	TDA	120%	135	
20	CHJ	120% / 115% *	60	* Assumes spill duration ≤6 hrs.
21	GCL [c]	115%	OT=5; DG=15	

[a] Apr 1-Aug 31 (FOP Spring and Summer Spill) TDG standards in effect at LWG, LGS, LMN, IHR, MCN, JDA, TDA, BON for ≤120% in the tailrace (OR, WA) and ≤115% in next downstream forebay (WA), except BON which does not have a downstream forebay standard. Current spill caps are online at: http://www.nwd-wc.usace.army.mil/tmt/documents/ops/spill/caps/

[b] IHR Spill Caps based on: Night 1800-0500 (11 hrs) = FOP spill; Day 0500-1800 (13 hrs) = lack of load spill (>FOP Day 45 kcfs).

[c] GCL spill is via outlet tubes (OT) or drumgates (DG). Transition to DG at forebay elevation 1267-1270 ft.

LEVEL 3 (LEVELS 4-7: same order as LEVEL 3)			
22	LWG	122%	52
23	LGS	122%	59
24	LMN (uniform)	122%	60
25	IHR (night)	122%	95 [b]
26	IHR (day)	122%	85 [b]
27	MCN	122%	152
28	JDA	122%	177
29	TDA	122%	160
30	BON	122%	160
31	CHJ	120%	100
32	GCL [c]	120%	OT=15; DG=40

SPILL PRIORITY LIST Effective May 15 – June 20, 2013

If necessary to spill above FOP spill rates, the Action Agencies will incrementally increase spill at projects in the following priority order. This order is intended to manage TDG on a system-wide basis while prioritizing extra spill in a manner that provides the most benefit to fish passage. *The order of the eleven projects below may be adaptively managed in-season based on TMT feedback and recommendations.*

Level	Priority Order	Project	TDG %	Spill Cap Estimate (kcfs)
LEVEL 1 – up to State TDG Standards [1]	01	LWG	120/115%	41
	02	LGS	120/115%	40
	03	LMN	120/115%	31
	04	IHR	120/115%	95 night / 75 day
	05	MCN	120/115%	175
	06	JDA	120/115%	146
	07	TDA	120/115%	135
	08	BON	120/115%	100
	09	CHJ	110%	25
	10	GCL	110%	0 (OT) or 30 (DG) [2]
	11	DWR	110%	30% of total river flow
LEVEL 2 – removes downstream forebay restriction	12	LWG	120%	45
	13	LGS	120%	52
	14	LMN	120%	44
	15	IHR	120%	95 night / 75 day
	16	MCN	120%	175
	17	JDA	120%	146
	18	TDA	120%	135
	19	BON	120%	120
	20	CHJ	120% [3]	60
LEVEL 3	21	LWG	122%	52
	22	LGS	122%	59
	23	LMN	122%	60
	24	IHR	122%	95 night / 85 day
	25	MCN	122%	185
	26	JDA	122%	177
	27	TDA	122%	160
	28	BON	122%	150
	29	CHJ	120%	115
	30	GCL	115%	5 (OT) or 40 (DG)
LEVEL 4	31	LWG	125%	63
	32	LGS	125%	70
	33	LMN	125%	80
	34	IHR	125%	110
	35	MCN	125%	230
	36	JDA	125%	190

EXHIBIT 4, Page 1 of 2
Declaration of Edward Bowles
Case No. 3:01-CV-00640-SI

Level	Priority Order	Project	TDG %	Spill Cap Estimate (kcfs)
	37	TDA	125%	269
	38	BON	125%	215
	39	CHJ	122%	160
	40	GCL	120%	15 (OT) or 50 (DG)
LEVEL 5	41	LWG	127%	85
	42	LGS	127%	95
	43	LMN	127%	120
	44	IHR	127%	124
	45	MCN	127%	280
	46	JDA	127%	206
	47	TDA	127%	294
	48	BON	127%	234
	49	CHJ	125%	190
	50	GCL	122%	20 (OT) or 60 (DG)
LEVEL 6	51	LWG	130%	90
	52	LGS	130%	125
	53	LMN	130%	180
	54	IHR	130%	145
	55	MCN	130%	321
	56	JDA	130%	250
	57	TDA	130%	360
	58	BON	130%	250
	59	CHJ	127%	250
	60	GCL	125%	25 (OT) or 80 (DG)
LEVEL 7	61	LWG	135%	200
	62	LGS	135%	177
	63	LMN	135%	250
	64	IHR	135%	240
	65	MCN	135%	375
	66	JDA	135%	300
	67	TDA	135%	400
	68	BON	135%	300
	69	CHJ	130%	280
	70	GCL	130%	42 (OT) or 120 (DG)

1. During Fish Passage Season (Apr 1–Aug 31), state TDG standards are ≤120% in the tailrace or ≤115% at the next downstream forebay (whichever is more restrictive) for the eight Lower Snake and Lower Columbia fish passage projects, and ≤110% at all other projects.

2. Spill at GCL is either through outlet tubes (OT) or drum gates (DG), depending on reservoir elevation. Spill through OT produces more TDG. Spill transitions to drum gates at forebay elevation of 1267-1270 feet.

3. CHJ Level 2 spill shaped to 115% in the Wells Dam forebay, up to 120% in the CHJ tailrace, depending on anticipated duration.

CERTIFICATE OF SERVICE

I certify that on January 18, 2017, I served the foregoing CORRECTED DECLARATION OF EDWARD BOWLES IN SUPPORT OF STATE OF OREGON'S MOTION FOR INJUNCTION upon the parties hereto by the method indicated below, and addressed to the following:

DR. HOWARD F. HORTON, Ph.D.
Department of Fisheries & Wildlife
Oregon State University
104 Nash Hall
Corvallis, OR 97331-3803

___ HAND DELIVERY
_X_ MAIL DELIVERY
___ OVERNIGHT MAIL
___ TELECOPY (FAX)
___ E-MAIL
___ E-FILE

s/ Nina R. Englander
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DEPARTMENT OF JUSTICE
TRIAL DIVISION

January 18, 2017

Via U.S. Mail and email to: mary_austad@ord.uscourts.gov

Mary Austad
740 U.S. Courthouse
1000 SW Third Avenue
Portland, OR 97204-2902

Re: *National Wildlife Federation et al. v. National Marine Fisheries Service*
United States District Court Case No. CV01-00640-KI

Dear Ms. Austad:

Enclosed please find a judge's copy of the recently filed Corrected Declaration of Edward Bowles in Support of State of Oregon's Motion for Injunction ("Corrected Bowles Declaration") (ECF No. 2023). The Corrected Bowles Declaration is intended to replace the Declaration of Edward Bowles in Support of State of Oregon's Motion for Injunction ("Bowles Declaration") (ECF No. 2115). Apart from the corrections described below and an explanatory Footnote 1 (which changes the numbering of subsequent footnotes), the Corrected Bowles Declaration makes no other changes to the Bowles Declaration.

The Corrected Bowles Declaration makes the following changes to Table 1 and Table 2 on Page 20 of the Bowles Declaration:

1. In Table 1, "56%" is corrected to read ">60%."
2. In Table 1, "14%" is corrected to read "10%."
3. In Table 1, the word "flow" is inserted after the word "high" in the parentheses that corresponds to "32% (high)."
4. In Table 1, the following sentence is added to the title: "All values are approximated."
5. The redline of the corrected Table 1 therefore reads as follows:

Table 1. Observed SARs since 1998 and model predicted probabilities of achieving SARs <1% and >2% at high, medium and low levels of flow for Snake River spring/summer Chinook under 2014 BiOp spill operations and "Spill Cap" operations requested by Oregon. Flow levels are based on conditions (i.e., hourly flow) in 2009 (medium), 2010 (low), and 2011 (high). [Footnote omitted]. All values are approximated.

Snake River Spring/Summer Chinook		
	<1% SAR	**>2% SAR**
Observed* since 1998	Occurred ~~56%~~ >60% of the time	Occurred ~~14%~~ 10% of the time
Probabilities under 2014 BiOp	47% (high flow) 60% (med. flow) 61% (low flow)	21% (high flow) 12% (med. flow) 12% (low flow)
Probabilities under Spill Cap operations requested by OR	30% (high flow) 35% (med. flow) 28% (low flow)	32% (high flow) 30% (med. flow) 32% (low flow)

*Note that the observed SARs since 1998 include several years (1998 to 2004) where there was no court-ordered spill.

6. In Table 2, the following sentence is added to the title: "All values are approximated."
7. The redline of the corrected Table 2 should therefore read as follows:

Table 2. Observed SARs since 1998 and model predicted probabilities of achieving SARs <1% and >2% at high, medium and low levels of flow for steelhead under 2014 BiOp spill operations and "Spill Cap" operations requested by Oregon. Flow levels are based on conditions (i.e., hourly flow) in 2009 (medium), 2010 (low), and 2011 (high). All values are approximated.

Steelhead		
	<1% SAR	**>2% SAR**
Observed* since 1998	Occurred >60% of the time	Occurred 15% of the time
Probabilities Under 2014 BiOp	32% (high flow) 45% (med. flow) 42% (low flow)	27% (high flow) 26% (med. flow) 15% (low flow)
Probabilities Under Spill Cap operations requested by OR	27% (high flow) 27% (med. flow) 12% (low flow)	48% (high flow) 51% (med. flow) 48% (low flow)

*Note that the observed SARs since 1998 include several years (1998 to 2004) where there was no court-ordered spill.

Respectfully,

s/ Nina R. Englander

Nina Englander, Assistant Attorney General
Sarah Weston, Assistant Attorney General
Of Attorneys for Plaintiff State of Oregon

cc:
all parties (by email)
Howard F. Horton, PhD (by U.S. mail)
enc.

7995304-v1/NE/maf

From: Pisces

Sent: Mon Jan 23 11:37:45 2017

To: Pisces

Subject: Pisces Release at 5pm tonight (1/23/17) - Please wrap up your work & log out prior to then!

Importance: Normal

Good Afternoon Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you have completed your work and are logged out prior to then. The system should be back online by 6pm – we will reach out if anything changes.

There is no new functionality being released to Pisces Web this month, but feel free to reach out with any questions you have. We are excited about making this functionality available for users to explore – and there will be more communication and some training opportunities rolled out gradually. By mid-February, we will share with you a timeline for training to prepare users for the transition to the new environment later this year.

Success tips for managing your contracts in the Pisces Web environment:

· You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!

· We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

· While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do everyday work in Pisces. Future training will support users with tips and tricks for how to be successful

· If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

- For system access, bugs, or feedback on new functionality – email support@cbfish.org.

- For questions about the Pisces Web project – email pisces@bpa.gov.

The Pisces Team

Bonneville Power Administration

This message is going to all Pisces Desktop users and Pisces Web project team

From: David Welch

Sent: Wed Jan 25 10:06:56 2017

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

Cc: Erin Rechisky

Subject: RE: date change.

Importance: Normal

Thanks, Christine

Currently my schedule is pretty open except for February 2nd (Thursday, next week), when Erin and I will be in Vancouver at a meeting.

David

P.S. No sign of the contract as yet—I assume that this was mailed/couriered, as opposed to emailed?

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Wednesday, January 25, 2017 9:46 AM
To: David Welch

Subject: RE: date change.

Hi David,

I think this shows that we are generally aligned in our understanding. I forwarded this to Jeff and Ben. Unfortunately we haven't been able to identify a good time for this phone call yet – this Wednesday morning would have been the best possibility as of last Friday, but unfortunately now Jeff Stier is out all day and hasn't been able to offer a substitute time yet. Expect to be contacted soon though.

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, January 24, 2017 10:33 AM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky
Subject: date change.

Thanks, Christine—

A bit of perspective on how we got to where we are today. When I had originally proposed the work to BPA, I broke the work down into three logical units (with peer-reviewed published research papers as the products) and made my best calculation as to how long it would take to do each of the three. I have pasted in below my original summary (devoid of the detailed calculations) as to who amongst Kintama staff would do what parts of which papers. This was generally agreed to, but last October it was belatedly realized that the source of funds available could not be used to fund all the work (Ben Z will know the details).

A total of $110K was then identified from another source. This amount fits with the 1st paper in the list, which I will call (A-Survival Rates). (b)(5) [redacted]

(b)(5) [redacted]

(C) is an update to the Fraser vs Columbia survival comparison paper published in PLoS Biology in 2008.

As I mentioned briefly on the phone last Friday, it occurred to me that we could probably incorporate important elements of paper (C) into paper (B) and save (at a best guess) half the funds needed for (C) if we did so, because it would become an "add-on" to (B) rather than a full stand-alone paper, and the elements of (B) would be the major focus. We can certainly do either (B) or (B)+(C), but the projected costs will be $162K or $232K to do the work, so more than the available budget. (Projected budgets are higher because none of the work has been done or written up for the study, unlike (A).

We can run through the above material briefly as part of the conference call, but I would suggest sharing at least elements of this email with people first. Ben earlier suggested we can also give a quick update on some work we did in the Fraser River looking at survival and movement speeds of tagged Chinook & sockeye, to give some context to the discussion, and which relates to study component (C).

David

BPA Study Component

Data Synthesis (Collection & Graph/Table Production, initial summary of major findings and explanation of methods)(a)

Report

Full Paper (b)

Total (USD)

(A) Comparison of Ocean & Hydrosystem Survival rates (Target Journal: Science)

Welch, 3 months; Porter, 1 month

$90,650

$ 18,130

$ 108,780

(B) Comparison of SARs & Extension back to beginning of data series (Target Journal: Transactions American Fisheries Society)

4 months of staff work for Aswea, 1 month for Erin, 2 months for Welch

$134,750

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$ 26,950

$ 161,700

(C) Comparative Salmon Survival in Fraser & Columbia Rivers using acoustic tags (Target Journal: PLoS Biology)

2 months of work for Welch, Porter, & Rechisky

$117,600

$ 23,520

$ 141,120

Sub-Totals

$225,400

$45,080

TOTAL

$ 411,600

(a) Professional staff charged at $700/day, Welch @ $1,000/day. Includes an overhead of 22.5%

(b) Time to convert initial to peer-reviewed scientific journal paper estimated at 20% of base cost plus $2K per paper for publication charges

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, January 19, 2017 2:08 PM
To: Erin Rechisky; David Welch
Subject: RE: date change.

Hi,

I didn’t respond last week. A lot of our internal communications were really disrupted by the snowstorm and people not being in the office, plus our manager returned from leave.

(b)(5) [redacted]

What we’re going to do is try to find a time to talk now that all of us are in the office, and I think we are likely to want to call you on the phone. I passed on that you had mentioned that the labor involved in a SARs literature review or Fraser comparison would be larger, (b)(5) [redacted]

In any case, when we try to schedule a call, I think that a reminder for everyone of the initial three paper options would be helpful, and it could be helpful to have ballpark figures for labor? I liked how you laid out the current paper that we put in the contract. Also, for none of these will you just be rehashing your already published Fraser and Columbia survivals, but you are both proposing a new framework for interpretation, plus adding new years of data.

More soon about scheduling.

From: Erin Rechisky [mailto:Erin.Rechisky@kintama.com]
Sent: Wednesday, January 11, 2017 1:46 PM
To: Petersen,Christine H (BPA) - EWP-4; David Welch
Subject: RE: date change.

Thanks Christine. Good luck with all of that snow.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: January 11, 2017 1:16 PM
To: Erin Rechisky; David Welch
Subject: RE: date change.

Hi

I sent a message to Jan asking her to change the dates, and also asking if we'd need to change the contract if you were to choose to include Fraser results. I think we were deliberately keeping the text a bit generalized.

We might be a bit slow to respond this week. It typically only snows once or twice in winter here, but we just got a foot of snow. I will ask Jeff if he would like to discuss this or have Ben or Anne and I call you. ...or not try to change things at this time.

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 1/11/17 12:09 PM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>, David Welch <David.Welch@kintama.com>
Subject: RE: date change.

Hi Christine,

We'd like to change the following end dates all within Work Element C:

- Milestone A: end on July 31
- Milestone B: end on June 30
- Milestone C: end on August 31
- Milestone E: end on August 31

Regarding the top paper priorities, David and I would like to discuss this with you and Ben, and perhaps Jeff as well. Could you set up a conference call? David and I are available for most of this Friday. We could meet anytime between 9 and 4. We are in the office tomorrow as well, but David has an appointment at 10:30 and I leave at about 2:00 on Thursdays.

Also, can you send a link to the news articles about the preliminary injunction you mentioned? Kintama could potentially submit a proposal to monitor smolts but we'd have to start this work ASAP in order to have the proposal reviewed, approved and then order transmitters prior to the outmigration- which might not be feasible at this late date.

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]

Sent: January 11, 2017 11:04 AM
To: Erin Rechisky; David Welch
Subject: RE: date change.

Hi Erin,

Can you tell me which dates you would like to change?

I was just talking to the CO in our procurement group and they are still working through their backlog and there could be a possibility of doing last minute changes.

(b)(5) [redacted]

(b)(5) [redacted]

Also of some interest for you or Ian Brosnan, there was a preliminary injunction asking the judge to require a spill to gas cap experiment this spring...there were some news articles about it yeaterday. It would be hard to design monitoring. Will this high snowpack result in high forced spill levels and high gas like in 2011 anyway?

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 1/11/17 9:49 AM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: date change.

Hi Christine,

I wanted to modify some of the milestones end dates in Pisces but I don't seem to have write permission. Can you give me access or should I tell you what we wanted to change.

Thanks,
Erin

From: David Welch
Sent: December 21, 2016 3:08 PM
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: date change.

Thanks, Christine—Sorry for the delay in responding—just back from my annual meeting with our IT service provider.

This sounds sensible—I will ask Erin to put it on her list to review the dates of the intermediate milestones held in PICES next, after she gets a manuscript off her desk and to our co-authors (by Friday, we are hoping).

I will wait for you to get some feedback on the broader issues of whether a pre-award is possible, and then we can more intelligently discuss the possibilities at that point.

If I don't hear from you before Friday noon, Merry Christmas to you and yours!

Regards, David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Wednesday, December 21, 2016 12:41 PM
To: Erin Rechisky; David Welch

Subject: date change.

Hello,

I changed the dates in the contract in a relatively simple way, moving the start and end dates one month forward. You might want to glance at the intermediate milestone dates describing goals like submitting the paper to a journal.

I will try to raise the question of whether it is in any way possible to do a pre-award agreement which would allow invoicing to the period before the final contract is issued, which is a practice we have for most of our regular Fish and Wildlife program contracts.

Talk to you soon,

Christine P.

From: Douglas,Jan M (BPA) - NSSP-4

Sent: Wed Jan 25 18:01:21 2017

To: david.welch@kintama.com

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

Subject: Contract 75025 from BPA for 1996 017 00 Western River Analysis

Importance: Normal

Attachments: 75025 1996 017 00 (2).pdf

SUBJECT: Contract 75025

Hello David,

Enclosed for your review and acceptance is the subject contract document. Please review the contract document and, if acceptable, sign and promptly return one fully executed signature page to me via email.

Christine Petersen is the Contracting Officer's Technical Representative (COTR) for this contract. You may contact Ms. Petersen at 503-230-44695, or email at chpetersen@bpa.gov. COTR designation letter to follow.

If you have any questions about the contract terms and conditions or administrative procedures, please contact me.

Thank you,

Call Anytime I Will Do My Very Best To Assist!

Jan Douglas (J.D.)

Bonneville Power Administration

Contracting NSSF – 4

jmdouglas@bpa.gov

503 230 4164

UNITED STATES GOVERNMENT

CONTRACT

Mail Invoice To:

fwinvoices@bpa.gov
F & W Invoices - KEWB-4
P. O. Box 3621
Portland OR 97208-3621

Contract : 00075025
Release :
Page : 1

Vendor:
KINTAMA RESEARCH SERVICES LTD
10-1850 NORTHFIELD RD
NANAIMO BC V9S 3B3

Please Direct Inquiries to:

JAN M. DOUGLAS
Title: CONTRACT SPECIALIST
Phone: 503-230-4164
Fax :

Attn: DAVID W WELCH

Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

Total Value : $110,000.00 ** NOT TO EXCEED **
Pricing Method: COST, NO FEE
Payment Terms: % Days Net 30
Performance Period: 02/01/17 – 01/31/18

Contractor Signature	BPA Contracting Officer
Printed Name/Title	Date Signed
Date Signed	

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TABLE OF CONTENTS
CONTRACT NUMBER 75025
TERMS AND CONDITIONS

UNIT 1 — COMMERCIAL

CONTRACT-BASIC TERMS (28-1.1)
(OCT 2014)(BPI 28.3.4)

a) This is a Firm Fixed Price contract for __1__year By signing the contract cover page, BPA and the Contractor agree, subject to the attached terms and conditions, that Contractor shall sell to BPA the Service identified herein at the prices set forth in the Schedule of Pricing and Statement of Work.

b) This contract shall become effective upon receipt of the signed contract and shall continue until the earlier of its expiration or termination pursuant to Clauses 28-9.1 and 28-9.2, Termination for Cause or Clauses 28-10.1 and 28-10.2, Termination for BPA's Convenience. BPA may extend the term of the base contract by exercising the pre-priced option, if any, by giving written notice to the Contractor.

SCHEDULE OF PRICING (28-2)
(JUL 2013)(BPI 28.3.4)

The contractor shall provide the Services at the prices identified in accordance with the table below and the statement of work. Invoices will only be paid for the completed hours of work. Hours of work must not be exceeded. Grand Total Pricing is not guaranteed.

Item No.	Description 2/1/2017-1/31/2018	Qty.	Hours	Unit Price	Totals
	PERSONNEL				
0001	CEO	480	Hours	$125.00	$60,000.00
0002	Data Analyst	163.5	Hours	$88.00	$14,396.00
0003	Research Manager	159	Hours	$88.00	$14,000.00
0004	Research Manager	16	Hours	$ 88.00	$ 1,400.00
	GRAND TOTAL				$88,796.00

INVOICE (28-3)
(JUL 2013) BPI 28.3.4)

(a) The Contractor shall submit an electronic invoice (or one hard-copy invoice, if authorized) to the address designated in the contract to receive invoices. An invoice must include --

(1) Name and address of the Contractor;
(2) Invoice date and number;
(3) Contract number, contract line item number and, if applicable, the order number;
(4) Description, quantity, unit of measure, unit price and extended price of the items delivered;
(5) Shipping number and date of shipment, including the bill of lading number and weight of shipment if shipped on Government bill of lading;
(6) Terms of any discount for prompt payment offered;
(7) Name and address of official to whom payment is to be sent;
(8) Name, title, and phone number of person to notify in event of defective invoice; and
(9) Taxpayer Identification Number (TIN). The Contractor shall include its TIN on the invoice only if required elsewhere in this contract.
(10) Electronic funds transfer (EFT) banking information.

(b) Invoices will be handled in accordance with the Prompt Payment Act (31 U.S.C. 3903) and Office of Management and Budget (OMB) prompt payment regulations at 5 CFR part 1315.

PAYMENT-FIRM FIXED PRICE (28-4.1)
(JUL 2013)(BPI 28.3.4)

(a) Payment.

(1) Items accepted. Payment shall be made for items accepted by BPA that have been delivered to the delivery destinations set forth in this contract.

(2) Prompt Payment. BPA will make payment in accordance with the Prompt Payment Act (31 U.S.C. 3903) and prompt payment regulations at 5 CFR Part 1315.

(3) Electronic Funds Transfer.

(i) Payments under this contract shall be made by electronic funds transfer (EFT). Contractor shall provide its taxpayer identification number (TIN) and other necessary banking information for BPA to make payments through EFT. Receipt of payment information, including any changes, must be received by BPA 30 days prior to effective date of the change. BPA shall not be liable for any payment under this contract until receipt of the correct EFT information from Contractor, nor be liable for any penalty on delay of payment resulting from incorrect EFT information. BPA shall notify the Contractor within 7 days of its receipt of EFT information which it determines to be defective.

(ii) If Contractor assigns the proceeds of this contract per Clause 28-18 Assignment, the Contractor shall require, as a condition of any such assignment, that the assignee agrees to be paid by EFT and shall provide its EFT information as identified in (iii) below. The requirements of this clause shall apply to the assignee as if it were the Contractor.

(iii) Submission of EFT banking information to BPA: The Contractor shall submit EFT enrollment banking information directly to BPA Vendor Maintenance Team, using Substitute IRS Form w9e, Request for Taxpayer Identification Number and Certification, available from the CO or the BPA Vendor Maintenance Team. Contact and mailing information:

Bonneville Power Administration
PO Box 491
ATTN: NSTS-MODW Vendor Maintenance
Vancouver, WA 98666-0491

email: VendorMaintenance@BPA.gov
phone: 360-418-2800
fax: 360-418-8904

(4) Discount. In connection with any discount offered for early payment, time shall be computed from the date of the invoice. For the purpose of computing the discount earned, payment shall be considered to have been made on the date which appears on the payment check or the specified payment date if an electronic funds transfer payment is made.

(5) Overpayments. If the Contractor becomes aware of a duplicate contract financing or invoice payment or that BPA has otherwise overpaid on a contract financing or invoice payment, the Contractor shall:

(i) Remit the overpayment amount to the payment office cited in the contract along with a description of the overpayment including the-

(A) Circumstances of the overpayment (e.g. duplicate payment, erroneous payment, liquidation error, date(s) of overpayment);
(B) Affected contract number and delivery order number, if applicable;

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(C) Affected contract line item or subline item, if applicable; and
(D) Contractor point of contact.

(ii) Provide a copy of the remittance and supporting documentation to the Contracting Officer.

(6) Interest.

(i) All amounts that become payable by the Contractor to BPA under this contract shall bear simple interest from the date due until paid unless paid within 30 days of becoming due. The interest rate shall be the interest rate established by the Secretary of Treasury as provided in Section 611 of the Contracts Disputes Act of 1978 (Public Law 95-563)(41 U.S.C. 7101-7109), which is applicable to the period in which the amount becomes due, as provided in (a)(6)(v) of this clause, and then at the rate applicable for each six-month period as fixed by the Secretary until the amount is paid. (ii) BPA may issue a demand for payment to the Contractor upon finding that a debt is due under the contract.

(ii) Final decision. The Contracting Officer will issue a final decision as required by BPI 21.3.11 if:

(A) The Contracting Officer and the Contractor are unable to reach agreement on the existence or amount of a debt within 30 days;
(B) The Contractor fails to liquidate a debt previously demanded by the Contracting Officer within the timeline specified in the demand for payment unless the amounts were not repaid because the Contractor has requested an installment payment agreement; or
(C) The Contractor requests a deferment of collection on a debt previously demanded by the Contracting Officer.

(iii) If a demand for payment was previously issued for the debt, the demand for payment included in the final decision shall identify the same due date as the original demand for payment.

(iv) Amounts shall be due at the earliest of the following dates:

(A) The date fixed under this contract.
(B) The date of the first written demand for payment, including any demand for payment resulting from a default termination.

(v) The interest charge shall be computed for the actual number of calendar days involved beginning on the due date and ending on—

(A) The date on which the designated office receives payment from the Contractor;
(B) The date of issuance of a BPA check to the Contractor from which an amount otherwise payable has been withheld as a credit against the contract debt; or
(C) The date on which an amount withheld and applied to the contract debt would otherwise have become payable to the Contractor.

INSPECTION/ACCEPTANCE-FIRM FIXED PRICE (28-5.1)
(JUL 2013)(BPI 28.3.4)

The Contractor shall only tender for acceptance those items that conform to the requirements of this contract. BPA reserves the right to inspect or test any supplies or services that have been tendered for acceptance. BPA may require repair or replacement of nonconforming supplies or re-performance of nonconforming services at no increase in contract price. If repair/replacement or re-performance will not correct the defects or is not possible, BPA may seek an equitable price reduction or adequate consideration for acceptance of nonconforming supplies or services. BPA must exercise its post-acceptance rights:

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(a) within a reasonable time after the defect was discovered or should have been discovered; and

(b) before any substantial change occurs in the condition of the item, unless the change is due to the defect in the item.

CHANGES (28-6)
(JUL 2013)(BPI 28.3.4)

Changes in the terms and conditions of this contract may be made only by written agreement of the parties.

STOP WORK ORDER (28-7)
(JUL 2013)(BPI 28.3.4)

(a) The Contracting Officer may, at any time, by written order to the Contractor, require the Contractor to stop all, or any part, of the work called for by this contract for a period of 90 days after the order is delivered to the Contractor, and for any further period to which the parties may agree. The order shall be specifically identified as a stop work order issued under this clause. Upon receipt of the order, the Contractor shall immediately comply with its terms and take all reasonable steps to minimize the incurrence of costs allocable to the work covered by the order during the period of work stoppage. Within a period of 90 days after a stop work order is delivered to the Contractor, or within any extension of that period to which the parties shall have agreed, the Contracting Officer shall either—

(1) Cancel the stop work order; or

(2) Terminate the work covered by the order as provided in the Termination for BPA's Convenience clause of this contract.

(b) If a stop work order issued under this clause is canceled or the period of the order or any extension thereof expires, the Contractor shall resume the work. The Contracting Officer shall make an equitable adjustment in the delivery schedule or contract price, or both, and the contract shall be modified, in writing, accordingly, if—

(1) The stop work order results in an increase in the time required for, or in the Contractor's cost properly allocable to, the performance of any part of this contract; and

(2) The Contractor asserts its right to the adjustment within 30 days after the end of the period of work stoppage; provided, that, if the Contracting Officer decides the facts justify the action, the Contracting Officer may receive and act upon the claim submitted at any time before final payment under this contract.

(c) If a stop work order is not canceled and the work covered by the order is terminated for the convenience of BPA, the Contracting Officer shall allow reasonable costs resulting from the stop work order in arriving at the termination settlement.

(d) If a stop work order is not canceled and the work covered by the order is terminated for cause, the Contracting Officer shall allow, by equitable adjustment or otherwise, reasonable costs resulting from the stop work order.

FORCE MAJEURE/EXCUSABLE DELAY (28-8)
(JUL 2013)(BPI 28.3.3.6)

The Contractor shall be liable for default unless nonperformance is caused by an occurrence beyond the reasonable control of the Contractor and without its fault or negligence such as, acts of God or the public enemy, acts of the Government in either its sovereign or contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, unusually severe weather, and delays of common carriers. The Contractor shall notify the Contracting Officer in writing as soon as it is reasonably possible after the commencement of any excusable delay, setting forth the full particulars in connection therewith, shall remedy such occurrence with all reasonable dispatch, and shall promptly give written notice to the Contracting Officer of the cessation of such occurrence.

TERMINATION FOR CAUSE-FIRM FIXED PRICE (28-9.1)
(JUL 2013)(BPI 28.3.4)

BPA may terminate this contract, or any part hereof, for cause in the event of any default by the Contractor, or if the Contractor fails to comply with any contract terms and conditions, or fails to provide BPA, upon request, with adequate assurances of future performance. In the event of termination for cause, BPA shall not be liable to the Contractor for any amount for supplies or services not accepted, and the Contractor shall be liable to BPA for any and all rights and remedies provided by law. If it is determined that BPA improperly terminated this contract for default, such termination shall be deemed a termination for convenience.

TERMINATION FOR BPA'S CONVENIENCE-FIRM FIXED PRICE (28-10.1)
(JUL 2013)(BPI 28.3.4)

BPA reserves the right to terminate this contract, or any part hereof, for its sole convenience. In the event of such termination, the Contractor shall immediately stop all work hereunder and shall immediately cause any and all of its suppliers and subcontractors to cease work. Subject to the terms of this contract, the Contractor shall be paid a percentage of the contract price reflecting a percentage of the work performed prior to the notice of termination, plus reasonable charges that the Contractor can demonstrate to the satisfaction of BPA using its standard record keeping system, have resulted from the termination. The Contractor shall not be required to comply with the cost accounting standards or contract cost principles for this purpose. This paragraph does not give BPA any right to audit the Contractor's records. The Contractor shall not be paid for any work performed or costs incurred which reasonably could have been avoided.

WARRANTY (28-11)
(JUL 2013)(BPI 28.3.4)(BPI 17.3.7.1)(BPI 17.4.2.1)(BPI 17.2.10.1)

The Contractor warrants and implies that the items delivered hereunder are merchantable and fit for use for the particular purpose described in this contract. All express warranties offered by the Contractor shall be incorporated into this contract.

LIMITATION OF LIABILITY (28-12)
(JUL 2013)(BPI 28.3.4)

Except as otherwise provided by an express warranty, the Contractor shall not be liable to BPA for consequential damages resulting from any defect or deficiencies in accepted items.

DISPUTES (28-13)
(JUL 2013)(BPI 28.3.4)

This contract is subject to the Contract Disputes Act of 1978, as amended (41 U.S.C. 7101-7109). Failure of the parties to this contract to reach agreement on any request for equitable adjustment, claim, appeal, or action arising under or relating to this contract shall be a dispute to be resolved in accordance with the clause at BPI Clause 21-2 Disputes, which is incorporated by reference. The Contractor shall proceed diligently with performance of this contract, pending final resolution of any dispute under the contract.

INDEMNIFICATION (28-14)
(JUL 2013)(BPI 28.3.4)

The Contractor shall indemnify BPA and its officers, employees, and agents against liability, including costs, for actual or alleged direct or contributory infringement of, or inducement to infringe, any United States or foreign patent, trademark, or copyright, arising out of the performance of this contract, provided the Contractor is reasonably notified of such claims and proceedings.

TITLE (28-16)
(JUL 2013)(BPI 28.3.4)

Unless specified elsewhere in this contract, title to items furnished under this contract shall pass to BPA upon acceptance, regardless of when or where BPA takes physical possession.

TAXES (28-17)
(JUL 2013)(BPI 28.3.4)

The contract price includes all applicable Federal, State, and local taxes and duties.

ASSIGNMENT (28-18)
(JUL 2013) (BPI 28.3.4)

The Contractor or its assignee may assign rights to receive payment due as a result of performance of this contract to a bank, trust company, or other financing institution, including any Federal lending agency in accordance with the Assignment of Claims Act (31 U.S.C. 3727). However, when a third party makes payment (e.g. use of a BPA purchase card), the Contractor may not assign its rights to receive payments under this contract.

OTHER COMPLIANCES (28-19)
(JUL 2013)(BPI 28.3.4)

The Contractor shall comply with all applicable Federal, State and local laws, executive orders, rules and regulations applicable to its performance under this contract.

REQUIREMENTS UNIQUE TO GOVERNMENT CONTRACTS (28-20)
(JUN 2016)(BPI 28.3.4)

(a) The Contractor shall comply with the BPI clauses in this paragraph (a) that the Contracting Officer has indicated as being incorporated into this contract by reference to implement provisions of law or Executive Orders applicable to acquisitions of commercial items:
[Contracting Officer check as appropriate.]

____ (1) Certification, Disclosure and Limitation Regarding Payments to Influence Certain Federal Transactions (Clause 3-3)
____ (2) Contractor Policy to Ban Text Messaging While Driving (Clause 15-14)
____ (3) Contractor Employee Whistleblower Rights (Clause 3-10)
____ (4) Printing (Clause 6-2)
____ (5) Utilization of Supplier Diversity Program Categories (Clause 8-3)
____ (6) Buy American-Supplies (Clause 9-3)
____ (7) Restriction on Certain Foreign Purchases (Clause 9-8)
____ (8) Equal Opportunity (Clause 10-1)
____ (9) Affirmative Action for Workers with Disabilities (Clause 10-2)
____ (10) Notification of Employee Rights Under the NLRA (Clause 10-6), see attached text.
____ (11) Equal Opportunity for Veterans (Clause 10-19)
____ (12) Employment Reports on Veterans (Clause 10-20)
____ (13) Child Labor-Cooperation with Authorities and Remedies (Clause 10-24)
____ (14) Combating Trafficking in Persons (Clause 10-25)
____ (15) Subcontracting with Debarred or Suspended Entities (Clause 11-7)
____ (16) Requirements for US Flag Vessel (Clause 14-16)
____ (17) Sustainability:
 ____ Ozone Depleting Substances (Clause 15-7)
 ____ Refrigeration Equipment (Clause 15-8)
 ____ Energy Efficiency in Energy Consuming Products (Clause15-9)

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____ Recovered Materials (Clause 15-10)
____ Bio-Based Materials (Clause 15-11)
____ (18) Acceleration of Payments to Small Business Contractors (Clause 22-21)

(b) The Contractor shall comply with the BPI clauses in this paragraph (b) that the Contracting Officer has indicated as being incorporated into this contract by reference to implement provisions of law or Executive Orders applicable to acquisitions of commercial services:

__x__ (1) Organizational Conflicts of Interest (Clause 3-2)
____ (2) Certification, Disclosure and Limitation Regarding Payments to Influence Certain Federal Transactions (Clause 3-3)
__x__ (3) Contractor Policy to Ban Text Messaging While Driving (Clause 15-14)
_____ (4) Contractor Employee Whistleblower Rights (Clause 3-10)
__x__ (5) Printing (Clause 6-2)
_____ (6) Utilization of Supplier Diversity Program Categories (Clause 8-3)
__x __(7) Restriction on Certain Foreign Purchases (Clause 9-8)
__x__ (8) Equal Opportunity (Clause 10-1)
__x__ (9) Affirmative Action for Workers with Disabilities (Clause 10-2)
__x__ (10) Service Contract Labor Standards (Clause 10-3), see attached text.
____ (11) Fair Labor Standards Act and Service Contract Act-Price Adjustment (Clause 10-4)
____ (12) Notification of Employee Rights Under the NLRA (Clause 10-6); see attached text.
____ (13) Employment Eligibility Verification (Clause 10-18)
____ (14) Equal Opportunity for Veterans (Clause 10-19)
____ (15) Employment Reports on Veterans (Clause 10-20)
____ (16) Contract Work Hours and Safety Standards Act-Overtime Compensation (Clause 10-21)
__x__(17) Combating Trafficking in Persons (Clause 10-25)
__x__(18) Minimum Wage for Federal Contracts (Clause 10-28)
__x__ (19) Subcontracting with Debarred or Suspended Entities (Clause 11-7)
__x__ (20) Sustainability:
__x__ Ozone Depleting Substances (Clause 15-7)
__x__ Refrigeration Equipment (Clause 15-8)
__x__ Energy Efficiency in Energy Consuming Products (Clause 15-9)
__x__ Recovered Materials (Clause 15-10)
__x__ Bio-Based Materials (Clause 15-11)
__x__ (21) Acceleration of Payments to Small Business Contractors (Clause 22-21)
____ (22) Nondisplacement of Qualified Workers (Clause 23-5)

(c) Examination of Records.
(1) The Comptroller General of the United States, an appropriate Inspector General appointed under section 3 or 8G of the Inspector General Act of 1978 (5 U.S.C. app.), the Contracting Officer or authorized representatives thereof shall have access to and right to-
(i) Examine any of the Contractor's or any subcontractors' records that pertain to, and involve transactions relating to, this contract; and
(ii) Interview any officer or employee regarding such transactions.
(2) The Contractor shall make available at its offices at all reasonable times the records, materials, and other evidence for examination, audit, or reproduction, until 3 years after final payment under this contract. If this contract is completely or partially terminated, the records relating to the work terminated shall be made available for 3 years after any resulting final termination settlement. Records relating to appeals under the disputes clause or to litigation or the settlement of claims arising under or relating to this contract shall be made available until such appeals, litigation, or claims are finally resolved.
(3) As used in this clause, records include books, documents, accounting procedures and practices, and other data, regardless of type and regardless of form. This does not require Contractor to create or maintain any record that the Contractor does not maintain in the ordinary course of business or pursuant to a provision of law.

(d) The Contractor shall include the requirements in the following clauses in its subcontracts when these clauses are included in the BPA contract for commercial items or services:

(1) Paragraph (c) Examination of Record of this clause. This paragraph shall be included in all subcontracts, except the authority of the Inspector General under paragraph (c)(2)does not flow down; and

(2) Those clauses contained in this paragraph (d)(2). Unless otherwise indicated below, the extent of the requirement shall be as identified by the clause:

(i) Contractor Employee Whistleblower Rights (Clause 3-10)
(ii) Utilization of Supplier Diversity Program Categories (Clause 8-3), if the subcontract offers further subcontracting opportunities.
(iii) Equal Opportunity (Clause 10-1),
(iv) Affirmative Action for Workers with Disabilities (Clause 10-2)
(v) Service Contract Labor Standards (Clause 10-3).
(vi) Notification of Employee Rights under the National Labor Relations Act (Clause 10-6).
(vii) Employment Eligibility Verification (Clause 10-18), unless subcontracting for commercial items.
(viii) Equal Opportunity for Veterans (Clause 10-19)
(ix) Employment Reports on Veterans (Clause 10-20)
(x) Contract Work Hours and Safety Standards Act (Clause 10-21)
(xi) Child Labor-Cooperation with Authorities and Remedies (Clause 10-24)
(xii) Combating Trafficking in Persons (Clause 10-25)
(xiii) Minimum Wage for Federal Contracts (Clause 10-28)
(xiv) Subcontracting with Debarred or Suspended Entities (Clause 11-7), unless subcontracting for COTS items.
(xv) Acceleration of Payments to Small Business Contractors (Clause 22-21)
(xvi) Nondisplacement of Qualified Workers (Clause 23-5).

(e) Text of clauses incorporated by reference is available at http://www.bpa.gov/Doing%20Business/purchase/Pages/default.aspx

ORDER OF PRECEDENCE (28-21)
(JUL 2013)(BPI 28.3.4)(BPI 17.3.1.1)

Any inconsistencies in this solicitation or contract shall be resolved by giving precedence in the following order:

(a) The Schedule of Pricing.

(b) The Assignments, Disputes, Payments, Invoice, Other Compliances, and Requirements Unique to Government Contracts clauses of this contract.

(c) Solicitation provisions if this is a solicitation.

(d) Other documents, exhibits, and attachments, including any license agreements for computer software.

(e) The specification or statement of work

APPLICABLE LAW (28-22)
(JUL 2013)(BPI 28.3.4)

United States law will apply to resolve any claim of breach of this contract.

UNIT 2 – OTHER CLAUSES

PRIVACY ASSURANCE (5-1)
(FEB 2016)(BPI 5.1.4)

The contractor acknowledges and agrees that, in the course of its contract with BPA, contractor may receive or access personally identifiable information (PII) belonging to BPA. Contractor represents and warrants that its collection, access, use, storage, disposal, and disclosure of PII will comply with all applicable privacy laws and regulations, including the Privacy Act (5 U.S.C. § 552a), the E-Government Act (44 U.S.C. § 101), and DOE regulations (10 CFR § 1008, et seq.). Contractor is responsible for the actions and omissions of its employees for the handling of PII. The contractor agrees not to share PII with any entity not explicitly authorized by the contract. The contractor agrees to report any security breach of PII within 24 hours of discovery of the breach. The contractor shall seek express consent from BPA before storing any PII on data servers, including redundant servers, which reside outside of the United States.

CERTIFICATION OF ELIGIBILITY (10-12)
(OCT 2014) (BPI 10.3.2.3)

(a) By entering into this contract, the Contractor certifies that neither it (nor he or she) nor any person or firm who has an interest in the Contractor's firm is a person or firm ineligible to be awarded Government contracts by virtue of 40 U.S.C. 3144(b)(2) or 29 CFR 5.12(a)(1).

(b) No part of this contract shall be subcontracted to any person or firm ineligible for award of a Government contract by virtue of 40 U.S.C. 3144(b)(2) or 29 CFR 5.12(a)(1).

(c) The penalty for making false statements is prescribed in the U.S. Criminal Code, 18 U.S.C. 1001.

CONTRACT TERMINATION - DEBARMENT (10-26)
(OCT 2014) (BPI 10.3.5.3)

Breach of the following clauses may be grounds for termination of the contract and debarment as a contractor and subcontractor as provided in 29 CFR 5.12: Clause 10-7 Construction Wage Rates Requirements; Clause 10-9 Payrolls and Basic Records; Clause 10-10 Apprentices, Trainees and Helpers; Clause 10-11 Subcontract (Labor Standards); Clause 10-12 Certification of Eligibility; Clause 10-21 Contract Work Hours and Safety Standards Act-Overtime Compensation; and Clause 10-23 Compliance with Copeland Act Requirements.

CONTRACT ADMINISTRATION REPRESENTATIVES (14-2)
(FEB 2016)(BPI 14.3.1)

(a) In the administration of this contract, the Contracting Officer may be represented by one or more of the following: Contracting Officer's Representative for administrative matters, and Contracting Officer's Technical Representative, Receiving Inspector, and/or Field Inspector for technical matters.

(b) These representatives are authorized to act on behalf of the Contracting Officer in all matters pertaining to the contract, except: (1) contract modifications that change the contract price, technical requirements or time for performance; (2) suspension or termination of the Contractor's right to proceed, either for default or for convenience of BPA; and (3) final decisions on any matters subject to appeal, as provided in a disputes clause. In addition, Field Inspectors may not make final acceptance under the contract.

SUBCONTRACTS (14-7)
(SEP 1998)(BPI 14.9.1)

The Contractor shall not subcontract any work without prior approval of the Contracting Officer, except work specifically agreed upon at the time of award. BPA reserves the right to approve specific subcontractors for work considered to be particularly sensitive. Consent to subcontract any portion of the contract shall not relieve the contractor of any responsibility under the contract.

BANKRUPTCY (14-18)
(OCT 2005)(BPI 14.19.1)

In the event the Contractor enters into proceedings relating to bankruptcy, whether voluntary or involuntary, the Contractor agrees to furnish written notification of the bankruptcy to the Contracting Officer responsible for administering the contract. This notification shall be furnished within five days of the initiation of the proceedings relating to bankruptcy filing. This notification shall include the date on which the bankruptcy petition was filed, the identity of the court in which the bankruptcy petition was filed, and a listing of Government contract numbers and contracting officers for all Government contracts against final payment has not been made. This obligation remains in effect until final payment under this contract.

CONTRACTOR SAFETY AND HEALTH (15-12)
(APR 2014)(BPI 15.6.4.1)

a) The Contractor shall furnish a place of employment that is free from recognized hazards that cause or have the potential to cause death or serious physical harm to employees; and shall comply with occupational safety and health standards promulgated under the Occupational Safety and Health Act of 1970 (Public Law 91-598). Contractor employees shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to their own actions and conduct.

(1) All construction contractors working on contracts in excess of $100,000 shall comply with Department of Labor Contract Work Hours and Safety Standards (40 U.S.C. § 3701 et seq.).

(2) The Contractor shall comply with

(i) National Fire Protection Association (NFPA) National Fire Codes for fire prevention and protection applicable to the work or facility being occupied or constructed;

(ii) NFPA 70E, *Standard for Electrical Safety in the Workplace;*

(iii) American Conference of Governmental Industrial Hygiene *Threshold Limit Values for*

Chemical Substances and Physical Agents and Biological Exposure Indices; and,

(iv) Any additional safety and health measures identified by the Contracting Officer.

This clause does not relieve the Contractor from complying with any additional specific or corporate safety and health requirements that it determines to be necessary to protect the safety and health of employees.

(b) The Contractor bears sole responsibility for ensuring that all contractor's workers performing contract work possess the necessary knowledge and skills to perform the work correctly and safely. The Contractor shall make any training and certification records necessary to demonstrate compliance with this requirement available for review upon request by BPA.

(c) The Contractor shall hold BPA and any other owners of the site of work harmless from any and all suits, actions, and claims for injuries to or death of persons arising from any act or omission of the Contractor, its subcontractors, or any employee of the Contractor or subcontractors, in any way related to the work under this contract.

(d) The Contractor shall immediately notify the Contracting Officer (CO), the Contracting Officer's Technical Representative (COTR), and the Safety Office by telephone at (360) 418-2397 of any death, injury, occupational disease or near miss arising from or incident to performance of work under this contract.

(1) The BPA Safety Office business hours are 7:00 AM to 4:00 PM Pacific Time. If the Safety Office Officials are not available to take the phone call the contractor shall leave a voicemail that includes the details of the event, and the Contractor's contact information. The Contractor shall periodically repeat the phone call to the Safety Office until the Contractor is able to speak directly with a BPA Safety Official.

(2) The Contractor shall follow up each phone call notification with an email to SafetyNotification@BPA.gov immediately for any fatality or within 24 hours for non-fatal events.

(3) The Contractor shall complete BPA form 6410.15e Contractor's Report of Personal Injury, Illness, or Property Damage Accident and submit the form to the CO, COTR, and Safety Office within five (5) working days of such an occurrence. The Contractor shall include photographs and witness statements with the report.

(4) In the case of a Near Miss Incident that does not involve injury, illness, or property damage, the Contractor shall complete BPA Form 6410.18e Contractor's Report of Incident/Near Miss and submit the form to the CO, COTR, and Safety Office within five (5) working days of such an occurrence. The Contractor shall include photographs and witness statements with the report.

(e) Notification of Imminent Danger and Workers Right to Decline Work

(1) All workers, including contractors and BPA employees, are responsible for identifying and notifying other workers in the affected area of imminent danger at the site of work. Imminent danger is any condition or practice that poses a danger that could reasonably be expected to cause death or severe physical hardship before the imminence of such danger could be eliminated through normal procedures.

(2) A contract worker has the right to ask, without reprisal, their onsite management and other workers to review safe work procedures and consider other alternatives before proceeding with a work procedure. Reprisal means any action taken against an employee in response to, or in revenge for, the employee having raised, in good faith, reasonable concerns about a safety and health aspect of the work required by the contract.

(3) A contract worker has the right to decline to perform tasks, without reprisal, that will endanger the safety and health of themself or of other workers.

(4) The Contractor shall establish procedures that allow workers to cease or decline work that may threaten the safety and health of the worker or other workers.

(f) BPA encourages all contractor workers to raise safety and health concerns as a way to identify and control safety hazards. The Contractor shall develop and communicate a formal procedure for submittal, resolution, and communication of resolution and corrective action to the worker submitting the concern. The procedure shall 1.) encourage workers to identify safety and health concerns directly to their supervisor and employer using the employer's reporting process; and 2.) inform workers that they may raise safety concerns to BPA or the State OSHA. Workers may notify the Safety Office at (360) 418-2397 if the employer's work process does not resolve the worker's safety and health concern. BPA may coordinate the response to a contractor worker's health and safety concerns with the State OSHA when necessary to facilitate resolution.

(g) BPA employees may direct the contractor to stop a work activity due to safety and health concerns. The BPA employee shall notify the Contractor orally with written confirmation, and request immediate initiation of corrective action. After receipt of the notice the Contractor shall immediately take corrective action to eliminate or mitigate the safety and health concern. When a BPA employee stops a work activity due to a safety and health concern the Contractor shall immediately notify the CO, provide a description of the event, and identify the BPA employee that halted the work activity. The Contractor shall not resume the stopped work activity until authorization to resume work is issued by a BPA Safety Official. The Contractor shall not be entitled to any equitable adjustment of the contract price or extension of the performance schedule when BPA stops a work activity due to safety and health concerns that occurred under the Contractor's control.

(h) The Contractor shall keep a record of total monthly labor hours worked at the site of work. The Contractor shall include a separate calculation of the monthly total labor hours for each subcontractor in the contractor's monthly data. Upon request by the CO, COTR or BPA Safety Office, the Contractor shall provide the total labor hours for a completed month to BPA no later than the 15th calendar day of the following month. The requestor shall identify the required reporting format and procedures.

(i) The Contractor shall include this clause, including paragraph (i) in subcontracts. The Contractor may make appropriate changes in the designation of the parties to reflect the prime contractor--subcontractor arrangement. The Contractor is responsible for enforcing subcontractor compliance with this clause.

INSURANCE (16-2)
(APR 2014)(BPI 16.3.5)

(a) Before commencing work under this contract, the Contractor shall provide to the Contracting Officer certificates of insurance from the insurance company, or an authorized insurance agent, stating the required insurance has been obtained and is in force. The certificate(s) shall identify the Contractor and name BPA as the named insured as follows:

Bonneville Power Administration
Attention: Contracting Officer – Stephanie Green, NSSP-4

The certificate shall also identify the contract number(s) for which coverage is provided. Should any of the policies required by this clause be cancelled before the expiration date thereof, notice will be delivered in accordance with the policy provisions.

(b) Throughout the period of the contract the Contractor shall deliver a new certificate of insurance to the Contracting Officer prior to existing policy expiration, changes, and changes to insurance providers. The Contractor shall notify BPA immediately if at any time any one of Contractor's insurers issues a notice of cancellation for any reason. The Contractor shall provide proof of replacement insurance prior to the effective date of cancellation. A certificate of insurance shall be furnished to BPA confirming the issuance of such insurance prior to Contractor's continuation of access to the Site of work. If the Contractor's insurance does not cover the subcontractors involved in the work, the Contractor shall provide the Contracting Officer with certificates of insurance stating that the required insurance has been obtained by the subcontractors.

(c) The Contractor may, with the approval of the Contracting Officer, maintain a self-insurance program; provided that, with respect to workers' compensation, the Contractor is qualified pursuant to statutory authority.

(d) The following minimum kinds and amounts of insurance are applicable in the performance of the work under this contract. All insurance required by this paragraph shall be in a form and amount and for those periods as the Contracting Officer may require or approve and with insurers approved by the Contracting Officer.

(1) Workers' compensation and employer's liability. Contractors are required to comply with applicable Federal and State workers' compensation and occupational disease statutes. Employer's liability coverage of at least $1,000,000 shall be required. BPA may require Contractors who are individuals (whether incorporated or not) to carry workers' compensation to protect agency interests. The Contracting Officer shall advise the Contractor regarding specific requirements.

(2) Commercial General liability. The contractor shall provide commercial general liability (CGL) insurance of at least $1,000,000 per occurrence. Any policy aggregate limits which apply shall be modified to apply to each location and project. The policy shall name BPA, its officials, officers, employees and agents, as additional insureds with respect to the contractor's performance of

services under the contract. The contractor's policy shall be primary and shall not seek any contribution from any insurance or self-insurance programs of BPA. The Contractor's CGL policy shall be issued on an occurrence basis.

RIGHTS IN DATA—USE OF EXISTING WORK (17-4)
(OCT 2011)(BPI 17.5.4.3.1)

(a) Except as otherwise provided in this contract, the Contractor grants to BPA, and others acting on its behalf, a paid-up non-exclusive, irrevocable, worldwide license to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of BPA, for all the material or subject matter called for under this contract.

(b) Contractor shall defend, at its expense, and hold BPA harmless from any claim or suit brought against BPA alleging that the Work Product furnished hereunder infringes a U.S. patent or copyright, violates trade secrets, rights of privacy, or any libelous or other unlawful matter contained in such Work Product, and shall pay all costs and damages finally awarded, provided Contractor is given prompt written notice of such claim and is given information, reasonable assistance, and sole authority to defend or settle the claim. In the defense of the claim, Contractor shall obtain for BPA the right to continue using the Work Product, replace or modify the Work Product to be non-infringing, or if such remedies are not reasonably available, grant BPA a refund for the work Product and accept its return.

UNAUTHORIZED REPRODUCTION OR USE OF COMPUTER SOFTWARE (23-3)
(SEP 1998)(BPI 23.2)(BPI 17.4.1.1)

The contractor shall hold BPA harmless for unauthorized reproduction or use of copyrighted or proprietary computer software and/or manuals or other documentation by the contractor's employees or subcontractors in the performance of the contract.

ENDANGERED SPECIES ACT REQUIREMENTS (25-9)
(SEP 1998)(BPI 25.1.1)

(a) To the extent requested by BPA, the contractor-agency shall:

  (1) Participate in consultations and conferences conducted under Section 7 of the Endangered Species Act (ESA);
  (2) Obtain, or assist BPA in obtaining permits under Section 10 of the ESA, and
  (3) Provide to BPA all information, materials, documents, records and other assistance requested by BPA for such consultations, conferences, or the acquisition of permits.

(b) The contractor-agency 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 contractor-agency shall comply with conditions identified during consultations and conferences and with the provisions of any requisite permit.

UNIT 3 — STATEMENT OF WORK

1. Statement of Work (9 Pages)

2. SCA Does not apply/ Work performed outside of USA

BPA Contract 75025 Page 16

Statement of Work Report

Data Current as of: 01/18/2017
Report Printed: 01/18/2017

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 ANALYSIS		
Contract #:	CONTRACT 75025		
Province:	Non-Provincial	**Subbasin:**	Basinwide
Workorder ID:	112280	**Task ID:**	1
Perf. Period Budget:	$110,000	**Perf. Period:**	2/1/2017 - 1/31/2018
Contract Type:	Request	**Pricing Type:**	Cost Reimbursement (CNF)
Contractor(s):	Kintama Research (Prime - KINTRESE00)		
BPA Internal Ref:	Contract 75025		
SOW Validation:	Last validated 12/23/2016 with 0 problems, and 0 reviewable items		
Contract Documents:	Budget - Contract (12/22/2016)	Budget Kintama Nov 2016	

Contract Description:

The objective of this contract is to provide novel information to BPA & Action Agencies on comparative fresh water and early marine survival rates of Columbia River spring Chinook populations and publish the analysis and their implications for management in a reputable, high ranking scientific journal.

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. These 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 successfully published in the scientific literature (e.g., Rechisky et al. 2009, Welch et al. 2011, Rechisky et al. 2012, Rechisky et al. 2013, amongst others).

In this contract, Kintama will revisit an analysis which was reported in Kintama's annual report to BPA in 2010, but was not submitted to a journal for publication because it was beyond the scope of the contract. This analysis estimates and compares survival rates (per time or distance) of acoustic-tagged salmon smolts migrating sequentially through the hydrosystem, the undammed lower river and estuary, the Columbia River plume, and the coastal ocean. Modeling survivorship as a rate function will allowed us to control for differences in either segment length or segment water flow rates that exist between habitat types and that would confound results if either affected survival. By comparing survival rates between habitats, rather than absolute survival estimates, we will control for these physical differences

The report will provide important perspective that is currently lacking on the relative rate survival of juvenile Columbia River salmon migrating through the hydrosystem, and should also provide a simple and consistent explanation for why transported smolts do not have substantially improved survival relative to smolts that migrate through the hydrosystem.

BPA-2021-00513-F 0952

Contacts:

Name	Role	Organization	Phone/Fax	Email	Address
Christine Petersen	COTR	Bonneville Power Administration	(503) 230-4695 / NA	chpetersen@bpa.gov	
Peter Lofy	F&W Approver	Bonneville Power Administration	(503) 230-4193 / (503) 230-4563	ptlofy@bpa.gov	905 NE 11th Ave. Portland OR 97232
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
Anne Creason	Interested Party	Bonneville Power Administration	(503) 230-3859 / NA	amcreason@bpa.gov	
David Welch	Supervisor	Kintama Research	(250) 729-2600 223 / (250) 729-2622	david.welch@kintama.com	10-1850 Northfield Road Nanaimo BC V9S 3B3
Erin Rechisky	Contract Manager	Kintama Research	(250) 729-2600 / NA	erin.rechisky@kintama.com	
Jan Douglas	Contracting Officer	Bonneville Power Administration	(503) 230-4164 / NA	jmdouglas@bpa.gov	AB

Work Element Budget Summary:

Work Element - Work Element Title	EC Needed*	Estimate	(%)
A : 185. Produce Pisces Status Report - Periodic Status Reports for BPA		$500	(0 %)
B : 162. Analyze/Interpret Data - Evaluate survival rates of Snake River spring Chinook smolts in four regions		$19,000	(17 %)
C : 183. Produce Journal Article - Impact of Coastal Ocean Survival Rates on Recovery and Management Options for Chinook Salmon		$90,000	(82 %)
D : 119. Manage and Administer Projects - Administer contract		$500	(0 %)
E : 132. Produce (Annual) Progress Report - Submit Progress Report N/A		$0	(0%)
	Total:	$110,000	

* Environmental Compliance (EC) needed before work begins.

Statement of Work Report

Work Element Details

A: 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.

Deliverable Specification:

Work Element Budget: $500.00 (0 %)

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Feb-Jun 2017 (2/1/2017 - 6/30/2017)	7/1/2017	7/15/2017	Inactive	
B. Jul-Sep 2017 (7/1/2017 - 9/30/2017)	10/1/2017	10/15/2017	Inactive	
C. Oct-Dec 2017 (10/1/2017 - 12/31/2017)	1/1/2018	1/15/2018	Inactive	
D. Final Jan 2018 (1/1/2018 - 1/31/2018)	1/17/2018	1/31/2018	Inactive	

B: 162. Analyze/Interpret Data

Title: Evaluate survival rates of Snake River spring Chinook smolts in four regions

Description: We will evaluate a survival rate analysis (survival per unit time or distance) completed under project #2003-114-00 to compare and contrast 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 reanalyze the data, as necessary, and interpret the results. We will also evaluate whether smolts moved out of the FCRPS by management actions such as increasing levels of spill or transport are likely to fare better in the ocean as a result, which is a critical unidentified assumption in current conservation thinking. The report will also attempt to 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.

Deliverable Specification: We will compare and contrast survival rates of Snake River spring Chinook smolts in four regions, evaluate whether smolts moved out of the FCRPS by management actions are likely to fare better in the ocean, and attempt to 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.

Work Element Budget: $19000.00 (17 %)

Planned Metrics:
* Primary R, M, and E Focal Strategy : Hydrosystem
* Primary R, M, and E Type : Uncertainty Research
* Secondary R, M, and E Type : Status and Trend Monitoring
* Secondary R, M, and E Focal Strategy : Estuary/Ocean

Locations:

Primary Focal Species: Chinook - Snake River Spring/Summer ESU

Country:
NPCC Subbasin:
State:
HUC5 Watershed:
County:
HUC6 Name:
Salmonid ESUs Present:

Data Repositories: Columbia Basin Fish & Wildlife Program Projects and Portfolios (http://www.cbfish.org/Report.mvc/SearchPublications/SearchByProjectAndContract)

Protocol: Not Applicable (1989-107-00) v1.0

Protocol Owner: John Skalski **Protocol State:** Draft

Area of Inference:

Name	Value
HUC3 - Basin	Lower Snake
Latitude, Longitude	46.528635, -124.277344
NPPC Provinces	COLUMBIA RIVER ESTUARY
NPPC Subbasins	COLUMBIA LOWER MIDDLE

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Estimate survival rates as necessary and interpret results	2/1/2017	6/1/2017	Inactive	For a group of Snake River spring Chinook smolt that passed between successive sub-arrays, we estimated the probability of survival between these two points using Cormack-Jolly-Seber models and then modeled survivorship as a rate function of either the distance or the elapsed median time to pass from sub-array to sub-array. We will re-evaluate these results as necessary, and express survivorship as the probability of survival for either unit distance traveled or per unit time. Modeling survivorship as a rate function will allow us to control for differences in either segment length or segment water flow rates that exist between habitat types and that would confound results if either affected survival. By comparing survival rates between habitats, rather than absolute survival estimates, we will control for these physical differences. Thus, allowing us to evaluate whether smolts moved out of the FCRPS by management actions such as increasing levels of spill or transport are likely to fare better in the ocean or not as a result, because if ocean survival rates are lower than survival rates in the hydrosystem, moving smolts more rapidly into the ocean could result in reduced overall survival. The report will also attempt to assess 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 by showing how variability in survival occurring during the marine phase of the life history reduces the statistical power of hypothesized relationships between hydrosystem operations and adult return rates (SARS). We will attempt to quantify just how large this additional variability from marine effects likely is, based on our observed survival measurements, and then demonstrate exactly how large correlations between hydrosystem survival and environmental conditions must be in order to preserve acceptable statistical power (normally specified as 80% power).
B. Review, revise, and publish protocol, study design, and methods in monitoringmethods.org	2/1/2017	1/31/2018	Inactive	The Protocol (including temporal and spatial design) and Methods for this work element are stored at monitoringmethods.org and need to be finalized (i.e., "Published" through monitoringmethods.org), preferably prior to data collection. Preparations for contract renewals must include reviewing any previously published Protocols/Methods to ensure that they are consistent with how work will be done in any subsequent contract.
Deliverable: C. Evaluate survival rate analysis		1/31/2018	Inactive	*See the Deliverable Specification above*

C: 183. Produce Journal Article

Title:	Impact of Coastal Ocean Survival Rates on Recovery and Management Options for Chinook Salmon
Description:	Produce a draft manuscript on the Impact of Coastal Ocean Survival Rates on Recovery and Management Options for Chinook Salmon for submission to a peer-reviewed scientific journal for publication, allow time for BPA feedback on management implications, revise and submit to journal.
Deliverable Specification:	Produce a manuscript on the relative survival rates of Snake River spring Chinook salmon smolts entitled: "Impact of Coastal Ocean Survival Rates on Recovery and Management Options for Chinook Salmon" for submission to a peer-reviewed scientific journal for publication.
Work Element Budget:	$90000.00 (82 %)
Planned Metrics:	# of draft scientific reports submitted: 1
Primary Focal Species:	Chinook - Snake River Spring/Summer

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Tech Rpt: BPA Review	3/1/2017	6/30/2017	Inactive	After a draft manuscript is completed, Kintama will provide BPA staff with an opportunity to review and provide feedback on the findings. Any technical comments can be taken into account, but BPA will not require any changes to be made. In order to maintain scientific independence, our request is that BPA staff confine their comments to the application of the scientific findings to management, so that Kintama can identify and expand upon those areas deemed of greatest importance for translating the scientific findings into useful management advice. Kintama staff will retain sole scientific authority over the scientific analysis and publication of the results.
B. Manuscript: Prepare draft	2/1/2017	5/31/2017	Inactive	Prepare draft of manuscript before intra-contractor technical review.
C. Manuscript: Submit to a journal for peer review	3/20/2017	6/30/2017	Inactive	Submit manuscript to Science or other high level journal for review. If the manuscript is not accepted for publication at the first journal, or any additional journals that it is submitted to, Kintama will provide the final draft to BPA for potential publication as gray literature. This may occur after the end date of the contract.
D. Optional travel to conference	2/1/2017	1/31/2018	Inactive	While the manuscript is in review or accepted for publication at a journal, Kintama may opt to present the material at scientific conferences or meetings. The timing of both the review process and conference acceptance make it challenging to commit to attendance at a specific meeting within the contract period so this activity will be considered optional.
Deliverable: E. Produce Journal Article		6/30/2017	Inactive	*See the Deliverable Specification above*

D: 119. Manage and Administer Projects

Title: Administer contract

Description: This is a newly initiated contract that is not expected to be renewed unless additional funding is identified.

Deliverable Specification: All administrative tasks shall be fulfilled on time and with quality products. Timely responses to requests for more information are required. Proactive communication between the contractor and BPA's Contracting Officer (CO) and Contracting Officer Technical Representative (COTR) is required if a significant lag in scheduled delivery is expected.

Work Element Budget: $500.00 (0 %)

Milestone Title	Start Date	End Date	Status	Milestone Description
A. Return signed contract to BPA's Contracting Officer within 30 days	2/1/2017	2/16/2017	Inactive	Respond to the CO and COTR indicating any problems with the contract within 20 days, or return the signed contract to the BPA Contracting Officer (CO) within 30 days.
B. Accrual - Submit September estimate to BPA	8/10/2017	9/10/2017	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. Data must be input in to Pisces by September 10 (begins Aug 10, ends Sep 10).
C. Facilitate inputting Cost Share information into Pisces at the Project level	2/1/2017	11/15/2017	Inactive	(a) I am the sole contractor under this project. I will enter previous federal FY's Cost Share information on the Project's Cost Share tab by Nov 15. (Milestone starts Sep. 30 and ends Nov. 15)
D. Comply with all applicable federal, state, tribal and local safety requirements, including reporting	2/1/2017	1/31/2018	Inactive	As described in the contract's Terms and Conditions, the contract manager and contractor shall comply with all applicable federal, state, tribal and local safety laws, rules, regulations and requirements.
Deliverable: E. All administrative tasks fulfilled with timely quality products		1/31/2018	Inactive	*See the Deliverable Specification above*

E: 132. Produce (Annual) Progress Report

Title: Submit Progress Report N/A

Description: This project will prepare a major manuscript as its primary deliverable, and this should suffice for the reporting requirement

Deliverable Specification:

Work Element Budget: $0.00 (0%)

Planned Metrics: <None>

Inadvertent Discovery Instructions

BPA is required by section 106 of the National Historic Preservation Act (NHPA) to consider the effects of its undertakings on historic properties (16 USC 470). Prior to approving the expenditure of funds or conducting a federal undertaking, BPA must follow the section 106 process as described at 36 CFR 800. Even though BPA has completed this process by the time an undertaking is implemented, if cultural materials are discovered during the implementation of a project, work within the immediate area must stop and the significance of the materials must be evaluated and adverse effects resolved before the project can continue (36 CFR 800.13(b)(3)). The Inadvertent Discovery of Cultural Resources Procedure form outlines the steps to be taken and notifications to be made. If the undertaking takes place on tribal lands (16 USC 470w), BPA must also "comply with applicable tribal regulations and procedures and obtain the concurrence of the Indian tribe on the proposed action" (36 CFR 800.13(d)).

Inadvertent Discovery of Cultural Resources Procedure form:

https://www.bpa.gov/efw/FishWildlife/InformationforContractors/IFCDocuments/InadvertentDiscoveryProcedure.pdf

From: Stier,Jeffrey K (BPA) - E-4

Sent: Thu Jan 26 14:12:52 2017

To: Zelinsky,Benjamin D (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; 'david.welch@kintama.com'; 'erin.rechisky@kintama.com'

Subject: Conf Call: Large Rivers Analysis w/ Kintama

Importance: Normal

This meeting is to discuss revisions to the desired work produced before work is started. Thanks for the voice mail message David, I scheduled an hour and half but it may not take that long.

Jennifer Yarman
(CONTR) Salient CRGT
Lead Secretary | Fish and Wildlife EW-4
Bonneville Power Administration | Department of Energy
bpa.gov | V: 503-230-4981 | F: 503-230-4563 | E: jayarman@bpa.gov
Please consider the environment before printing this email

From: David Welch
Sent: Thu Jan 26 15:03:12 2017
To: Stier,Jeffrey K (BPA) - E-4
Subject: Accepted: Conf Call: Large Rivers Analysis w/ Kintama
Importance: Normal

From: Erin Rechisky
Sent: Fri Jan 27 00:14:15 2017
To: Yarman,Jennifer A (CONTR) - EW-4
Subject: Accepted: Conf Call: Large Rivers Analysis w/ Kintama
Importance: Normal

From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Fri Jan 27 09:43:50 2017

To: Stier,Jeffrey K (BPA) - E-4; Petersen,Christine H (BPA) - EWP-4; 'david.welch@kintama.com'; 'erin.rechisky@kintama.com'

Subject: RE: Conf Call: Large Rivers Analysis w/ Kintama

Importance: Normal

(b)(6) [redacted]

-----Original Appointment-----
From: Stier,Jeffrey K (BPA) - E-4
Sent: Thursday, January 26, 2017 2:13 PM
To: Stier,Jeffrey K (BPA) - E-4; Zelinsky,Benjamin D (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; 'david.welch@kintama.com'; 'erin.rechisky@kintama.com'
Subject: Conf Call: Large Rivers Analysis w/ Kintama
When: Friday, January 27, 2017 10:00 AM-11:30 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Director's Office, Phone Bridge: 503-230-5600, no passcode

This meeting is to discuss revisions to the desired work produced before work is started. Thanks for the voice mail message David, I scheduled an hour and half but it may not take that long.

Jennifer Yarman
(CONTR) Salient CRGT
Lead Secretary | Fish and Wildlife EW-4
Bonneville Power Administration | Department of Energy
bpa.gov | V: 503-230-4981 | F: 503-230-4563 | E: jayarman@bpa.gov

Please consider the environment before printing this email

BPA-2021-00513-F 0962

From: Zelinsky,Benjamin D (BPA) - EWP-4

Sent: Fri Jan 27 10:04:12 2017

To: Stier,Jeffrey K (BPA) - E-4; Petersen,Christine H (BPA) - EWP-4; 'david.welch@kintama.com'; 'erin.rechisky@kintama.com'

Subject: RE: Conf Call: Large Rivers Analysis w/ Kintama

Importance: Normal

(b)(6) [redacted] I'll join when I can.

-----Original Appointment-----
From: Stier,Jeffrey K (BPA) - E-4
Sent: Thursday, January 26, 2017 2:13 PM
To: Stier,Jeffrey K (BPA) - E-4; Zelinsky,Benjamin D (BPA) - EWP-4; Petersen,Christine H (BPA) - EWP-4; 'david.welch@kintama.com'; 'erin.rechisky@kintama.com'
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Bonneville Power Administration | Department of Energy
bpa.gov | V: 503-230-4981 | F: 503-230-4563 | E: jayarman@bpa.gov
Please consider the environment before printing this email

From: chpetersen@bpa.gov

Sent: Mon Jan 30 12:54:48 2017

To: Erin Rechisky

Subject: RE: Outline of change in Kintama contract direction

Importance: Normal

No, it is very good to ask about expected time line and process because we all might ask or review why we came to doing the mod in the first place, and we initially had to work with our finance team to arrange to redirect funds from the closeout of the 15 Mile Steelhead project.

I looked back, and one of the major announcement emails for starting your project managed to leave Jeff Stier's email address off out of the dozen recipients even though he was the one who advocated for soliciting a new proposal. So he had heard Lorri and John were going but didn't see the details. Myself, I can see why it made sense to go forward with the existing contract because it is a compelling topic and we earlier had a certain budget. At the program level, I know that some maneuvering often has to happen, particularly with habitat projects where prices for land and options can be very negotiable.

I will write back later

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>

Date: 1/30/17 12:39 PM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: Outline of change in Kintama contract direction

Right. We needed hear back from Jeff Stier after his meeting with Lorri Bodi. Sorry to put undue pressure on you.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: January 30, 2017 12:35 PM
To: Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction

Let me go find Ben again this afternoon. I just spoke to him earlier about another situation where he is supposed to gather information regarding spring spill.

(b)(5) [redacted]

Ben was going to follow up with Jeff today, but he has an unusual job where he often is outside the building working with other agencies.

More later

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 1/30/17 12:19 PM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Cc: David Welch <David.Welch@kintama.com>
Subject: RE: Outline of change in Kintama contract direction

Hi Christine.

Are we going to hold off on amending the contract for now?

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: January 27, 2017 4:33 PM
To: David Welch; Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction

Thanks,

Jeff Stier is going to try to pull strings for the budget on Monday, and I will try to check in with both Ben and Jeff early next week.

Have a nice weekend!

Christine Petersen

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, January 27, 2017 1:52 PM
To: Stier,Jeffrey K (BPA) - E-4; Petersen,Christine H (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - EWP-4
Cc: Erin Rechisky
Subject: Outline of change in Kintama contract direction

Jeff, Christine, Ben—

Here is an outline of what we would do under the “Course Correction” that we have just discussed. We will entirely change the focus of the work as follows:

(b)(5)

[redacted]

4) Budget implications: The current agreed budget for the work originally planned is $110K. **We will commit to doing the new & expanded focus of the work for a budget of $232K.** (Changing course and doing both #1 & #2 above was originally costed out at $162K and $141K ($303K). If we roll them together into one published paper instead of two we can cut the cost of the #2 component in half).

Regards,

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [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: David Welch
Sent: Tue Jan 31 13:51:35 2017
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction
Importance: Normal

Thanks for the update!

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Tuesday, January 31, 2017 1:51 PM
To: David Welch; Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction

Hi David and Erin,

Jeff Stier asked Lorri Bodi and another administrator for the extra funding – he included your revised paper description for clarify. As of this afternoon, I haven't heard if they found a way to sort out the finance, but they are usually the type to be able to make a quick yes or no decision. They might have had to reach out to our accounting team to find a way to make it happen.

With the contract starting Feb 1., we definitely need to make clear what our expectations are going forward. Tomorrow morning or later this afternoon I will ask Jeff or Ben if they have made any headway, or at least get the status from them.

Thank you for your patience,
Christine Petersen

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Tuesday, January 31, 2017 1:08 PM
To: Petersen,Christine H (BPA) - EWP-4; Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction

Hi Christine-

Just checking in as to whether there was any formal decision about the change in focus within the contracted work? Erin and I are in the office tomorrow (Wednesday) but then over in Vancouver at the university for Thursday & Friday if there is a need to discuss next steps.

(I'm here for the next 30 minutes or so, but then will be out and (eventually) working from home—I [redacted] (b)(6)

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, January 27, 2017 4:33 PM

To: David Welch; Erin Rechisky
Subject: RE: Outline of change in Kintama contract direction

Thanks,

Jeff Stier is going to try to pull strings for the budget on Monday, and I will try to check in with both Ben and Jeff early next week.

Have a nice weekend!

Christine Petersen

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, January 27, 2017 1:52 PM
To: Stier,Jeffrey K (BPA) - E-4; Petersen,Christine H (BPA) - EWP-4; Zelinsky,Benjamin D (BPA) - EWP-4
Cc: Erin Rechisky
Subject: Outline of change in Kintama contract direction

Jeff, Christine, Ben—

Here is an outline of what we would do under the "Course Correction" that we have just discussed. We will entirely change the focus of the work as follows:

(b)(5)

[redacted]

4) Budget implications: The current agreed budget for the work originally planned is $110K. **We will commit to doing the new & expanded focus of the work for a budget of $232K.** (Changing

course and doing both #1 & #2 above was originally costed out at $162K and $141K ($303K). If we roll them together into one published paper instead of two we can cut the cost of the #2 component in half).

Regards,
David

David Welch, Ph.D.
kintamav_RGB

President, Kintama Research Services Ltd.
Nanaimo, BC, Canada
Office: (250) 729-2600 Mobile: [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/

Please consider the environment before printing this e-mail

From: Salmon Ocean Ecology

Sent: Wed Feb 01 09:56:25 2017

To: alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; camfresh@uvic.ca; campblac@dfw.wa.gov; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chrys.Neville@dfo-mpo.gc.ca; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; david.huff@noaa.gov; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; dower@uvic.ca; dstormer@uvic.ca; ebeamer@skagitcoop.org; ed.farley@noaa.gov; elan.downey@cahs-bc.ca; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erik.Neatherlin@dfw.wa.gov; erin.rechisky@kintama.com; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; gruggerone@nrccorp.com; hans@pgst.nsn.us; Eric Hertz; Ian.Perry@dfo-mpo.gc.ca; ibeveridge@lgl.com; ikemp@lltk.org; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; Jackie.King@dfo-mpo.gc.ca; jamal.moss@noaa.gov; jclark@ak.net; Jeff Rutter; jeanette.gann@noaa.gov; jen.zamon@noaa.gov; jenkins@psc.org; jennifer.gosselin@noaa.gov; Jessica Miller; jgmusslewhite@fs.fed.us; jgw3@uw.edu; jim.murphy@noaa.gov; Jessica Holden; Julie Keister; joe.orsi@noaa.gov; Joshua.Chamberlin@noaa.gov; Joshua Russell; journey@uw.edu; jpkarnezis@bpa.gov; juanes@uvic.ca; kathryn.sobocinski@noaa.gov; Katrina Cook; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; kym.jacobson@noaa.gov; Lance.Campbell@dfw.wa.gov; Mike lapointe; Laura Kennedy; laurie.weitkamp@noaa.gov; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org; mara.zimmerman@dfw.wa.gov; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; Matt Miller; mckinnell@shaw.ca; mcrewson@tulaliptribes-nsn.gov; megan.moore@noaa.gov; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; meredith.journey@noaa.gov; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; moore.jed@nisqually-nsn.gov; mschmidt@lltk.org; Megan McPhee; ndavis@npafc.org; neala.kendall@dfw.wa.gov; nick.leone@dfo-mpo.gc.ca; Paige Borrett; pearsalli@psf.ca; Amy Teffer; rabeamish@shaw.ca; ralexander@lgl.com; raphael.girardin@noaa.gov; rick.brodeur@noaa.gov;?rmflagg@uvic.ca; Sandra.ONeill@dfw.wa.gov; sarah.ballard@noaa.gov; Scott Hinch; sean.hayes@noaa.gov; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; sue.grant@dfo-mpo.gc.ca; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov; whitney.friedman@noaa.gov; willduguid@hotmail.com; David Welch;

john.kocik@noaa.gov; cbyron@une.edu; pete.lawson@peak.org; tcwainw@gmail.com; lynne.krasnow@noaa.gov; potoole@nwcouncil.org

Subject: REMINDER - Register, book your hotel and submit abstracts for the 2017 Salmon Ocean Ecology Meeting!

Importance: Normal

This is a reminder to register for the 18th Annual Salmon Ocean Ecology Meeting! Please also consider reserving your hotel room ASAP as we don't have a room block, and rooms fill up here in the big city. Finally, The deadline to submit your abstract is February 17th! Original message with the relevant links is below.

NOAA Employees, please use your travel card for registration, as lunches are provided.

The meeting will be held March 22-23 at the Landing at Tyee on Lake Union in Seattle, Washington. A pre-meeting workshop will also occur on March 21st, for a focused, small-group discussion on salmon prey and competition. To register for the meeting and optional workshop, please visit http://salmonoceanecology2017.-brownpapertickets.com/. Meeting registration will close Friday, March 10th.

For information about nearby hotels and submitting abstracts, please visit the meeting website at https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

The abstract deadline is February 17th. Also, please reserve your hotel room early to ensure you have a spot near the meeting location. No room blocks could be held for this meeting. Most of the hotels listed are within a short walking distance. They are listed in order of proximity to the meeting on the web site.

Thank you,

The 2017 SOEM Organizing Committee

From: David Welch

Sent: Fri Feb 03 13:33:44 2017

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

Subject: RE: Will call...

Importance: Normal

(b)(6) [redacted] but the snow is scheduled to continue here until then!

Will call—got your msg from last night too, but we've been in meetings.

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, February 03, 2017 1:32 PM
To: David Welch; Erin Rechisky
Subject: RE: Will call...

Yes – that will work fine. I owe you a status update, but there is not that much information to pass on. Basically, there will be a more substantive meeting next week where our staff will go into our budget for technical services and I will get more information at that point about actually moving additional funds into your contract. However, we could take some initial steps to modify the statement of work.

Here were are seeing freezing rain.

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, February 03, 2017 1:29 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: Will call...

Hi Christine—

Erin and I are in the middle of the Strait of Georgia, trying to get back from a meeting in Vancouver. (It's snowing here and all float plane flights are grounded).

I will give you a call about 3 PM if that works for you… does it?

Best, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: (b)(6) [redacted]

Skype: david.welch.kintama

david.welch@kintama.com

www.kintama.com

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

P Please consider the environment before printing this e-mail

From: David Welch

Sent: Fri Feb 03 17:21:37 2017

To: Douglas,Jan M (BPA) - NSSP-4

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

Subject: RE: Contract 75025 from BPA for 1996 017 00 Western River Analysis

Importance: Normal

Attachments: BPA-Signed Contract Page 1 (26 Jan 2017).pdf

Hello, Jan & Christine—

I have reviewed the contract, and have two comments to make:

1) [**See Section 28-4.1(a)(3)—Requirement for Electronic Funds Transfer**]. It is hard to believe, but the US & Canadian banking systems are still not electronically compatible. I emailed Kintama's accounts manager at our bank, but the long and short of it is that countries' one banking system uses an 8-digit e-transfer code and the other system uses 9 digits… and the 8-digit system cannot simply pad out the transfer code with a "leading zero" to make the two systems compatible. So, a direct electronic funds transfer (EFT) doesn't work. It used to be that we had to get special dispensation to have paper cheques cut at the San Francisco Treasury Department and mailed to Canada, but there seems to be some progress in the last 5 or 6 years. My bank has provided instructions for what "seems to work", which I have pasted in below, along with our Canadian Bank officer's contact info.

2) Allocation of time. Given the changes contemplated in the work focus, I would like to have some greater flexibility to re-allocate time expended for Erin & Aswea on this project and reduce mine if appropriate. As we are now looking to modify the amount of work (& the work focus) within this contract, we can either change this now or simply ask for an amendment keeping to the new price but requesting the ability to vary the allocation of time spent by various staff on the project, if appropriate. Is this reasonable?

Regards, David Welch

Ok, wire transfers. Let me start by saying that it is not a straightforward process. Banks in the US have their own agreements with international organizations, and what works for one bank may not work for another. Below are the instructions that seem to work most of the time. You can cut and paste the following to your contact at the DOE. One caveat – it's against our privacy policy to email an account #; you'll have to paste that (and your company name/address) into the info below. (You can also give them my contact info if there is an issue.

Cheers – Scott

When sending money from the USA:

Do NOT use 'CIBCCATT' as the swift code. Instead, send as a 'Fedwire payment' to Bank of America - treat it as a domestic payment and not international.

Beneficiary Bank (BBK): (swift F57 - account with institution)

[redacted]

Canadian Imperial Bank of Commerce

6570 Island Highway

Nanaimo, B.C., CANADA

Beneficiary Customer (BNF): (swift F59)

/YOUR ACCT NUMBER: [redacted]

Your Name and address: Kintama Research Services Ltd., 4737 Vista View Cr., Nanaimo, BC Canada V9V 1N8

For bank use:

Pay direct to CIBCATT and provide cover or pay through the following correspondent: [redacted] (ABA [redacted] cid:image001.png@01D097BD.732370E0

Scott White | Manager | Commercial Banking
6570 Island Highway | Nanaimo BC V9V 1K8 | T: 250 756-3430 x402 | F: 250 390-1915 | scott.white@cibc.com

From: Douglas,Jan M (BPA) - NSSP-4 [mailto:jmdouglas@bpa.gov]
Sent: Wednesday, January 25, 2017 6:01 PM
To: David Welch
Cc: Petersen,Christine H (BPA) - EWP-4
Subject: Contract 75025 from BPA for 1996 017 00 Western River Analysis

SUBJECT: Contract 75025

Hello David,

Enclosed for your review and acceptance is the subject contract document. Please review the contract document and, if acceptable, sign and promptly return one fully executed signature page to me via email.

Christine Petersen is the Contracting Officer's Technical Representative (COTR) for this contract. You may contact Ms. Petersen at 503-230-44695, or email at chpetersen@bpa.gov. COTR designation letter to follow.

If you have any questions about the contract terms and conditions or administrative procedures, please contact me.

Thank you,

Call Anytime I Will Do My Very Best To Assist!

Jan Douglas (J.D.)

Bonneville Power Administration

Contracting NSSF – 4

jmdouglas@bpa.gov

503 230 4164

UNITED STATES GOVERNMENT

CONTRACT

Mail Invoice To:

fwinvoices@bpa.gov
F & W Invoices - KEWB-4
P. O. Box 3621
Portland OR 97208-3621

Contract : 00075025
Release :
Page : 1

Vendor:
KINTAMA RESEARCH SERVICES LTD
10-1850 NORTHFIELD RD
NANAIMO BC V9S 3B3

Please Direct Inquiries to:

JAN M. DOUGLAS
Title: CONTRACT SPECIALIST
Phone: 503-230-4164
Fax :

Attn: DAVID W WELCH

Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

Total Value : $110,000.00
Pricing Method: COST, NO FEE
Performance Period: 02/01/17 - 01/31/18

** NOT TO EXCEED **
Payment Terms: % Days Net 30

(b)(6) [redacted]
Contractor Signature
DAVID WELCH, President
Printed Name/Title
26/1/2017
Date Signed

Stephanie Green Digitally signed by Stephanie Green DN: cn=Stephanie Green, o=BPA, ou=NSSM, email=sagreen@bpa.gov, c=US Date: 2017.01.19 10:26:56 -08'00'
BPA Contracting Officer

Date Signed

From: Douglas,Jan M (BPA) - NSSP-4

Sent: Tue Feb 07 14:57:01 2017

To: 'David Welch'

Cc: Yearout,Marcia T (CONTR) - FTD-2

Subject: RE: Contract 75025 from BPA for 1996 017 00 Western River Analysis

Importance: High

Attachments: BPA-Signed Contract Page 1 (26 Jan 2017).pdf

David deep breath all is well,

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She will find an answer to getting a payment thru the system, we have made arrangements for many foreign countries, I'm sure she will assist you in payments on this contract.

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Beneficiary Bank (BBK): (swift F57 - account with institution)

[redacted]

Canadian Imperial Bank of Commerce

6570 Island Highway

Nanaimo, B.C., CANADA

Beneficiary Customer (BNF): (swift F59)

/YOUR ACCT NUMBER:[redacted]

Your Name and address: Kintama Research Services Ltd., 4737 Vista View Cr., Nanaimo, BC Canada V9V 1N8

For bank use:

Pay direct to CIBCATT and provide cover or pay through the following correspondent:[redacted]

cid:image001.png@01D097BD.732370E0

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BPA Contracting Officer

Date Signed

BPA-2021-00513-F 0993

From: Yearout,Marcia T (CONTR) - FTD-2

Sent: Wed Feb 08 10:02:47 2017

To: 'David Welch'; Douglas,Jan M (BPA) - NSSP-4

Cc: Hodgson,Connie R (BPA) - FTD-2

Subject: RE: Contract 75025 from BPA for 1996 017 00 Western River Analysis

Importance: Normal

You are correct. The most recent payment was by check to you on 12/17/12.

I sure wish I knew more about Foreign Wires but that is an area I have yet to be trained on!

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov AP Mail box

mtyearout@bpa.gov

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Wednesday, February 08, 2017 9:56 AM
To: Yearout,Marcia T (CONTR) - FTD-2; Douglas,Jan M (BPA) - NSSP-4
Cc: Hodgson,Connie R (BPA) - FTD-2
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Hello, All—

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52071, which terminated in 2011.

Hope this Is of some help,

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [redacted]

Skype: david.welch.kintama

david.welch@kintama.com

www.kintama.com

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

P Please consider the environment before printing this e-mail

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Nanaimo, B.C., CANADA

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Thank you,

Call Anytime I Will Do My Very Best To Assist!

Jan Douglas (J.D.)

Bonneville Power Administration

Contracting NSSF – 4

jmdouglas@bpa.gov

503 230 4164

From: Erin Rechisky

Sent: Thu Feb 09 12:06:40 2017

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

Subject: RE: Will call...

Importance: Normal

Thanks Christine.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: February 8, 2017 1:58 PM
To: Erin Rechisky
Subject: RE: Will call...

Hi Erin

This sounds very reasonable.

With regards to editing Pisces, can you wait until tomorrow. I will return from Corvallis, and managers are holding a meeting where they will go over prioritization of tasks for the technical services budget. I expect Ben Zelinsky to be able to have some information for the amount of funds we could potentially add with a contract modification.

I will remind them that your contract has started and you are beginning work.

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: Erin Rechisky <Erin.Rechisky@kintama.com>
Date: 2/7/17 11:48 AM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Subject: RE: Will call...

Hi Christine,

Our plan is to begin working on the contract in the next week or two and then ramping up as we clear more things off of our plates. This means we will begin billing BPA at the end of February. Do we need to have a updated SOW in place in Pisces so that the tasks that we bill for are in line with the SOW? If so, should I/we edit Pisces to reflect what work we can accomplish up to a max of $110k for the moment (until more finds are confirmed)? So for instance, we will not get to the paper submission milestone with the newly proposed work, but we may complete the analysis.

Feel free to call if it's easier to discuss.

250-667-6951 or use skype. My user name is erin_rechisky.

Thanks,
Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: February 3, 2017 1:32 PM
To: David Welch; Erin Rechisky
Subject: RE: Will call...

Yes – that will work fine. I owe you a status update, but there is not that much information to pass on. Basically, there will be a more substantive meeting next week where our staff will go into our budget for technical services and I will get more information at that point about actually moving additional funds into your contract. However, we could take some initial steps to modify the statement of work.

Here were are seeing freezing rain.

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, February 03, 2017 1:29 PM
To: Petersen,Christine H (BPA) - EWP-4
Subject: Will call...

Hi Christine—

Erin and I are in the middle of the Strait of Georgia, trying to get back from a meeting in Vancouver. (It's snowing here and all float plane flights are grounded).

I will give you a call about 3 PM if that works for you... does it?

Best, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [redacted]

Skype: david.welch.kintama

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Sent: Fri Feb 10 09:53:25 2017

To: 'David Welch' (David.Welch@kintama.com)

Cc: Douglas,Jan M (BPA) - NSSP-4; Vendor Mtc Team

Subject: Contract 75025 - In Canada / Payment Options

Importance: High

Attachments: RE: Contract 75025 from BPA for 1996 017 00 Western River Analysis ; BPA-Signed Contract Page 1 (26 Jan 2017).pdf

Hello Vendor Maintenance!

Mr. Welch is wondering about payment options for his soon to be finalized contract and I think a foreign wire is the option because checks take a long time to get there but and regular EFT doesn't work between the two banking systems.

Can you help on this?

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

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mtyearout@bpa.gov

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Sent: Wed Feb 08 09:55:42 2017

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Cc: Hodgson,Connie R (BPA) - FTD-2

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kintamav_RGB

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Fax :

Attn: DAVID W WELCH

Contract Title: 1996-017-00 EXP SURVIVAL IN LARGE WESTERN RIVERS ANALYSIS

Total Value : $110,000.00
Pricing Method: COST, NO FEE
Performance Period: 02/01/17 - 01/31/18

** NOT TO EXCEED **
Payment Terms: % Days Net 30

(b)(6) [redacted]
Contractor Signature
DAVID WELCH, President
Printed Name/Title
26/1/2017
Date Signed

Stephanie Green Digitally signed by Stephanie Green DN: cn=Stephanie Green, o=BPA, ou=NSSM, email=sagreen@bpa.gov, c=US Date: 2017.01.19 10:26:56 -08'00'
BPA Contracting Officer

Date Signed

From: Yearout,Marcia T (CONTR) - FTD-2

Sent: Fri Feb 10 09:58:49 2017

To: 'David Welch'

Subject: RE: Contract 75025 - In Canada / Payment Options

Importance: Normal

I apologize that Connie hadn't responded. I thought she had and asked this morning about it and she had not. I am sure Vendor Maintenance will have the answer.

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov AP Mail box

mtyearout@bpa.gov

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, February 10, 2017 9:55 AM
To: Yearout,Marcia T (CONTR) - FTD-2
Subject: RE: Contract 75025 - In Canada / Payment Options

Thanks, Marcia.

David

From: Yearout,Marcia T (CONTR) - FTD-2 [mailto:mtyearout@bpa.gov]
Sent: Friday, February 10, 2017 9:53 AM
To: David Welch
Cc: Douglas,Jan M (BPA) - NSSP-4; Vendor Mtc Team
Subject: Contract 75025 - In Canada / Payment Options
Importance: High

Hello Vendor Maintenance!

Mr. Welch is wondering about payment options for his soon to be finalized contract and I think a foreign wire is the option because checks take a long time to get there but and regular EFT doesn't work between the two banking systems.

Can you help on this?

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov **AP Mail box**

mtyearout@bpa.gov

From: Yearout,Marcia T (CONTR) - FTD-2

Sent: Fri Feb 10 10:50:04 2017

To: 'David Welch' (David.Welch@kintama.com)

Subject: FW: Contract 75025 - In Canada / Payment Options

Importance: Normal

See below

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov **AP Mail box**

mtyearout@bpa.gov

From: Brenner,Shelly (BPA) - NSTS-MODW
Sent: Friday, February 10, 2017 10:49 AM
To: Yearout,Marcia T (CONTR) - FTD-2; Douglas,Jan M (BPA) - NSSP-4
Cc: Vendor Mtc Team
Subject: RE: Contract 75025 - In Canada / Payment Options

Hi Ladies

It is lunchtime in Canada. I just went ahead and put in the foreign wire information. IF he changes his mind and wants a check payment I can always switch it back. We do not have a problem sending checks to foreign countries.

Let me know if I can be of further assistance with Kitama.

Thanks!

Shelly

From: Vendor Mtc Team
Sent: Friday, February 10, 2017 10:03 AM
To: Brenner,Shelly (BPA) - NSTS-MODW
Subject: FW: Contract 75025 - In Canada / Payment Options
Importance: High

Shelly – Can you please take a look at this…

Thanks..

From: Yearout,Marcia T (CONTR) - FTD-2
Sent: Friday, February 10, 2017 9:53 AM
To: 'David Welch' (David.Welch@kintama.com)
Cc: Douglas,Jan M (BPA) - NSSP-4; Vendor Mtc Team
Subject: Contract 75025 - In Canada / Payment Options
Importance: High

Hello Vendor Maintenance!

Mr. Welch is wondering about payment options for his soon to be finalized contract and I think a foreign wire is the option because checks take a long time to get there but and regular EFT doesn't work between the two banking systems.

Can you help on this?

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov AP Mail box

mtyearout@bpa.gov

From: Brenner,Shelly (BPA) - NSTS-MODW

Sent: Fri Feb 10 11:29:23 2017

To: 'David Welch'; Yearout,Marcia T (CONTR) - FTD-2; Douglas,Jan M (BPA) - NSSP-4

Cc: Vendor Mtc Team

Subject: RE: Contract 75025 - In Canada / Payment Options

Importance: Normal

Thank you David,

I have set up the company to now receive wire transfers. It speeds up the payment process and then you're not waiting for a check.

Thank you for getting right back to me

Have a good day,

Shelly

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Friday, February 10, 2017 11:20 AM
To: Brenner,Shelly (BPA) - NSTS-MODW; Yearout,Marcia T (CONTR) - FTD-2; Douglas,Jan M (BPA) - NSSP-4
Cc: Vendor Mtc Team
Subject: RE: Contract 75025 - In Canada / Payment Options

Thanks, Shelley

As you note, we were previously set up to receive checks.

I have no problem with moving towards wire transfers, and it does move us some small way along the path to electronic banking. If you don't think it will be an issue, let's try doing wire transfers in future.

Thank you, David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [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: Brenner,Shelly (BPA) - NSTS-MODW [mailto:nmbrenner@bpa.gov]
Sent: Friday, February 10, 2017 10:24 AM
To: David Welch; Yearout,Marcia T (CONTR) - FTD-2; Douglas,Jan M (BPA) - NSSP-4
Cc: Vendor Mtc Team
Subject: RE: Contract 75025 - In Canada / Payment Options

Hello Mr Welch

As of right now we have your company set up to receive check payments. We can do a foreign wire if you would prefer. Marcia did send along the banking information. Is this how you would like to be paid? If so, it is not a problem to do a foreign wire.

Thank you

Shelly

Shelly Brenner

Vendor Maintenance Coordinator – NSTS/MODW

Bonneville Power Administration

360-418-2185

From: Vendor Mtc Team
Sent: Friday, February 10, 2017 10:03 AM
To: Brenner,Shelly (BPA) - NSTS-MODW
Subject: FW: Contract 75025 - In Canada / Payment Options
Importance: High

Shelly – Can you please take a look at this…

Thanks..

From: Yearout,Marcia T (CONTR) - FTD-2
Sent: Friday, February 10, 2017 9:53 AM
To: 'David Welch' (David.Welch@kintama.com)
Cc: Douglas,Jan M (BPA) - NSSP-4; Vendor Mtc Team
Subject: Contract 75025 - In Canada / Payment Options
Importance: High

Hello Vendor Maintenance!

Mr. Welch is wondering about payment options for his soon to be finalized contract and I think a foreign wire is the option because checks take a long time to get there but and regular EFT doesn't work between the two banking systems.

Can you help on this?

Thank You! J

Have a great day!

Marcia Yearout

Disbursement Specialist

Adecco (Contractor)

Bonneville Power Administration

503-230-5787 Hotline, Direct 503-230-4538

acctspay@bpa.gov AP Mail box

mtyearout@bpa.gov

From: David Welch

Sent: Fri Feb 10 11:36:42 2017

To: Brenner,Shelly (BPA) - NSTS-MODW

Subject: Read: Contract 75025 - In Canada / Payment Options

Importance: Normal

Your message

To: David Welch
Subject: RE: Contract 75025 - In Canada / Payment Options
Sent: Friday, February 10, 2017 11:29:23 AM (UTC-08:00) Pacific Time (US & Canada)

was read on Friday, February 10, 2017 11:36:27 AM (UTC-08:00) Pacific Time (US & Canada).

From: Salmon Ocean Ecology

Sent: Fri Feb 10 11:42:45 2017

To: alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; Cameron Freshwater; campblac@dfw.wa.gov; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chrys.Neville@dfo-mpo.gc.ca; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; David?Huff - NOAA Affiliate; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; dower@uvic.ca; dstormer@uvic.ca; ebeamer@skagitcoop.org; ed.farley@noaa.gov; elan.downey@cahs-bc.ca; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erik.Neatherlin@dfw.wa.gov; Erin Rechisky; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; Greg Ruggerone; hans@pgst.nsn.us; Eric Hertz; Ian.Perry@dfo-mpo.gc.ca; ibeveridge@lgl.com; ikemp@lltk.org; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; Jackie.King@dfo-mpo.gc.ca; jamal.moss@noaa.gov; jclark@ak.net; Jeff Rutter; jeanette.gann@noaa.gov; jen.zamon@noaa.gov; jenkins@psc.org; jennifer.gosselin@noaa.gov; Jessica Miller; jgmusslewhite@fs.fed.us; jgw3@uw.edu; jim.murphy@noaa.gov; Jessica Holden; Julie Keister; joe.orsi@noaa.gov; Joshua Chamberlin - NOAA Federal; Joshua Russell; journey@uw.edu; jpkarnezis@bpa.gov; Francis Juanes; Kathryn Sobocinski - NOAA Affiliate; Katrina Cook; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; Kym Jacobson; Lance.Campbell@dfw.wa.gov; Mike lapointe; Laura Kennedy; laurie.weitkamp@noaa.gov; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org; mara.zimmerman@dfw.wa.gov; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; Matt Miller; mckinnell@shaw?ca; mcrewson@tulaliptribes-nsn.gov; megan.moore@noaa.gov; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; Meredith Journey - NOAA Affiliate; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; moore.jed@nisqually-nsn.gov; Michael Schmidt; Megan McPhee; ndavis@npafc.org; neala.kendall@dfw.wa.gov; nick.leone@dfo-mpo.gc.ca; Paige Borrett; pearsalli@psf.ca; Amy Teffer; rabeamish@shaw.ca; ralexander@lgl.com; Raphael Girardin - NOAA Affiliate; Rick Brodeur ?NOAA Federal); rmflagg@uvic.ca; Sandra.ONeill@dfw.wa.gov; sarah.ballard@noaa.gov; Scott Hinch; sean.hayes@noaa.gov; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; sue.grant@dfo-mpo.gc.ca; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov; whitney.friedman@noaa.gov; willduguid@hotmail.com; David Welch;

john.kocik@noaa.gov; Carrie Byron; pete.lawson@peak.org; tcwainw@gmail.com; lynne.krasnow@noaa.gov; Patty O'Toole-Perkins

Subject: SOEM 2017 REMINDER - Abstracts due in one week

Importance: Normal

Just a reminder that abstracts are due on February 17th - one week from today. And you might as well register while on the website :).

Also, we created a note to the speakers of the Workshop on March 21st that might be informative if you're wondering whether to attend the workshop or not. It's available on the website (link below).

Apologies for the spam to those who have already indicated they can not make the meeting.

Looking forward to seeing you in just over 5 weeks!
-The SOEM 2017 Organizing Committee

[text from previous email below]

This is a reminder to register for the 18th Annual Salmon Ocean Ecology Meeting! Please also consider reserving your hotel room ASAP as we don't have a room block, and rooms fill up here in the big city. Finally, The deadline to submit your abstract is February 17th! Original message with the relevant links is below.

NOAA Employees, please use your travel card for registration, as lunches are provided.

The meeting will be held March 22-23 at the Landing at Tyee on Lake Union in Seattle, Washington. A pre-meeting workshop will also occur on March 21st, for a focused, small-group discussion on salmon prey and competition. To register for the meeting and optional workshop, please visit http://salmonoceanecology2017-.brownpapertickets.com/. Meeting registration will close Friday, March 10th.

For information about nearby hotels and submitting abstracts, please visit the meeting website at https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

The abstract deadline is February 17th. Also, please reserve your hotel room early to ensure you have a spot near the meeting location. No room blocks could be held for this meeting. Most of the hotels listed are within a short walking distance. They are listed in order of proximity to the meeting on the web site.

Thank you,

The 2017 SOEM Organizing Committee

From: Erin Rechisky

Sent: Tue Feb 14 08:55:44 2017

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

Subject: RE: call, on schedule

Importance: Normal

Hi Christine,

We can call you today before 10, or after 3:30 as you suggest.

I am in the office and David should be here soon.

Just let us know your preference.

Erin

From: David Welch
Sent: February 13, 2017 12:38 PM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky
Subject: Re: call, on schedule

Hi Christine

Today is a stat holiday here, so I'm not sure if Erin will check her email at all. I am in the office all day tomorrow, as is Erin so far as I know. I am then away until March 4th.

How about a discussion tomorrow at a time that works for you? (Anytime after 9 should work, [redacted]

In short, we can make this work...somehow/someway. Some of our BC work is still up in the air awaiting a funding decision, but I think we can work around that given what you have outlined.

[redacted] so just wanted to let you know my initial response.

Set a time tomorrow after 9, and we can discuss in greater detail.

David

David Welch, Kintama Research

Tel: +1 (250) 729-2600 x223

Cell: +[redacted]

Sent from my iPad

On Feb 13, 2017, at 12:30, Petersen,Christine H (BPA) - EWP-4 <chpetersen@bpa.gov> wrote:

Hi,

Let's see – are either of you available for a phone call in the next couple of days. Unfortunately I have to attend a long meeting tracking the Corps research plans. I should be available after 3:30 today, or 8-10, after 3 tomorrow, or all of Wednesday.

In short, Lorri Bodi, Jeff Stier gave top priority to adding additional funds to your project, but I am trying to work out an optimal scheduling balance so that we wouldn't necessarily have to bump some medium priority work. Some of this could be achieved by allowing some tasks to go over into the next fiscal year starting October

(b)(5) [redacted]

In order to help make this judgment call for how much funding we would need to allocate to get you to a certain stage by Sept 30 when we could draw from the next fiscal year, I would like to know your best estimate for a schedule of work (given all of your obligations and activities at Kintama this year).

-If we were to ask you to work quickly (given all other commitments), how early could you complete at least a Columbia vs. Fraser SARs analysis, and give either a presentation of key preliminary results or an early draft?

-If were asked you to work more slowly, and to get to a stage by Sept 30th where you have a fairly developed draft, but held off on the peer review publication submission and revisions – what fraction of the total budget (including submission to journal) do you think this would be? You do have ‘report’ vs ‘full paper’ totals in an earlier email, on the three separate papers.

Hopefully I can make this more clear over the phone.

Christine Petersen

From: Erin Rechisky

Sent: Tue Feb 14 09:01:50 2017

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

Subject: RE: call, on schedule

Importance: Normal

We should both be here. Call when it is convenient for you.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: February 14, 2017 8:41 AM
To: David Welch
Cc: Erin Rechisky
Subject: RE: call, on schedule

Hi,

I'm working around a long Corps meeting where they provide opportunity to provide feedback on their research projects. They have been cruising very quickly through their agenda, so I might be able to try to call you a little after

11am? If not, 3pm might be the best time to try to reach you.

Talk to you soon

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Monday, February 13, 2017 12:38 PM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky
Subject: Re: call, on schedule

Hi Christine

Today is a stat holiday here, so I'm not sure if Erin will check her email at all. I am in the office all day tomorrow, as is Erin so far as I know. I am then away until March 4th.

How about a discussion tomorrow at a time that works for you? (Anytime after 9 should work, [redacted]

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[redacted], so just wanted to let you know my initial response.

Set a time tomorrow after 9, and we can discuss in greater detail.

David

David Welch, Kintama Research

Tel: +1 (250) 729-2600 x223

Cell: +[redacted]

Sent from my iPad

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(b)(5) [redacted]

In order to help make this judgment call for how much funding we would need to allocate to get you to a certain stage by Sept 30 when we could draw from the next fiscal year, I would like to know your best estimate for a schedule of work (given all of your obligations and activities at Kintama this year).

-If we were to ask you to work quickly (given all other commitments), how early could you complete at least a Columbia vs. Fraser SARs analysis, and give either a presentation of key preliminary results or an early draft?

-If were asked you to work more slowly, and to get to a stage by Sept 30th where you have a fairly developed draft, but held off on the peer review publication submission and revisions – what fraction of the total budget (including submission to journal) do you think this would be? You do have 'report' vs 'full paper' totals in an earlier email, on the three separate papers.

Hopefully I can make this more clear over the phone.

Christine Petersen

From: Erin Rechisky

Sent: Wed Feb 15 11:43:10 2017

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

Subject: RE: Contract modification

Importance: Normal

Thanks for the update Christine. I'll stand by for more budgeting information before making any changes to the SOW.

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: February 15, 2017 11:21 AM
To: Erin Rechisky; David Welch
Subject: Contract modification

Hi Erin and David,

This morning I was able to talk with one of our accountants. They may be figuring out a strategy to cover our increasing set of requests drawing from our technical services budget this year – coming from our hatchery, hydro, habitat, and communications subprograms. We may be able add the full amount to cover your project with this contract modification rather than to use the approach I was suggesting over the phone, where we would delay some fraction of the total effort to occur after the start of the next fiscal year, starting October 1, 2018.

In any case, as we develop the new line item budget and text for the contract work elements better describing the refocused data analysis and paper themes, I think it would be a good idea to go over the expected pace and schedule of work. Please do not hesitate to let us understand any other constraints you might have in scheduling work, so that we do not inadvertently pressure you into dropping something to meet a certain timeline.

More later as we work on budgeting over here.

Christine Petersen

From: Pisces

Sent: Thu Feb 16 08:56:59 2017

To: Pisces

Subject: Pisces Release at 5pm tonight (2/16/17) - Please wrap up your work & log out prior to then!

Importance: Normal

Good morning Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you have completed your work and are logged out prior to then. The system should be back online by 6pm – we will reach out if anything changes.

This coming month, we will be reaching out to encourage more experimenting in Pisces Web. Most of the basic capabilities of Pisces Desktop are available via the web, so now is a great time for you to work with your COTR or contractor and take a trial run at creating, modifying, or reviewing your SOW – entering Status Reports – you name it.

Success tips for managing your contracts in the Pisces Web environment:

· You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!

- We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

- While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do everyday work in Pisces. Future training will support users with tips and tricks for how to be successful

- If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

- For system access, bugs, or feedback on new functionality – email support@cbfish.org.

- For questions about the Pisces Web project – email pisces@bpa.gov.

The Pisces Team

Bonneville Power Administration

This message is going to all Pisces Desktop users and Pisces Web project team

From: David Welch

Sent: Thu Feb 16 08:57:18 2017

To: Pisces

Subject: Automatic reply: Pisces Release at 5pm tonight (2/16/17) - Please wrap up your work & log out prior to then!

Importance: Normal

I will be out of the office from 15 Feb-4 March, 2017, inclusive and will have only sporadic internet or phone access during that time.

For Kintama issues during this time, please contact:

Dr Erin Rechisky, erin.rechisky@kintama.com; +1 250-667-6951

For important personal issues requiring my immediate attention, please call my cell: +(b)(6) [redacted]

Otherwise, please email again on or after March 4th and I will respond as quickly as possible.

Regards, David Welch

From: Michael Schmidt

Sent: Sat Feb 18 20:05:06 2017

To: Salmon Ocean Ecology; alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; camfresh@uvic.ca; campblac@dfw.wa.gov; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chrys.Neville@dfo-mpo.gc.ca; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; david.huff@noaa.gov; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; dower@uvic.ca; dstormer@uvic.ca; ebeamer@skagitcoop.org; ed.farley@noaa.gov; elan.downey@cahs-bc.ca; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erik.Neatherlin@dfw.wa.gov; erin.rechisky@kintama.com; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; gruggerone@nrccorp.com; hans@pgst.nsn.us; Eric Hertz; Ian.Perry@dfo-mpo.gc.ca; ibeveridge@lgl.com; Iris Kemp; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; Jackie.King@dfo-mpo.gc.ca; jamal.moss@noaa.gov; jclark@ak.net; Jeff Rutter; jeanette.gann@noaa.gov; jen.zamon@noaa.gov; jenkins@psc.org; jennifer.gosselin@noaa.gov; jessica.miller@oregonstate.edu; jgmusslewhite@fs.fed.us; jgw3@uw.edu; jim.murphy@noaa.gov; jjulin.holden@gmail.com; jkeister@u.washington.edu; joe.orsi@noaa.gov; Joshua.Chamberlin@noaa.gov; joshuarussell0407@gmail.com; journey@uw.edu; jpkarnezis@bpa.gov; juanes@uvic.ca; kathryn.sobocinski@noaa.gov; katrina.vcook@gmail.com; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; kym.jacobson@noaa.gov; Lance.Campbell@dfw.wa.gov; lapointe@psc.org; Laura Kennedy; laurie.weitkamp@noaa.gov; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org; mara.zimmerman@dfw.wa.gov; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; matt@ktoo.org; mckinnell@shaw.ca; mcrewson@tulaliptribes-nsn.gov; megan.moore@noaa.gov; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; meredith.journey@noaa.gov; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; moore.jed@nisqually-nsn.gov; Megan McPhee; ndavis@npafc.org; neala.kendall@dfw.wa.gov; nick.leone@dfo-mpo.gc.ca; pborrett@uvic.ca; pearsalli@psf.ca; peter.w.lawson@noaa.gov; Amy Teffer; rabeamish@shaw.ca; ralexander@lgl.com; raphael.girardin@noaa.gov; rick.brodeur@noaa.gov; rmflagg@uvic.ca; Sandra.ONeill@dfw.wa.gov; sarah.ballard@noaa.gov; scott.hinch@ubc.ca; sean.hayes@noaa.gov; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; sue.grant@dfo-mpo.gc.ca; thomas.wainwright@noaa.gov; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov; whitney.friedman@noaa.gov;

willduguid@hotmail.com; David Welch

Cc: Brian Burke - NOAA Federal (brian.burke@noaa.gov); 'brian.beckman@noaa.gov'; 'kurt.fresh@noaa.gov'

Subject: ISSUE RESOLVED: Registration for the Salmon Ocean Ecology Meeting 2017 is now open

Importance: Normal

All, we recently found an issue with our payments processing that was preventing folks from registering for the Salmon Ocean Ecology Meeting. The issue has been addressed. Please visit the brown paper tickets site at http://salmonoceanecology2017.brownpapertickets.com/ to get registered. Also, if you are coming from out of town, don't forget to reserve a room ASAP before they fill up. Hotel information can be found at https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

PS. If you have any issues with registering, please reach out to me immediately at mschmidt@lltk.org.

Regards,

Michael Schmidt and the rest of you SOEM 2017 Organizing Committee

From: Salmon Ocean Ecology [mailto:salmonocean2017@gmail.com]

Subject: Registration for the Salmon Ocean Ecology Meeting 2017 is now open

Greetings Salmon Ocean Ecologists;

Registration for the 18th Annual Salmon Ocean Ecology Meeting is now open! The meeting will be held March 22-23 at the Landing at Tyee on Lake Union in Seattle, Washington. A pre-meeting workshop will also occur on March 21st, for a focused, small-group discussion on salmon prey and competition. To register for the meeting and optional workshop, please visit http://salmonoceanecology2017.brownpapertickets.com/. Meeting registration will close Friday, March 10th.

For information about nearby hotels and submitting abstracts, please visit the meeting website at https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

The abstract deadline is February 17th. Also, please reserve your hotel room early to ensure you have a spot near the meeting location. No room blocks could be held for this meeting. Most of the hotels listed are within a short walking distance. They are listed in order of proximity to the meeting on the web site.

Happy New Year!

Your 2017 SOEM Organizing Committee

From: Stier,Jeffrey K (BPA) - E-4

Sent: Mon Feb 27 11:44:10 2017

Subject: Master Contracts and Invoicing Requirements

Importance: Normal

Attachments: Email to Sponsors_Master Contracts and Invoicing Req_022717_Attachment A....pdf

Dear Fish and Wildlife Sponsor,

BPA's Fish and Wildlife program is undergoing two changes to our contract and billing practices based on the results of an internal audit that revealed some inconsistencies in BPA's invoicing standards.

First, when applicable and agreeable to our partners, we are converting our annual contracts to five-year Master Agreements (which will contain the Terms and Conditions, e.g. payment terms) and annual one-year releases (which will include the SOW and Budget). This is intended to reduce the administrative burden of reviewing contractual terms and conditions for both your staff and ours. Your Contracting Officer (CO), Lead BPA manager, or Contracting Officer's Technical Representative (COTR) will contact you soon regarding the Master Agreement process if he/she hasn't already.

The second change, and the main purpose of this communication, is that BPA has updated its Payment in Arrears clause 25-50 (see attached), and the updated clause will be included in all FY17 contracts (which you have already seen in many of your contracts already). The goal of these changes is to increase compliance with invoicing requirements and consistency between the budgeting and invoicing processes. The attached update outlines the billing requirements necessary for your organization to be consistent with Bonneville Purchasing Instructions.

The updated clause may affect you in the following ways:

· Minimum documentation requirements – Line Item Budgets must reflect items in a way that is consistent with your invoice format. For example, entities that use an hourly rate for personnel costs in their invoices should also represent personnel costs using an hourly rate in the Excel budget for that contract.

· Performance periods – Invoices must clearly state the performance period pertinent to the charges.

· Consistency between budgets and invoices – In each invoice, a summary should be provided for each line item. This summary must include the approved budget, expenditures for the invoiced period, cumulative expenditures, balances and percent expended. The invoice should also include enough detail so that there is a clear link between each invoice charge and the line item budget.

· Vague description must be clarified, and unusual charges must be explained and justified (e.g., “AL Cash Out items”).

Next steps: In order to help you clearly understand these changes and to reduce the administrative burden these changes may have on your organization, we will be providing technical assistance over the coming weeks and months. For larger contractors, your CO will be contacting you to schedule a phone call or in-person meeting to discuss both of these changes. For smaller contractors, your Lead BPA manager or COTR may be contacting you. Our goal is to have 100% compliance by the end of fiscal year 2017.

If you have any questions, please contact your BPA Project Manager/COTR.

Sincerely,

Jeffrey K. Stier

Acting Fish & Wildlife Director

Bonneville Power Administration

PAYMENTS IN ARREARS (25-50)
(SEP 2016)

(a) The contractor shall submit a proper invoice on a monthly basis in arrears to:

Bonneville Power Administration
PO Box 3621, M/S EWB-4
Portland OR 97208-3621
fwinvoices@bpa.gov

Note: a SF-270 may be used in lieu of a proper invoice, however the backup documentation requirements per this clause remain unchanged.

If a proper invoice is submitted, it must include all of the following information:

1) Name of contractor (must reasonably match the name on the contract)

2) Contractor address (only when not set up as Electronic Funds Transfer)

3) Invoice date

4) BPA contract number

5) Contractor invoice number (must be a number unique to the contractor and not used on any other invoice with BPA)

6) Invoice Performance Period (e.g., "For work actually performed during the period of June 1 through June 30, 2003"). If the invoice performance period covers more than one budget period or BPA fiscal year, the contractor must provide a sub-total of the costs attributable to each budget period or fiscal year. For example, work performed prior to September 30 should be sub-totaled separately from work performed after September 30)

7) Shipping terms, if applicable (i.e., FOB Destination)

8) Contact name, title, telephone number and email

9) For fixed price contracts: Description (including, for example, contract line/sub-line number), price, and quantity of goods and services rendered

10) For cost reimbursement contracts: Documentation required under section (b), below

(b) For Cost Reimbursement Contracts, the contractor will provide invoice-specific and summary information. For the contract provide:

1. Approved contract value

2. Subject invoice amount

3. Expenditures to date (which includes the subject invoice)

4. Remaining contract balance (after the subject invoice is paid).

(s) For Line Items provide:

1. Approved budget

2. Cumulative expenditures

3. Balances

4. Percent expended

The categories in Table A below are the minimum level of documentation required for each line item. BPA may request more detailed backup documentation to support invoices upon request by the CO or as delegated to the COTR.

TABLE A: COST REIMBURSEABLE CONTRACT REQUIREMENTS		
Line Item Description	**Minimum Documentation Required**	**Documentation NOT required but may be requested.**
Salaries – direct labor only	A list, by position title and/or name, showing hours and hourly rate. This should be consistent with the labor categories shown in the awarded budget.	Individual time sheets and employee names.
Salary Fringes	Fringe benefit dollar amount per employee shall be provided.	Detailed information supporting fringe benefit amounts, such as insurance policies, etc.
Travel and transportation (including per diem)	A description of the travel completed including traveler name, date(s) purpose, main destination for the trip, and amounts. Airline costs, lodging and per diem amounts shall be separated out the backup data. International travel will only be reimbursed if explicitly approved in the budget.	Airline ticket receipts, hotel receipts, meal receipts, etc.
Vehicles	Lease GSA: identify the cost per month. Do not bill for costs such as new tires, repairs, etc., since these costs are included in the GSA rental cost. Very limited, legitimate non-GSA covered costs may be allowed, but only if they are explicitly specified in the approved budget. State Motor Pool: Same as GSA. State/tribe owned (project-assigned) vehicles: Repairs and maintenance costs, operational costs (gas, oil, etc.). Lease private: Show lease payment, additional lease costs. Privately Owned Vehicles (POVs): must show costs in miles multiplied by rate. POVs do not receive additional reimbursement for repairs, and maintenance costs.	Copies of receipts, gas bills, etc.

TABLE A: COST REIMBURSEABLE CONTRACT REQUIREMENTS		
Line Item Description	**Minimum Documentation Required**	**Documentation NOT required but may be requested.**
Training/Tuition	Description of the training received, who received the training, dates of the training, and cost of the training.	Conference registration receipts, payment vouchers, etc.
Capitalized Equipment	Copy of receipt which shall include the description of the equipment, date of purchase, purchase cost, model number, and serial number. Capitalization criteria as defined by the contractor's indirect agreement or greater than $10,000.	
Trackable equipment	These are the types of items that go on the BPA-required Inventory. A cost for each item purchased is required to be shown.	Copies of receipts, freight bills, etc.
Supplies and non-trackable equipment	Summarize the kinds and dollar amounts of non-trackable equipment (e.g., hand tools, waders) and supplies by type (e.g., office supplies).	Copies of receipts, freight bills, etc.
Repair and maintenance (including computer services) which may include minor parts	Provide description of what service was obtained and the cost associated (e.g., boat motor repair, computer repair, copier repair, etc.).	Copies of payment vouchers, repair invoices, parts bills, etc.
Equipment Rental	Provide equipment description, dates, rental rates, and whether rates include operator. (e.g. Backhoe w/o operator; $400/d, Dec 2nd – 3rd).	Rental receipts, time sheets, etc.
Temporary rental/lease of real property	Specify lease/rental type rate and duration. Examples: • Office space 3 months at $1,000 per month • Storage locker rental 2 month at $75 per month • 500 Acre grazing allotment at $11,000 per year	

TABLE A: COST REIMBURSEABLE CONTRACT REQUIREMENTS		
Line Item Description	**Minimum Documentation Required**	**Documentation NOT required but may be requested.**
Overhead/Other Indirect Costs	Identify the overhead/indirect rate used to calculate the dollar amount. Rates shall be applied consistent with the current rate negotiated by the Cognizant Audit Agency. Identify the line items to which the indirect rate applies, and the total, cumulative expenditures of these line items to which the indirect rate was applied.	Itemized lists or records of costs included in overhead or other indirect costs.
Subcontracts (also include when work being billed was performed by subcontractor)	A copy of the subcontractor's or service provider's invoice. Subcontractor invoice with same detail as contractor.	
Summary Financial Information	Provide a running balance report using the approved budget. Include line item budget, current expenditures, cumulative expenditure, and remaining balance.	

(d) Allowable costs shall be determined in accordance with the cost principles of 2 CFR 200.

(e) Invoices will be returned if:

1) The cumulative charged amount exceeds the contract award ceiling

2) The invoice billing period is for work performed after the last day of the contract performance period

3) Non-itemized and/or incomplete billings will be returned to the contractor without processing for payment until a corrected invoice is received

(f) Adjustments

(1) Refunds, Rebates or Credits.

(A) Contracts in issued status: Refunds or credits to BPA as a result of previous errors in billing, overpayments, or other rebates or refunds shall be applied by the contractor to the invoice submitted immediately following the identification of the need to issue a refund, credit, or rebate to BPA. The invoice where the credit or refund has been applied shall include an explanation of the reason for the refund or credit. Do not submit the refund or credit as a check or cash if additional invoices will be submitted.

(B) Closed Contracts: In instances where no additional invoices will be submitted, refunds or credits to BPA as a result of previous errors in billing, overpayments, or other rebates or refunds shall be returned to BPA in the form of a check. Contact the CO to determine to whom to address the check. An explanation of the reason for the refund or credit shall be included with the check. Please do not submit cash.

(2) Corrected or Revised Invoices: If the contractor needs to correct or revise a previously submitted but not yet paid invoice, a newly numbered invoice with the revised information should be submitted, and the contractor –agency shall note on the corrected or revised invoice: "Corrected/Revised Invoice – Corrects invoice #________ previously submitted." The new invoice must have a new date and different invoice number.

(g) Final payment.

The Contractor shall submit an invoice marked "Final Invoice" promptly upon completion of the work. Upon approval of that invoice and upon the Contractor's compliance with all terms of this contract, BPA shall promptly pay any allowable costs not previously paid. If it cannot be determined until after an invoice was sent that it was a final invoice, an email to fwinvoices@bpa.gov shall be sent to confirm a previous invoice was the final one.

From: David Welch

Sent: Mon Feb 27 11:44:30 2017

To: Stier,Jeffrey K (BPA) - E-4

Subject: Automatic reply: Master Contracts and Invoicing Requirements

Importance: Normal

I will be out of the office from 15 Feb-4 March, 2017, inclusive and will have only sporadic internet or phone access during that time.

For Kintama issues during this time, please contact:

Dr Erin Rechisky, erin.rechisky@kintama.com; +1 250-667-6951

For important personal issues requiring my immediate attention, please call my cell: +(b)(6) [redacted]

Otherwise, please email again on or after March 4th and I will respond as quickly as possible.

Regards, David Welch

From: Erin Rechisky

Sent: Tue Feb 28 09:16:34 2017

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

Subject: RE: contract modification

Importance: Normal

Thanks for the update Christine. That's great news!

I am busy today and tomorrow, and out of the office on Thursday (at a conference), but I'll be able to talk and make modifications on Friday.

Thanks,

Erin

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: February 28, 2017 8:55 AM
To: Erin Rechisky; David Welch
Subject: contract modification

Hello,

I realize that David is still traveling. Our finance team was able to make funds available for a contract modification yesterday. I will initiate a CCR (or a modification) today. Pisces typically must update overnight, so this should be visible to you for editing tomorrow if you log in.

Later this week, let's discuss potential text for the modified statement of work. It does not necessarily need to be lengthy or elaborate. We also will need to start with the original line item budget and add two columns to the right. One column will show a changed value for each line item, and the next one should show the new budgeted value. Your budget does not have that many different lines for travel, equipment, and so forth so it should hopefully just be an adjustment of labor hours etc adding up to the new total.

I should be fairly available for a call in the remainder of the week.

Talk to you soon,

Christine Petersen

From: Pisces

Sent: Thu Mar 02 09:41:44 2017

To: Pisces

Subject: Pisces release at 5pm tonight (3/2/17) - Please wrap up your work & log out prior to then!

Importance: Normal

Good morning Pisces Users:

At 5pm today, we will be releasing a new version of Pisces Desktop and CBfish.org. Please be sure you have completed your work and are logged out prior to then. The system should be back online by 6pm – we will reach out if anything changes.

Have you logged into cbfish.org and looked at your Pisces contract information yet? If not, you should definitely check it out. You can develop most of your SOW via the web and also take advantage of the new REVIEW SOW capability – which is not available on Pisces Desktop and enables you to exchange comments on various parts of the SOW and manage your refinement process all via the system.

Success tips for managing your contracts in the Pisces Web environment:

· You don't have to go do any work now in the Pisces Web environment – but we encourage you to check it out!

· We have a test environment where you can go explore without concern of messing up your actual contract information – let us know if you would like to access that

· While we've worked to duplicate the user experience as much as we can, web-based navigation requires some fundamental changes in how you do everyday work in Pisces. Future training will support users with tips and tricks for how to be successful

· If you are working on contract actions in Pisces Desktop, don't work on the same contract in Pisces Web: changes are real-time since both operate with the same data

As always…

- For system access, bugs, or feedback on new functionality – email support@cbfish.org.

- For questions about the Pisces Web project – email pisces@bpa.gov.

The Pisces Team

Bonneville Power Administration

This message is going to all Pisces Desktop users and Pisces Web project team

From: Salmon Ocean Ecology

Sent: Mon Mar 06 20:53:49 2017

To: Andrew.Claiborne@dfw.wa.gov; Munguia, Angelica; Cheryl.Morgan@noaa.gov; Neville, Chrys; David.Kuligowski@noaa.gov; David Welch; Erik.Neatherlin@dfw.wa.gov; Ian.Perry@dfo-mpo.gc.ca; Jackie.King@dfo-mpo.gc.ca; Losee, James P (DFW); Jen Zamon - NOAA Federal; Joshua Chamberlin - NOAA Federal; Kathryn Sobocinski - NOAA Affiliate; Katrina Cook; Lance.Campbell@dfw.wa.gov; Laurie Weitkamp - NOAA Federal; Kendall, Neala W (DFW); Raphael Girardin - NOAA Affiliate; Sweeting, Ruston; Ruston.Sweeting@pac.dfo-mpo.gc.ca;?Sandra.ONeill@dfw.wa.gov; alan.byrne@idfg.idaho.gov; alex.andrews@noaa.gov; amcreason@bpa.gov; andrew.gray@noaa.gov; angelica.munguiaa@oregonstate.edu; Barbara Shields; barry.berejikian@noaa.gov; bconnors@essa.com; bev.agler@alaska.gov; Brenna Collicutt; brian.beckman@noaa.gov; brian.burke@noaa.gov; brian.wells@noaa.gov; Brian Riddell; Christine Stevenson; Cameron Freshwater; campblac@dfw.wa.gov; Carrie Byron; Cameron Freshwater; cecile.vanwoensel@cahs-bc.ca; David Noakes; cheryl.morgan@oregonstate.edu; Chris Kondzela - NOAA Federal; correigh.greene@noaa.gov; cruff@skagitcoop.org; davebea@uw.edu; david.greenslime@gmail.com; David Huff - NOAA Affiliate; david.tallmon@uas.alaska.edu; david.teel@noaa.gov; Jared Siegel; desmondmaynard@msn.com; dmwebber@vemco.com; don.noakes@viu.ca; Donald Van Doornik - NOAA Federal; dower@uvic.ca; David Stormer; ebeamer@skagitcoop.org; ed.farley@noaa.gov; Eric Hertz; elan.downey@cahs-bc.ca; Elizabeth Daly - NOAA Affiliate; elizabeth.daly@oregonstate.edu; ellen.yasumiishi@noaa.gov; emily.fergusson@noaa.gov; Elizabeth Phillips; eric.buhle@noaa.gov; eric.warner@muckleshoot.nsn.us; Erin Rechisky; espascoe@uvic.ca; evelynb@lummi-nsn.gov; geiger@ak.net; Geoffrey Osgood; gordrees@uvic.ca; Jennifer L. Gosselin; Greg Ruggerone; hans@pgst.nsn.us; Eric Hertz; ibeveridge@lgl.com; Iris Kemp; ilysa.iglesias@noaa.gov; Iris Kemp; isaac.kaplan@noaa.gov; iwanicki@uvic.ca; jamal.moss@noaa.gov; jclark@ak.net; Jacob Weil; Jeff Rutter; Jeff Rutter; Jeanette Gann - NOAA Federal; jenkins@psc.org; jennifer.gosselin@noaa.gov; Jessica Miller; Jennifer Gardner; jgmusslewhite@fs.fed.us; jgw3@uw.edu; Jim Murphy - NOAA Federal; James J Anderson; Jessica Holden; Julie Keister; joe.orsi@noaa.gov; john.kocik@noaa.gov; Jordan Watson - NOAA Federal; Joshua Russell; journey@uw.edu; jpkarnezis@bpa.gov; Francis Juanes; Kristin Connelly; kcox@uvic.ca; kristin.cieciel@noaa.gov; kurt.fresh@noaa.gov; Kym Jacobson; Mike lapointe; Laura Kennedy; leon.shaul@alaska.gov; litzm@onid.orst.edu; litzm@oregonstate.edu; lizj@ssraa.org;?lynne.krasnow@noaa.gov; Madilyn Gamble; mara.zimmerman@dfw.wa.gov; Michael Arbeider; marc.trudel@dfo-mpo.gc.ca; margaret.wright@dfo-mpo.gc.ca; mark.saunders@dfo-mpo.gc.ca; Matt Miller; mckinnell@shaw.ca; mcrewson@tulaliptribes-nsn.gov; Megan Moore - NOAA Federal; megan.sabal@noaa.gov; melissa.nottingham@dfo-mpo.gc.ca; Meredith Journey - NOAA Affiliate; mgamble@u.washington.edu; mgamble@uw.edu; michael.ofarrell@noaa.gov; Michael Kohan; mmalick@sfu.ca; mmg.gr@dartmouth.edu; moore.jed@nisqually-nsn.gov; msaunders@yearofthesalmon.org; Michael Schmidt; Megan McPhee; nate.mantua@noaa.gov; ncddavis54@gmail.com;

ndavis@npafc.org; nick.leone@dfo-mpo.gc.ca; Paige Borrett; pearsalli@psf.ca; pete.lawson@peak.org; Amy Teffer; Patty O'Toole-Perkins; rabeamish@shaw.ca; ralexander@lgl.com; Rick Brodeur (NOAA Federal); rmflagg@uvic.ca; sarah.ballard@noaa.gov; Scott Hinch; Scott Vulstek - NOAA Federal; sean.hayes@noaa.gov; seanbob655321@gmail.com; shannon.anderson@dfo-mpo.gc.ca; shrushow@sfu.ca; ssteltzner@squaxin.us; Steve Healy; steve.lindley@noaa.gov; sue.grant@dfo-mpo.gc.ca; Tanya Rogers; tcwainw@gmail.com; tjminicucci@alaska.edu; tquinn@u.washington.edu; tzackey@tulaliptribes-nsn.gov; wes.strasburger@noaa.gov; whitney.friedman@noaa.gov; willduguid@hotmail.com

Subject: SOEM 2017 Agenda and Abstracts

Importance: Normal

Attachments: SOEM 2017 Agenda.pdf; SOEM 2017 Abstracts.pdf

Hi all,
Attached are 1) the almost-final SOEM 2017 Agenda and 2) a list of abstracts. Sorry for the mass email, but I thought maybe even those not attending might like to see the agenda.

For those attending, please don't forget to register before Friday (the earlier, the better).

Looking forward to seeing you in a couple weeks,
-SOEM Organizing Committee

https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

2017 Salmon Ocean Ecology Meeting

Tuesday 21 March (Workshop)

8:00	**Coffee/Registration**	
8:30	Part I: Ecology of Salmon Prey	
	David Huff	Toward Ecosystem-Oriented Process Studies in Pacific Ocean Salmon Research
	Meredith Journey	Linking growth and diet in Strait of Georgia juvenile coho
10:00	**Coffee Break**	
10:30	Part I: Ecology of Salmon Prey (cont.)	
	Kathryn Sobocinski	Salmon trophic dynamics: can models bring together pieces of a puzzle?
	Raphael Girardin	Puget Sound Salmon early marine survival through the eyes of the Atlantis ecosystem model
12:00	**Lunch**	
1:30	Part II: Competition	
	Josh Chamberlin	From competitor to predator: how interactions among Pacific herring and Chinook salmon affect individual growth rates in Puget Sound
	Kym Jacobson	Does Abundance of Coastal Pelagic Species Affect Survival of Juvenile Salmon During Early Marine Residence?
3:00	**Coffee Break**	
3:30	Part II: Competition (cont.)	
	Greg Ruggerone	Evidence for competition among salmon at sea
	Francis Juanes	TBD

2017 Salmon Ocean Ecology Meeting

Wednesday 22 March

8:00	**Coffee/Registration**	
8:30	Introductions	
8:50	Nate Mantua	Blame-storming North Pacific Climate Extremes Since 2013
9:50	Katrina Cook	Fate and Condition of Pacific Salmon Released from Commercial Purse Seine Fisheries: Results from Marine Holding Studies and Lessons from Fishers
10:10	Megan Moore	Changes in harbor-seal x steelhead predator-prey interactions with variable steelhead survival rates through Puget Sound
10:30	**Coffee**	
11:00	Kristin Connelly	Size-Selective Mortality of Hatchery and Wild Chinook Salmon (*Oncorhynchus tshawytscha*) in Puget Sound
11:20	Cameron Freshwater	Ecological drivers of covariance in productivity among Fraser River sockeye salmon conservation units
11:40	Eric Hertz	Patterns in salmon dynamics in space and time on the Central Coast of British Columbia
12:00	**Lunch**	
1:00	James Losee	Recent trends in abundance of Pacific Salmon in Puget Sound
1:20	Jim Anderson	Model linking SAR to smolt growth, size and predator size distributions.
1:40	Neala Kendall	Declining patterns of Pacific Northwest steelhead trout adult abundance and smolt survival in the ocean
2:00	Chrys Neville	The future of Chinook salmon rearing as juveniles in the Strait of Georgia
2:20	Chris Kondzela	Distribution of chum salmon stocks intercepted in Alaska groundfish fisheries
2:40	**Coffee**	
3:10	Bill Peterson	TBD
3:30	Cheryl Morgan	Good ocean? Bad ocean? Depends on who you ask
3:50	Jim Murphy	Southeast Alaska Coastal Monitoring
4:10	Mark Saunders	The International Year of the Salmon
4:45	**Happy Hour**	
5:00	Posters	
6:30	Banquet	

2017 Salmon Ocean Ecology Meeting

Thursday, 23 March

8:00	**Coffee/Registration**	
8:20	Welcome	
8:30	Skip McKinnell	Hunting Extrema in the Salty Salmosphere
9:30	Ric Brodeur	Predation impact by juvenile salmon on early life stages of northern anchovy off the west coast during summer months
9:50	Whitney Friedman	Environmental and geographic relationships to salmon forage assemblages along the continental shelf of the California Current.
10:10	Michael Arbeider	Preferred prey hotspots for juvenile salmon in the Skeena estuary
10:30	**Coffee**	
11:00	Jennifer Gardner	Interannual Comparison of Habitat Use, Growth, and Diet Composition of Hatchery and Wild Chinook Salmon (*Oncorhynchus tshawytscha*) in Puget Sound
11:20	Elizabeth Daly	Feeding ecology of salmon in eastern and central Gulf of Alaska
11:40	Madi Gamble	Ecological factors affecting stage-specific growth of hatchery and wild Chinook salmon (*Oncorhynchus tshawytscha*) in Puget Sound
12:00	**Lunch**	
1:00	Iris Kemp	Developing a cross-border, multi-habitat comparison of diet content in juvenile Salish Sea Chinook salmon
1:20	Jacob Weil	A hyperiid amphipod trophically links a large scyphozoan jellyfish to juvenile Chinook Salmon in the Salish Sea
1:40	Emma Pascoe	Quantifying interannual variability in the condition of juvenile Pacific herring (*Clupea pallasii*) in the Strait of Georgia, BC
2:00	Laurie Weitkamp	Juvenile salmon during the downstream migration in the Columbia River: more complicated that we expected!
2:20	David Stormer	The Cost of Living in a Warming World: Physiological and Behavioral Response of Juvenile Chinook Salmon to Simulated Seasonal Water Temperature
2:40	**Coffee**	
3:10	Jessica Miller	Migratory patterns of Snake River spring Chinook salmon: comparison of hatchery and presumably wild yearlings
3:30	Christine Stevenson	Impacts of physiological condition and age on migration survival and behaviour of sockeye salmon smolts (*Oncorhynchus nerka*)
3:50	Lance Campbell	Successful juvenile life history strategies in returning adult Chinook from five Puget Sound populations

2017 Salmon Ocean Ecology Meeting

Thursday, 23 March (cont.)

4:10	Steve Healy	Smolt migration through the Salish Sea: routes and survival for hatchery steelhead (*Oncorhynchus mykiss*)
4:30	Jen Zamon	Spatial and temporal variation in ocean avian predation risk to Columbia River Chinook salmon
4:50		Final Remarks

Poster Session (Wednesday evening)

Andrew Claiborne	Correspondence between scale growth and survival of adult Chinook salmon returning to Puget Sound and Coastal Washington: implications for forecasting
Elizabeth Daly	Warm ocean conditions in 2016 reflected in trophic and physical characteristics of Chinook salmon and their prey
Will Duguid	Fine scale oceanography and the ecology of juvenile Chinook Salmon in the Salish Sea
Cameron Freshwater	Density-dependent effects on juvenile sockeye salmon size, growth, and migration during early marine residence
Jenn Gosselin	Conservation planning for freshwater carryover effects on Chinook salmon survival across different large-scale marine conditions
Jackie King	Building a Report Card for West Coast Vancouver Island Coho Salmon
Angelica Munguia.	Potential indicators of habitat use: diet and stable isotope composition during juvenile migration through the lower Columba River and estuary
Tanya Rogers	State-dependence of predation pressure on juvenile Chinook salmon in the California Current Ecosystem
Jeff Rutter	Exploring Differential Survival Using Simple Models
Rusty Sweeting	Diet of Chinook (*Oncorhynchus tshawystcha*) and coho (*O. kisutch*) salmon in the Strait of Georgia, and the importance of pelagic fishes.
Don Van Doornik	Stock specific abundance of Columbia River juvenile Chinook salmon in the Gulf of Alaska
Scott Vulstek	Long-term changes in length at maturity of Pacific salmon in Auke Creek, Alaska
Jordan Watson	Response of juvenile Chinook salmon abundance to increasing temperatures in the Northern Bering Sea

Note: Prior to the meeting, all abstracts will be available on the Meeting website. With author permission, all presentations (in PDF format) will be available following the meeting. Website: https://www.nwfsc.noaa.gov/news/events/salmon_ocean_ecology_meeting_2017.cfm

Model linking SAR to smolt growth, size and predator size distributions.

James J. Anderson

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Oral

A major challenge in salmonid management is in understanding and predicting adult returns, i.e. Smolt-to-Adult-Ratio (SAR). For Columbia River salmon, studies have demonstrated correlations of SAR with date and fish size at ocean entrance, ocean growth rate and various physical and biological measures of the coastal marine environment. None of these studies has a mechanistic basis. This talk links these factors through a three-parameter model based on gape-limited predation in which X0 characterizes juvenile fish ocean-entrance size relative to the size distribution of predators, H characterizes the number of predators a fish encounters while vulnerable to gape-limited predation and B characterizes the effect of size on compensatory growth. The model quantifies the relative effects of size and growth rate on SAR and the transition between high mortality during ocean entrance and low mortality of returning adults. The model also offers a new and unique perspective for viewing the effects of predator heterogeneity and freshwater experience on SAR. Finally, because the model parameters can be estimated from size and SAR, it is plausible to forecast SAR by establishing relationships of the parameters with biological and physical measures of the marine and freshwater environments.

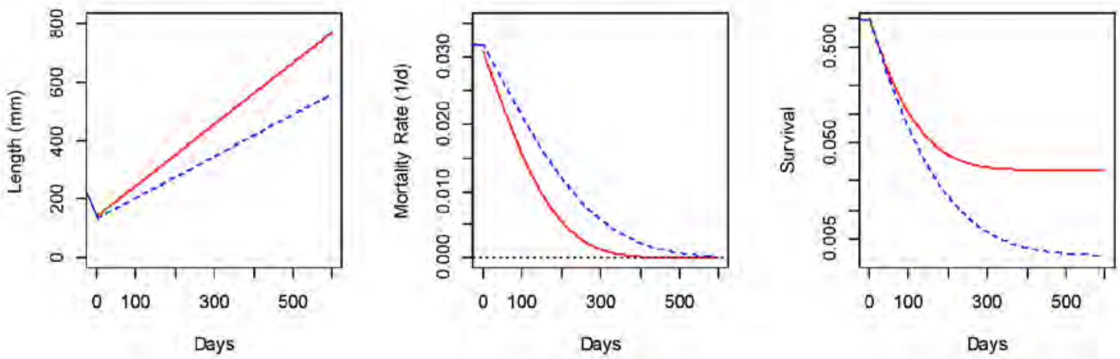

Figure 1. Modeled temporal distributions of growth, mortality rate and log survival for Columbia River spring Chinook salmon over two years of ocean residence. Curves derived from model fits of smolt length vs. SAR for 2008 (—) and 2009 (—) out migrations.

Preferred prey hotspots for juvenile salmon in the Skeena estuary

Michael Arbeider[1], Charmaine Carr-Harris[2], Ciara Sharpe[1], Jonathan W Moore[1]

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Abstract: Food web interactions can control the dynamics of salmon (*Oncorhynchus* sp.) populations. Estuary food webs and habitat provide nurseries for a myriad of fishes, including juvenile salmon, whose population dynamics and habitat preferences may be controlled by prey abundance and distribution. For example, juvenile salmon can rear for extended periods in estuaries where they feed and grow during their residency. On-going collaborative research between First Nations fisheries programs and Simon Fraser University have been investigating juvenile salmon food webs and habitat use in the estuary of the Skeena river. The Skeena is the second-largest salmon watershed in Canada and its estuary is poised for major industrial developments that coincide with areas of high juvenile salmon abundance. We surveyed zooplankton and fish communities and analyzed salmon diets across the lower Skeena estuary. We identified preferred prey for sockeye (*O. nerka*) and coho salmon (*O. kisutch*) and sites that contain higher abundances of important salmon prey. Coho salmon selected for larval fish the most but both gastropod larvae and larval fish had high Index of Relative Importance (IRI) scores. Sockeye salmon were more generalist in their selectivity but harpacticoid copepod's IRI score was 2.5 times higher than average. We linked this information with zooplankton abundance across time throughout the estuary to map locations of prey hotspots. There was substantial variation across the estuary in terms of the abundance of preferred prey and abundance hotspots did not correlate predictably with any combination of abiotic or habitat variables. This research is a step towards understanding the food-web component of juvenile salmon habitat use in an estuary at a key point in its planning and development trajectory.

Predation impact by juvenile salmon on early life stages of northern anchovy off the west coast during summer months

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*presenter

Oral

Abstract: Although predation is thought to be the major limiting factor in fish recruitment, there have been few studies examining the effects of predators on prey populations. Juvenile Chinook and coho salmon are highly piscivorous (60-90% of their diets by weight) in their first summer at sea and are likely to be one of the most important fish predators on larval and juvenile fishes in coastal waters. The aim of this study was to examine the consumption of larval and juvenile Northern anchovy (Engraulis mordax) prey by Chinook and coho salmon in coastal regions of the Northern California Current (Oregon and Washington) by: 1) examining proportions of the anchovy prey in the diets of each predator by season and year and comparing these to available anchovy from contemporary trawl sampling, 2) comparing sizes of anchovy prey consumed relative to available sizes from the trawl sampling, and 3) estimating overall anchovy consumption by coho and Chinook salmon using bioenergetics modeling. Juvenile anchovies were the dominant prey consumed in late summer and fall by Chinook salmon over a seven year period (2005-2011), and in monthly sampling off the Columbia River in summer of 2011 and 2012, but they were of lesser importance to coho salmon. Anchovy prey sizes ranged from >10 mm to <100 mm, and size-selectivity of anchovy prey varied by salmon species and study. Consumption rates of larval and juvenile anchovy by Chinook salmon, and to a lesser extent coho salmon, indicated that a substantial portion of the anchovy population was consumed over the years examined and suggests that predation may be a factor in regulating anchovy survival in some years.

Successful juvenile life history strategies in returning adult Chinook from five Puget Sound populations

Lance Campbell, Andrew Claiborne, Joe Anderson, Evelyn Brown, Andrew Fowler, Aaron Bosworth, Nathaniel Overman, James Losee, Tara Livingood-Schott, Matt McDonald, Jamieson Atkinson, Kevin Pellet, Dan Bottom, Kim Jones, Michael Schmidt

Workshop

Growing evidence suggests juvenile Chinook salmon (*Oncorhynchus tshawytscha*), can utilize portions of both freshwater and salt water components of estuaries before full seaward migration. However a clear link between juvenile outmigration strategies (early fry, late parr) and successful returning adults has not been made. To test the hypothesis that early migrants (and potentially estuary rearing juveniles) contribute to adult populations, we recovered adult otolith samples on the spawning grounds of five Puget Sound populations. Laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) was used to analyze chemical patterns in otoliths. Otolith microchemistry was used to estimate the size and timing of juvenile outmigration for selected adult populations. The success of fry (<60mm) parr (>60mm) and yearling smolts were documented in the 5 watersheds examined. Apparent differences in life history expression were found between geographic regions (northern vs mid and southern Puget Sound). Where the success of the early fry migrant appeared to be related to geographic location, and estuarine habitat quality.

Correspondence between scale growth and survival of adult Chinook salmon returning to Puget Sound and Coastal Washington: implications for forecasting

Andrew Claiborne[1], Lance Campbell[1], and Joe Anderson[1]

[1]Washington Department of Fish and Wildlife

Oral

Marine survival of Pacific salmon (Oncorhynchus spp.) is influenced by a variety of abiotic, biotic and anthropogenic factors. In this study, we used scale analysis of returning adults to examine the relationship between early marine growth and survival for 3 Puget Sound and 2 coastal populations of Chinook salmon (O. tshawytscha). In total, we examined scales from 2,604 individuals over 7 outmigration years characterized by relatively poor, average, and good survival from 1976 to 2008. We observed a positive relationship between growth during the first year at sea and survival for adults returning to the Skagit, Green/Duwamish, and Puyallup Rivers. In addition, growth of age 31 fish from north and mid Puget Sound was a useful predictor of cohort survival (age 31 to 51). Conversely, we observed no evidence of a relationship between growth and survival for fish returning to the Quillayute River but, on average, fish returning to northern costal Washington grew 14% (SD = 9%) more during the first year at sea than Puget Sound populations. These results support previous research that factors influencing early marine growth (i.e. prey abundance and quality) are important to the survival of Puget Sound Chinook salmon. In addition, early marine growth may a useful biological indicator for pre-season forecasting of some Chinook salmon populations in Puget Sound.

Size-Selective Mortality of Hatchery and Wild Chinook Salmon (Oncorhynchus tshawytscha) in Puget Sound

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*Presenter (Email: kconnel@uw.edu, Tel: 206-619-4252)

Oral

Evidence of size-selective mortality has been observed for Pacific Salmon during juvenile life history stages. Understanding the mechanisms and dynamics of size-selective mortality may allow for more informed recruitment estimates and direct management actions toward locations and times critical to juvenile growth and survival. We used a fine-scale sampling scheme to determine if, when and where size-selective mortality affects juvenile Chinook salmon (Oncorhynchus tshawytscha) in Puget Sound, a region that has seen drastic declines in Chinook salmon marine survival rates since the 1980's. In 2014 and 2015, we followed nine cohorts of sub-yearling Chinook salmon smolts (seven hatchery release groups and two wild populations) from four different rivers through their outmigration and first marine summer. We measured fish lengths and weights, and took scale samples from each cohort at hatchery release, and in freshwater, estuarine, nearshore marine, and offshore epi-pelagic habitats, to identify changes in the average back-calculated growth history of each cohort among and within habitats and periods. We also compared the intensity of size-selective mortality among cohorts to determine whether size-selective processes were disproportionally affecting certain cohorts or mark types (natural-origin versus hatchery-produced). Water temperatures in Puget Sound were anomalously warm during spring and summer of 2015. The results of our two years of sampling were compared to assess inter-annual variability potentially linked to environmental conditions. Preliminary results suggest that there was little to no size-selective mortality operating on Puget Sound sub-yearling Chinook smolts during our 2014-2015 sampling period, and there was no evidence that a singular habitat or period is most linked to survival. This study has improved our understanding of growth dynamics and size-selective mortality during early life history stages, and suggests that multiple habitats and periods may be critical for juvenile Chinook salmon growth and survival in Puget Sound.

Fate and Condition of Pacific Salmon Released from Commercial Purse Seine Fisheries: Results from Marine Holding Studies and Lessons from Fishers.

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Oral

Abstract: Commercial fisheries for Pacific Salmon in coastal British Columbia (BC) capture a mixture of co-migrating populations and species, some which have sufficient numbers to sustain exploitation and others that do not and must be released. This research aims to evaluate how capture stressors impact Pacific salmon released from commercial fisheries and how changes in handling could potentially improve post-release survival. Physical injury and impairment as well as physiological and genomic responses to capture stress have been quantified to reveal how fish condition changes with commercial capture scenarios of varying severity. Through years of research, the magnitude of injury sustained during capture has consistently emerged as an indicator of survival. We have therefore begun to explore how capture-induced injury influences immune health and pathogen development in the days following release and how fisheries could be modified to reduce injury. Although the resulting data has great potential to inform appropriate handling measures that would maximize the potential for a successful live release in commercial Pacific salmon purse seine fisheries, ample knowledge mobilization research has revealed that such scientific results are often not effectively integrated into management without direct engagement with stakeholders. To evaluate the perspectives of the BC commercial purse seine fleet on the issues facing the industry, interview-based research was conducted. These qualitative results will help both scientists and managers to better understand the factors influencing the willingness of fishers to adopt handling methods that may improve the survival of released fish, and will work towards achieving practical solutions to management issues.

Warm ocean conditions in 2016 reflected in trophic and physical characteristics of Chinook salmon and their prey

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[3]Pacific States Marine Fisheries Commission, Newport, Oregon 97365, USA

Poster

Abstract: The biomass and composition of fish larvae in late winter provides an index of juvenile fish that are the common prey of juvenile salmon as they out-migrate, and is related to salmon adult returns. In 2016, the biomass was above average, while the composition was poor. Yearling Chinook salmon (Oncorhynchus tshawytscha) were highly piscivorous in May and June of 2016, similar to other warm-ocean years, and ate warm-ocean prey taxa including: juvenile rockfish, anchovy (June), and sardines. In May, they also consumed high amounts of juvenile cottids, which are typically cold-water taxa. The juvenile sardines eaten in May and June represent the only occurrence of this species in the salmon diets recorded during the 19-y time-series. Sardine had an anomalously early timing and inshore location of spawning in 2016 due to the warm ocean conditions- whereby they were of a sufficient prey size for Chinook salmon to consume in May and June, albeit in small amounts. Stomach fullness was 2nd highest of the time-series in May, similar to other warm ocean conditions, and above average in June. Typically in warm ocean conditions, the salmon are thin for their length in May, but in 2016, they were close to average. This suggests that the amount of food available to the juvenile salmon during the warm-ocean year of 2016 may have been sufficient for their early marine growth. Condition of the June yearling Chinook salmon was the highest of the time-series, but the stock composition of the yearlings caught in June 2016 was highly anomalous, and thus we cannot conclude that the salmon were directly comparable to other years. The salmon were small in May of 2016, like other warm years, and the smallest of the time-series in June.

Feeding ecology of salmon in eastern and central Gulf of Alaska

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Oral

Abstract: Trophic habits of five Pacific salmon species caught in the marine waters of the eastern and central regions of the Gulf of Alaska (GOA) were analyzed for spatial, interannual, seasonal, and ontogenetic differences. For all the salmon, diets were most different interspecifically, with the piscivorous (Chinook and coho salmon) and planktivorous (chum, sockeye and pink salmon) being highly different from each other, and only juvenile pink and sockeye salmon did not have significant diet differences from each other. The diets of the salmon were also highly different between years (all tested pairs were significant), followed by ontogenetic changes (> 90% pairs were significantly different), seasonal differences (60% different), and lastly eastern and central GOA diet differences were significant in approximately 50% of the comparisons. Synchronous prey increases were observed in most of the salmon in a year, such as more euphausiids were eaten by the salmon in 2010, or pteropods in 2014, or capelin by the piscivorous salmon in 2013. Stomach fullness for the juvenile salmon in EGOA, was low in 2011 and 2013, average in 2014, and high in 2010 and 2012, and in WGOA, 2013 was lower than 2011-12. We also examined the condition of the juvenile salmon based on their length and weight, and the salmon were in lowest condition in 2011 (thinnest), most were of their highest condition in 2013 (fattest), and all juvenile salmon were in positive condition in 2014 (slightly fatter than average). Interannual fluctuation in the GOA ecosystem appeared to impact this diverse group of salmon similarly. While the salmon in the GOA primarily fed on different prey, they would uniformly consume particular prey types in higher amounts in specific years, had similar patterns of stomach fullness in a year, and also had similar fluctuations in their condition in a given year.

Fine scale oceanography and the ecology of juvenile Chinook Salmon in the Salish Sea

William Duguid and Francis Juanes

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While many juvenile Pacific Salmon migrate rapidly onto the continental shelf, some stocks remain in coastal basins and inlets through their first marine summer. Epipelagic habitats in these regions may be highly structured: wind and tidal currents interact with complex topography, resulting in spatial variability in water column stratification and generating hydrological features including tidal jets. This structure may result in regions where conditions conducive to rapid growth lead to predictable concentrations of juvenile salmon; potentially modulating both intraspecific density dependence and interactions with higher and lower trophic levels. We are employing a flexible, low cost, small vessel based approach (microtrolling), coupled with sampling of zooplankton and water column properties, to investigate distribution, diet and growth of juvenile Chinook Salmon in Salish Sea. Our results suggest that diet and growth of juvenile salmon varies between spatially adjacent but oceanographically dissimilar sites. Furthermore, distribution and/or feeding activity is in some cases spatiotemporally structured by tidal forcing at scales of 100s of meters or less. Understanding utilization of foraging hotspots should inform attempts to determine factors controlling early marine survival in the Salish Sea and provide general insights into how behavior interacts with fine scale oceanography to influence the ecology of juvenile salmon.

Density-dependent effects on juvenile sockeye salmon size, growth, and migration during early marine residence

Cameron Freshwater[1], Marc Trudel[1,2], Terry Beacham[3], Sue Grant[4], Stewart Johnson[3], Chrys Neville[3], and Francis Juanes[1]

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[4]Fisheries and Oceans Canada, Delta BC, Canada (sue.grant@dfo-mpo.gc.ca)

Poster

We tested for density-dependent effects on the body size, growth, and marine migratory rate of juvenile sockeye salmon (Oncorhynchus nerka) in two years with contrasting competitor densities during their early marine life. Juvenile sockeye salmon entering the marine environment during a year with high competitor densities (conspecifics and nine other pelagic species groups) were approximately 12 mm smaller and entered the ocean almost a week earlier. Shifts between the high- and low-density years in entry size, but not entry date, were strongest in nursery lakes with high parental spawner abundance and are consistent with freshwater density-dependent effects. Mean daily growth rates of sockeye salmon during early marine residence did not vary between years after accounting for variation in ocean entry characteristics, even though the catch-per-unit-effort of the most abundant juvenile salmon species increased more than five-fold. However, juvenile sockeye salmon entering in the high-density year did migrate away from their ocean entry points significantly more rapidly (estimated 40% increase in bl sec-1). Our results suggest that juvenile sockeye salmon growth during early marine residency may not be strongly limited by competition and that shifts in marine migratory rate or spatial distribution may buffer individuals from competitive interactions.

Ecological drivers of covariance in productivity among Fraser River sockeye salmon conservation units

Cameron Freshwater[1], Brian Burke[2], Eric Buhle[2], Mark Scheuerell[2], Sue C.H. Grant[3], Marc Trudel[1,4], and Francis Juanes[1]

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Oral

Although the importance of diversity to maintaining metapopulation stability is widely recognized, the ecological characteristics that lead to synchronous or divergent dynamics are often unclear. We used dynamic factor analysis to explore patterns of covariance among Fraser River sockeye salmon conservation units (CUs) and determine whether coherent trends in productivity were best predicted by the spatial characteristics of nursery lakes, return migration phenology, genetic similarity, or early marine migratory traits. The top-ranked model identified two coherent trends – one representing the dynamics of 16 CUs that rear in nursery lakes prior to ocean entry and a second for the single sea-type CU included here, Harrison River. The uniform response of lake-type CUs, as well as Harrison River CU's unique ocean life history, suggests that variation in Fraser River sockeye salmon productivity is moderated by large-scale, regional mechanisms, which may influence marine growth or survival. Furthermore, we document that productivity among Fraser River CUs has become increasingly synchronous, which suggests the importance of large-scale marine drivers may have increased relative to local processes occurring during freshwater residence. Given the apparent disconnect between ecological diversity and asynchrony among Fraser River sockeye salmon CUs, our results suggest there may be relatively little benefit to preserving specific population groups and conservation efforts should emphasize sustaining the maximum number of CUs possible.

Environmental and geographic relationships to salmon forage assemblages along the continental shelf of the California Current.

Whitney Friedman, Brian K. Wells, Jarrod A. Santora, Isaac D. Schroeder, David D. Huff, Richard Brodeur, John C. Field.

Oral

This study extends prior research to relate oceanographic and biogeographic variables to juvenile Chinook salmon forage assemblages along the California Current Large Marine Ecosystem (CCLME). Early ocean entry is a critical period in the life history of juvenile Chinook salmon during which recruitment typically is set. Early survival is affected by availability of suitable prey on the continental shelf during the first few critical weeks after of ocean entry. Therefore, quantifying the spatial coherence of salmon forage assemblages and associated environmental conditions along the CCLME may elucidate coherence of salmon population survivals as well. We describe the distribution of marine micronekton assemblages relative to biogeographic and oceanographic conditions along the California Current shelf ecosystem from Monterey CA (36.5°N) to Willapa Bay, WA (46.5°N). Nekton samples were collected on the shelf (<=200m) during May-June, 2011, 2013, 2014, and 2015. We used non-metric multidimensional scaling to identify samples that were similar based on their catch composition. There was a latitudinal gradient in the forage compositions. Collections made south of Cape Blanco (42°50' N) were characterized by market squid (Doryteuthis), sanddabs (Citharichthys), turbot (Pleuronichthys), sculpin (Cottidae), and rockfishes (Sebastes), whereas northern communities were more likely to include butter/rock sole (Pleuronectidae). We identified five oceanographic variables as strong candidates in defining these forage assemblages: temperature, northward and eastward components of Ekman transport centered at the time and region of each trawl, as well as upwelling and the 26.0 isopycnal depth centered on trawl locations 4 months before each sample event. Regression-tree analysis and generalized additive models revealed southern forage assemblages were associated with positive upwelling and a deeper depth of the 26.0 isopycnal 4 months prior to the survey, as well as onshore and weak equatorward transport during the time of the survey. Northern forage assemblages were characterized by downwelling and shallower isopycnal depths 4 months prior to the trawl and stronger equatorward transport during the survey period. Krill was most abundant in the southern range of the study and significantly related to the depth of the 26.0 isopycnal depth.

Ecological factors affecting stage-specific growth of hatchery and wild Chinook salmon (Oncorhynchus tshawytscha) in Puget Sound

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Oral

Abstract: Size-selective mortality is a prevalent force regulating marine survival for many anadromous salmonid species, including ESA-listed Chinook salmon (Oncorhynchus tshawytscha) in Puget Sound, WA. However, there is no strong evidence that size-selective mortality acts on juvenile Chinook between marine entry and a previously identified critical growth period associated with offshore feeding through July of the first marine growth season. Therefore, growth achieved through mid-summer could influence size-related survival bottlenecks at later life stages. The objectives of this study were to compare the weights and growth rates of juvenile Chinook from different populations across habitats and time during their first marine growth season in Puget Sound and to determine how prey quality, prey availability, or water temperature influenced growth rate differences. To address these objectives we repeatedly sampled seven hatchery-origin and two wild stocks of sub-yearling Chinook every two weeks in nearshore marine and offshore epi-pelagic habitats associated with four major rivers flowing into Puget Sound. During each sampling event we recorded juvenile weights, took diet samples, and measured water temperature. We used bioenergetics models to examine the relative roles of prey quality, prey availability, and temperature in regulating stage-specific growth rates of juvenile Chinook across stocks, habitats, and time. Juvenile Chinook in all stocks were larger and grew faster in offshore habitats than juveniles sampled concurrently in nearshore habitats. Diet analysis and bioenergetics modeling suggested that differences in feeding rate and water temperature interacted to confer higher growth rates in offshore habitats. Feeding rates were generally low across Puget Sound, suggesting that prey availability limited overall early marine growth. Growth was relatively insensitive to temperature fluctuations in offshore habitats, whereas warmer temperatures in more than half of the observed nearshore growth periods reduced growth considerably under the feeding rates estimated by model simulations.

Interannual Comparison of Habitat Use, Growth, and Diet Composition of Hatchery and Wild Chinook Salmon (Oncorhynchus tshawytscha) in Puget Sound

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Oral

The marine survival rates of Chinook salmon (Oncorhynchus tshawytscha) stocks in the Salish Sea have been in decline since the 1980s but the same trend has not been seen for stocks from adjacent regions along the west coast of Washington and Vancouver Island. It is necessary to determine factors that may be driving this decline within the Salish Sea in order to inform management plans and develop recovery strategies. As part of the Salish Sea Marine Survival Project, juvenile Chinook salmon were rigorously sampled every two weeks during the course of their outmigration in both 2014 and 2015. Sampling efforts were focused on four different rivers and their associated estuarine and nearshore habitats, and offshore basins within Puget Sound. These efforts successfully sampled enough fish in each habitat to identify and follow seven hatchery and two wild stocks through their outmigration and early marine residence both years. We compared habitat usage and outmigration timing among stocks and between years. We were also able to compare growth and diet composition between stocks, habitats and sampling years. Diets in both years showed early reliance on insects in the nearshore habitats, switching to reliance on larval crab and fish prey once offshore. All seven hatchery release groups were significantly larger in the offshore habitat in July in 2015 than in 2014. This is likely due to temperature because throughout the Puget Sound offshore temperatures were significantly warmer May through July in 2015 than in 2014. This growth difference may be important as previous work has shown a strong correlation between outmigrant size by July of the first growing season and marine survival. The unexpected warmth of 2015 may have given a glimpse into what the future might hold as the climate continues to warm and what that warming could mean for Salish Sea salmon stocks.

Conservation planning for freshwater carryover effects on Chinook salmon survival across different large-scale marine conditions

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Poster presentation preferred

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Conservation of migratory species can be improved when carryover effects are considered across different habitats occupied throughout their life cycle. Experiences affecting the biological condition of individuals in one habitat may carryover to the next and influence survival. This understanding can be important to year-to-year and seasonal variations in smolt-to-adult return survival (hereafter survival), and the conservation strategy of transporting smolts through a hydropower system. We investigated the relationships of Chinook salmon survival with fish history through the hydropower system of the Snake and Columbia rivers (Idaho, Washington and Oregon, USA), local river conditions, estuarine and coastal ocean environments, and a large-scale ocean index. Three types of factors tested were rear-type (hatchery vs. wild), passage-type (run-of-river vs. transported), and covariates experienced. The study included 1.2 million tagged fish over outmigration years 1999-2013 in our analyses using generalized linear mixed effects modeling. The relative effect of transportation on survival was also assessed. The largest effects on survival were a categorical index of the Pacific Decadal Oscillation (PDO) designating year-to-year cool/warm ocean phases, and smolt migration date highlighting seasonal patterns. Survival was higher in cool than warm PDO years. Seasonally, survival increased then decreased, except for the wild, run-of-river type, which showed a seasonal decline. The relative benefit of transportation was greater for wild Chinook in cool PDO years, but greater for hatchery Chinook in warm PDO years. Transportation was disadvantageous for wild Chinook survival early in the season, but generally beneficial to hatchery counterparts through the season. The study indicates that survival benefits of transporting smolts through highly modified rivers, to mitigate for direct mortality, are influenced by rear-type, migration timing and the PDO phase. Data available pre- and within-season in both freshwater and marine systems can be used for more effective implementation of conservation strategies.

Smolt migration through the Salish Sea: routes and survival for hatchery steelhead (Oncorhynchus mykiss)

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Oral

Abstract: The Salish Sea has been labelled as a potentially critical region of migration for Pacific salmonid smolts, yet little is known regarding movement behavior and survival here. For steelhead (Oncorhynchus mykiss) smolts, spatiotemporal variability in movement patterns, such as individualized routes, has the potential to influence survival though this marine water body. To investigate route-specific movements and survival during outmigration, we surgically implanted acoustic tags into 243 hatchery steelhead smolts and tracked their migration through coastal British Columbia for up to ~400 km from their freshwater release. Survival was lowest in the river, and in the first marine inlet smolts encountered upon leaving the estuary. Smolts transported and released beyond this inlet had survival over twice as high to the first marine array compared to smolts released in the river. Survival in all other migratory segments was similar between groups, suggesting that the first marine inlet is a region particularly poor survival for outmigrating steelhead smolts. Cumulative survival to the final marine array (~400 km from river release) was 27.3% and 9.1% for marine-released and river-released smolts, respectively. Route-specific survival was detected though a series of channels ~200 km from release, with survival in the westernmost route estimated to be over twice as high compared to other channels through this region. This westernmost passage was also more favored by smolts, with 77% of individuals selecting this route. Migration rates increased through these channels, suggesting the influence of strong tidally-driven currents in this region. 'Milling patterns', such as reversals in migration direction or lateral movements along an array were detected in ~10% of tagged smolts. Our findings highlight critical regions of the migration, and demonstrate route-specific survival of a migrant organism, for which examples remain rare in migration ecology.

Patterns in salmon dynamics in space and time on the Central Coast of British Columbia

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Oral

Understanding the population dynamics of salmon is important for conservation and management, but the factors driving spatial and temporal variation in salmon populations remain poorly understood. Understanding these patterns in abundance is important for coastal First Nations, who in recent years have taken on an increased role of the management of salmon in their traditional territories. Using data from 200 unique spawning locations on the Central Coast of British Columbia, we quantified shared patterns in abundance of salmon over space and time, and measured the extent to which portfolio effects stabilize variation in stocks over time. We found strong declines in Sockeye Salmon abundance across the central coast, which was accompanied by an increase in the covariation among stocks. Chum and Pink Salmon also showed generally similar patterns, though the odd-year lineage of Pink Salmon showed increased abundance in recent years. We suggest that ocean conditions operating on broad scales may be responsible for the spatial and temporal patterns observed. This research facilitated a common understanding—among First Nations, fisheries managers, biologists, and non-governmental organizations—of patterns and knowledge gaps revealed by existing data. This is a first and critical step towards understanding potential drivers of the dynamics of salmon populations, and the regional economies that depend on them.

Does Abundance of Coastal Pelagic Species Affect Survival of Juvenile Salmon During Early Marine Residence?

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Workshop

What is the relationship among coastal pelagic fish, aka "forage fish", and juvenile Pacific salmon? Do adult coastal pelagic fish compete for prey with juvenile salmon during early marine residence, or do they benefit juvenile salmon by serving as a buffer from predation? A third possibility is no effect of small pelagics on juvenile salmon. Diet overlap studies conducted to date have shown little overlap among juvenile salmonids and coastal pelagic fish (Miller et al. 2010, Jacobson et al. 2012, Hill et al. 2015). However, these studies were conducted during years of relatively cool ocean conditions, would this change under warm ocean conditions as the prey base may change in both species composition and abundance? Or might this change as abundance of salmon or forage fish changes and prey abundance changes? If no direct diet overlap exists, is there an indirect effect of the food web that could still negatively affect juvenile salmon growth and survival? An alternative interaction could be a positive one. Emmett and Sampson (2007) developed a trophic model to examine the interaction between forage fish abundance, juvenile salmonids and predation by Pacific hake. Their model showed that when hake numbers are relatively low and forage fish abundances are high that hake eat relatively few salmonids, but when hake are abundant and forage fish are not, there is a strong increase in the number of juvenile salmon eaten by hake. They concluded that a similar study should be done with other predators. Do we have the definitive answer on the interactions among coastal pelagic fishes and juvenile salmon? Do we need it? What new data would we need and how do we get it?

Developing a cross-border, multi-habitat comparison of diet content in juvenile Salish Sea Chinook salmon

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Oral

Declining returns of Salish Sea Chinook, coho, and steelhead over recent decades have driven efforts to understand the factors contributing to juvenile survival in the marine environment. One important factor affecting marine survival may be regional prey availability and feeding patterns during outmigration; a positive relationship has been shown between juvenile Chinook salmon summer weight and overall marine survival. To investigate this hypothesis, researchers implemented a Salish Sea-wide sampling program for juvenile salmon to examine estuarine and early marine feeding, growth, and survival within the Salish Sea. The Nisqually, Snohomish, Skagit, Nooksack Rivers, and the San Juan Islands (United States), and the Cowichan, Big Qualicum, and Puntledge Rivers (Canada) were selected for intensive sampling. Chinook salmon were collected in freshwater, nearshore, and offshore habitats of these watersheds February-October, 2014-2015 (U.S.) and April-August, 2013-2016 (Canada) using a variety of sampling methods (smolt traps, fyke nets, river seines, beach seines, and purse seines). These collections produced extensive U.S. and Canadian datasets on Salish Sea Chinook salmon outmigrants. Previous data suggested regional variation in Chinook salmon feeding habits, but a fully-integrated cross-border analysis on this scale has not been conducted. In this presentation, we review the challenges of calibrating datasets across multiple field and lab groups, with a focus on issues specific to gut content data, and present preliminary results on outmigrating juvenile Chinook salmon feeding habits observed in U.S.-Canadian beach and purse seine collections.

Declining patterns of Pacific Northwest steelhead trout adult abundance and smolt survival in the ocean

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Oral

Abstract: Examination of population abundance and survival trends over space and time can guide management and conservation actions with information about the spatial and temporal scale of factors affecting them. Here, we analyzed steelhead trout (anadromous Oncorhynchus mykiss) adult abundance time series from 35 coastal British Columbia and Washington populations along with smolt-to-adult return ("smolt survival") time series from 48 populations from Washington, Oregon, and the Keogh River in BC. Over 80% of the populations have declined in abundance since 1980. A multivariate autoregressive state space (MARSS) model revealed smolt survival 4 groupings: Washington and Oregon coast, lower Columbia River, Strait of Juan de Fuca, and Puget Sound/Keogh River populations. Declines in smolt survival rates were seen for 3 of the 4 groupings. Puget Sound and Keogh River populations have experienced low rates since the early 1990s. Correlations between population pairs' time series and distance apart illustrated that smolt survival rates were more positively correlated for proximate populations, suggesting that important processes, including those related to ocean survival, occur early in the marine life of steelhead.

Building a Report Card for West Coast Vancouver Island Coho Salmon

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Poster

Abstract: The smolt survival of coho salmon from the west coast of Vancouver Island (WCVI) has been shown to be positively correlated to first marine summer growth rates. Estimates of this summer growth have been used, along with other indices, to forecast marine survival and return abundance of coho salmon for WCVI stocks. However, in most recent years it has been large-scale climate ocean indices, and not coho summer growth estimates, which have been aligned to observed marine survival and return abundances. Specifically, in 2014 and 2015 the May-September mean value of the North Pacific Gyre Oscillation (NPGO) index predicted the observed poor marine survival, but the coho summer growth estimates predicted the opposite. The current large-scale climate North Pacific ocean indices used are based on sea surface temperatures (SST), either spatial patterns (e.g. NPGO or Pacific Decadal Oscillation index), or local observations (e.g. lighthouse SST). We have compiled additional oceanographic and biological indices in an attempt to characterize the ecosystem state and productivity off WCVI during the early marine summer phase for coho smolts. Measures of the relative upwelling intensity, the timing of spring transition, the copepod community available and potential predators are investigated as indices for a coho salmon report card. Expanding to a suite of ecosystem indicators may help to elucidate the marine processes underlying the mechanisms of marine survival for these coho salmon stocks. We welcome feedback from participants on proposed indices and methodology.

Distribution of chum salmon stocks intercepted in Alaska groundfish fisheries

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Oral

Salmon are intercepted incidentally in federally managed Bering Sea/Aleutian Island and Gulf of Alaska groundfish fisheries. Concern over low chum and Chinook salmon returns to some western Alaska rivers and high salmon bycatch in groundfish fisheries led to genetic analysis of salmon bycatch samples to determine stock of origin. This has become one of our primary tasks at the Auke Bay Laboratories Genetics Program, with stock composition estimates presented annually to the North Pacific Fishery Management Council. Groundfish fleets span much of the eastern Bering Sea and Gulf of Alaska throughout the year, with salmon bycatch being caught across a large portion of this spatial extent. With genetic data from chum and Chinook salmon bycatch from 2005 to 2015, we now have the capacity to examine spatial-temporal distributions and variability in the stock compositions of bycatch. These spatial-temporal analyses are being examined in the context of existing salmon ocean migration models, groundfish fleet dynamics, and environmental variability across the region to better understand factors that influence interactions and impacts to salmon populations from commercial fishing.

Recent trends in abundance of Pacific Salmon in Puget Sound

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Washington Department of Fish and Wildlife, 600 Capitol Way N. 360-280-1762

Oral

All five species of Pacific Salmon (Oncorhynchus spp.) inhabit Puget Sound Washington and support robust commercial, tribal, and sport fisheries. In recent years, numerous species-specific status reports have been completed; however, formal comparisons between species are not available. The current study was designed to compare spatial and temporal patterns of abundance and marine survival between all five species of Pacific Salmon in Puget Sound, Washington. Total runsize by region was calculated from estimates of escapement (spawners) with stock-specific estimates of harvest (catch) in Puget Sound marine and freshwater. In all, the analysis includes run size at the entrance to Puget Sound (Strait of Juan de Fuca) for Chum (O. keta), Pink (O. gorbuscha), Sockeye (O. nerka), Coho (O. kisutch), and Chinook (O. tshawytscha) Salmon returning to Puget Sound for years 1970-2015. Overall, we found that trends in abundance varied by species although environmental variates explained some of the variance through time. This information combined with estimates of survival for each species will allow fisheries managers to evaluate recovery plans and harvest objectives as well as identify trends in survival as they relate to climate and life history expression.

Migratory patterns of Snake River spring Chinook salmon: comparison of hatchery and presumably wild yearlings

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Interannual variation in survival of Snake River spring Chinook salmon, which emigrate as yearlings, has been positively related to early marine growth and size attained during their first ocean summer. However, this population remains listed as "threatened" on the US Endangered Species Act, and it is unclear if hatchery and wild fish display similar patterns of migration and early marine growth. Therefore, ocean collections in 2015 and 2016 focused on collecting adequate numbers of yearlings to compare marked and unmarked individuals. We combined field collections with otolith structural and chemical analyses to determine size and timing of freshwater emigration and early marine growth. We also developed two new approaches for characterizing migration history, including a qualitative categorization of marine residence to improve our ability to compare fish with similar marine residence times and a quantitative, conservative estimate for growth and residence in the freshwater tidal portion of the lower Columbia River. The majority of unmarked yearlings were collected in 2016 ($n = 30$) but 2011, 2015, and 2016 collections were included (unmarked $n = 47$, total $n = 315$). We observed consistent and significant increases in body size and condition with greater marine residence, highlighting the rapid (~14 d) changes that occur within a population during marine migration. Overall, wild yearlings were smaller at freshwater emigration and displayed significantly more growth in freshwater tidal portions of the lower river than hatchery fish. There was evidence that wild fish emigration was slightly later and more protracted than hatchery fish. Additionally, wild fish displayed slower growth during early marine residence than hatchery fish. The observation that a substantial portion of the population (32%) had detectable growth in freshwater tidal portions of the river prior to marine entry (with 20% growing ≥4 mm) highlights the importance of habitat throughout the entire migration corridor.

Changes in harbor-seal x steelhead predator-prey interactions with variable steelhead survival rates through Puget Sound

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Presenter: Megan Moore

Oral

Abstract: Early marine survival of steelhead smolts (from river mouth to the Strait of Juan de Fuca) has been estimated at 20% or less for several populations originating in Puget Sound. This low survival rate is likely affecting overall smolt-to-adult return rates, and limiting recovery of these threatened populations. Harbor seals are a known predator of migrating steelhead smolts, and populations in Puget Sound have increased to carrying capacity over the last 30 years. Harbor seals were captured in 2014 (12 seals) and 2016 (16 seals) and outfitted with acoustic telemetry receivers and GPS tags to quantify likely predation events and estimate foraging area overlap with acoustically tagged steelhead smolts. In 2014, survival of steelhead through Central Puget Sound (Tacoma Narrows to Admiralty Inlet) was low (19%) and stationary tags were detected at harbor seal haulouts in both regions. In 2016 survival of steelhead through Central Puget Sound was high (69%), and no steelhead tags were detected stationary at harbor seal haulouts in those regions. Harbor seals outfitted with instrument packs in South Puget Sound (2016 only) detected stationary tags near haulouts in the Nisqually River estuary that accounted for approximately half of the estimated mortality in South Puget Sound. In both years, detection patterns of some tags were consistent with harbor seal movements suggesting that tagged smolts had been eaten and were being carried by harbor seals. Smolts implanted with continuously pinging tags and smolts implanted with tags that were silent for the first 10 days after release were detected in similar proportions leaving Puget Sound in 2014 (95% CI for the difference between proportions = -0.105 to 0.077) and 2016 (95% CI = -0.073 to 0.156), confirming that tag noise did not influence vulnerability to predation. This study suggests that harbor seals contribute to mortality of migrating steelhead smolts, and that the magnitude of predation can vary substantially during years of high steelhead survival.

Potential indicators of habitat use: diet and stable isotope composition during juvenile migration through the lower Columba River and estuary

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Poster

In the lower Columbia River and estuary (LCR&E), salmon recovery efforts have become more focused on wetland restoration. Although wetland residence by subyearlings has been well documented in the LCR&E, it is less clear how important these habitats are for rapidly migrating species like ESA-listed interior yearling Chinook salmon. As part of a collaborative effort to evaluate ecological benefits of restoration actions for interior juvenile salmon in the LCR&E, diet and stable isotope analyses will be combined to determine the feeding habits and food sources of emigrating yearlings. Diet analysis provides a snapshot of their last meal (< 30 hrs.), while stable isotope analysis of fin tissue can provide an integrated signal on recent diet switches (7-10 days). Reconstructing the food web of fast moving yearling Chinook salmon is challenging and requires a suite of tools. Hence, examining recent feeding and tissues with relatively fast turnover rates could provide insight on stomach fullness, diet composition and the primary producers supporting emigrating yearling salmon. Sampling occurred in 2016 and will be repeated in 2017. Fish were collected from three upper mainstem sites using a Kodiak pair trawl and at the mouth of the estuary using a purse seine. Initial data analysis focused on the threatened stock of Snake River yearling Chinook salmon collected at the uppermost riverine site and the estuary mouth. Fish at the estuary site were significantly larger and less full than fish sampled at the uppermost site. We also observed a significant shift in mean $\delta 13C$ signatures between sites, which indicates that juvenile residence times were long enough to integrate a shift in the carbon source of their prey. Further analysis of diet composition and carbon sources of salmon prey will provide additional insight on potential benefits and food web linkages to wetland habitats.

Southeast Alaska Coastal Monitoring

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The Southeast Alaska Coastal Monitoring (SECM) project has provided key ecological data on salmon ocean ecology and the epi-pelagic ecosystem of Southeast Alaska since 1997. We include a broad overview of information collected on juvenile salmon during SECM surveys, and highlight current approaches used to address salmon fisheries concerns in Southeast Alaska, including harvest forecast models for Pink Salmon fisheries. Surface trawl catch data, and origin information from coded-wire tags and otolith thermal marks provide insight into the distribution, abundance, and migratory patterns of juvenile salmon stocks within the northern region of Southeast Alaska. Data collected on juvenile growth, condition, and diet provide insight into how salmon stocks are responding to recent warming climate conditions in Southeast Alaska

The future of Chinook salmon rearing as juveniles in the Strait of Georgia

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Oral

Chinook salmon that rear as juveniles in the Strait of Georgia are important to commercial and sport fisheries and to First Nations. In addition, these southern BC Chinook salmon are a major component of the diet of Southern Resident Killer Whales. The decline in marine survival of these fish over the past three decades is well documented although the mechanisms driving the decline are not understood. The increasing temperatures over the past 60 years in rivers and in the Strait of Georgia with the relative certainty of continued increases in temperature identify the urgency to understand the factors regulating recruitment. We use DNA stock identification to show that the present interpretation of the distribution and survival of juveniles from key Chinook salmon stocks in the Strait of Georgia differs from the past understanding.

Quantifying interannual variability in the condition of juvenile Pacific herring (Clupea pallasii) in the Strait of Georgia, BC

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Oral

Pacific herring (Clupea pallasii) is an ecologically and culturally significant forage fish in the NE Pacific. Although numerous studies have focused on adult and larval Pacific herring, the juvenile stage has been largely overlooked. In particular, the extent to which variability in the growth and condition of juvenile herring may affect the food quality that they represent to their predators, such as Pacific salmon, remains unknown. Here we quantify variability in juvenile Pacific herring growth and condition in the Strait of Georgia from 2013-2016 using four proxies: Fulton's K, RNA:DNA ratios, otolith microstructure, and lipid analysis. The RNA:DNA ratio in animal tissue can provide an estimate of growth over short time periods, and is thus a good proxy for condition. RNA:DNA values in juvenile herring were higher in September 2013 compared to September 2015, though Fulton's K remained unchanged between the two years. These results may reflect a decrease in the metabolic condition of juvenile herring over time. Anomalously warm waters have been observed in the North Pacific from 2014-2015 and may have contributed to variability in growth rates and feeding success by altering the physiological responses of Pacific herring and the distribution of their prey. An analysis of herring from the Strait of Georgia after the return of typical sea surface temperatures in 2016 can aid our understanding of this connection. Otolith microstructure and lipid analyses will be used to supplement these findings and provide additional insight into patterns of interannual variability in juvenile Pacific herring growth and condition, with potential implications for the food quality that they represent to their predators.

State-dependence of predation pressure on juvenile Chinook salmon in the California Current Ecosystem

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Poster

Avian predation can be a significant source of juvenile salmon mortality; however, predation pressure on salmon is predicted to vary with available seabird forage base, which in turn may be influenced by oceanographic conditions. In this study, we use threshold autoregressive models and empirical dynamic models to test for nonlinear state-dependence of predation by Common Murres on forage fish, including juvenile Chinook salmon, using oceanographic indices as predictors. The goal is to develop better methods to predict predation pressure on juvenile salmon, and in turn salmon cohort survival, based on oceanographic indices.

Exploring Differential Survival Using Simple Models

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Poster

A profound difference between the survival of hatchery and wild-reared Columbia River Basin spring/summer Chinook salmon has been observed. Most notably, hatchery fish experience much greater mortality than wild-reared fish of the same size. This work explores possible causal mechanisms for this difference. I used a simple model integrating the effects of mortality (both size-selective and not), food availability/growth, and transit time. This model allowed me to explore how observed differences in survival might be attributable to each of these four areas. Since survival in the early ocean stage of migration is strongly associated with overall return strength, I focused on the geographic area from the mouth of the Columbia River to Willapa Bay. Using existing studies, I laid out plausible ranges for parameters and explored necessary changes in parameters between groups which could result in the observed difference in SAR. The explanations requiring the smallest total adjustment in parameters between the groups included substantial differences in transit time and both size-selective and size-independent mortality. Differences in growth rate played no significant role. This suggests behavioral and/or physiological differences leading to greater susceptibility of hatchery fish.

Impacts of physiological condition and age on migration survival and behaviour of sockeye salmon smolts (Oncorhynchus nerka)

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Oral

Abstract: Over the past 5 years, we have tracked ~2000 age-2 Chilko Lake sockeye smolts (Oncorhynchus nerka) from freshwater rearing to coastal regions. Particularly low survival (57–78%) was consistently observed during migration in the upper-river reaches (80 km distance). Key factors contributing to smolt mortality include predation, osmoregulatory failure, and microbes. However, ~96% of Chilko Lake sockeye smolts emigrate at age-1, and their survival and behaviour remains unknown. In 2016, we tagged age-1 Chilko Lake sockeye smolts (n = 200) in addition to age-2 smolts (n = 100) with acoustic transmitters and tracked individuals for 1150 km using large-scale receiver arrays. We used non-lethal gill biopsies to assess microbe presence and biomarkers associated with stress, osmoregulatory processes, and immune responses. Cumulative survival of age-1 and age-2 smolts to the ocean was 16% and 2% respectively. Average migration rates in the upper tributaries (80 km from release) were ~40 km/d for both age-1 and age-2 smolts and survival was low in this region (68% and 41%, respectively). Age-1 marine migration rates were variable (4–13 km/d) and marine survival was lowest as smolts entered the Strait of Georgia (36%, 225 km from release). We predict that smolts with higher and more variable microbe loads will exhibit low survival and slow migration rates. Expanding research to include age-1 smolts and assessing the impacts of microbes and physiological condition on their marine survival should provide a more complete perspective on improving our understanding of the long-term decline in adult sockeye returns.

The Cost of Living in a Warming World: Physiological and Behavioral Response of Juvenile Chinook Salmon to Simulated Seasonal Water Temperature

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Abstract: Rising temperatures in the Northeast Pacific Ocean over the past 30+ years have been associated with declines in the early marine survival of many southern British Columbia populations of Chinook salmon, but the mechanisms are unclear. Our objectives were to experimentally evaluate the effects of variable seasonal water temperature on juvenile ocean-type Chinook salmon cortisol levels, basic metabolism and behavior. Summer plasma cortisol concentration (ng/ml) of juvenile Chinook increased with increasing water temperature from 15°C (19.1 ng/ml) to 21°C (58.7 ng/ml), exceeding the known unstressed levels (~ 40 ng/ml) in Chinook salmon. Water temperatures were reduced in autumn, and the cortisol levels of Chinook were similar across temperature treatments by the end of this season. The respiration rate of fish also increased with temperature, and was higher during the summer than autumn across water temperatures. Overall fish activity was similar across treatments during the summer, while aggression varied among water temperatures, and both behavioral metrics decreased during autumn. In summary, juvenile Chinook salmon inhabiting natural systems that encounter environmental conditions similar to those simulated in this study, particularly during summer, could suffer negative impacts to physiology resulting from increased stress and metabolic demands, as well as altered behavior.

Diet of Chinook (Oncorhynchus tshawystcha) and coho (O. kisutch) salmon in the Strait of Georgia, and the importance of pelagic fishes.

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Poster

Chinook (Oncorhynchus tshawystcha) and coho (O. kisutch) salmon are important cultural and commercial fish in the Pacific Northwest. In Canada and the United States, the marine survival of these two species have declined significantly over the past 3 decades from levels well over 10% to averages of 1-3%. As part of a long-term study (1998-2012) investigating the early marine survival of Pacific salmon in British Columbia, the diets of midwater-trawl captured juvenile Chinook and coho salmon rearing in the Strait of Georgia, British Columbia, Canada were observed. Both exhibited similar varied diets composed of significant amounts of decapods (primarily crab megalops and zoea), euphausiids and amphipods (primarily hyperids), indicating a high degree of niche overlap. Both species also had significant portions of pelagic fishes such as juvenile Pacific herring (Clupea harengus pallasi) and Pacific sand lance (Ammodytes hexapterus). In years of reduced herring and/or sandlance availability (due to poor recruitment or early marine survival), percentages observed in the diets decreased significantly. These years also demonstrated reductions in marine survival rates in chinook but not coho salmon. There also appeared to be a threshold level of ~140 mm in juvenile chinook salmon beyond which pelagic fish become the major diet component.

This paper will discuss the implications of these results for salmon marine survival in the face of future climate change, identify knowledge gaps in regional pelagic fish life histories and trends, and hopefully provide management with information to improve salmon productivity.

Stock specific abundance of Columbia River juvenile Chinook salmon in the Gulf of Alaska

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Poster

Abstract: Migration patterns of juvenile Columbia River Chinook salmon (Oncorhynchus tshawytscha) differ among stocks and life history types, creating diverse marine distributions of these fish. This results in different stocks being subject to different ocean conditions during their first summer of marine residence, a time that is critical for their survival. Understanding their early marine distributions, and the conditions that may affect their survival, may enhance conservation efforts for these stocks, many of which are protected under the Endangered Species Act. We analyzed juvenile Chinook salmon samples collected in trawls made from 2011-2015 in the Gulf of Alaska, and off the coasts of Washington and Oregon. We used genetic stock identification techniques to estimate stock proportions of juvenile Chinook salmon in each of these areas. Results indicated that the majority of juvenile Chinook salmon in our Gulf of Alaska study area in July originate from Columbia River spring-run stocks. Catch per unit effort (CPUE) over all stocks was correlated between the Gulf of Alaska and the Washington and Oregon coast samples. In 2011, CPUE for Columbia River spring-run stocks in the Gulf of Alaska was lower than for the Washington and Oregon coast, suggesting a differing level of marine mortality that year somewhere between the two areas. We also found a positive correlation between juvenile CPUE of interior Columbia River spring-run stocks in the Gulf of Alaska and adult counts at Bonneville Dam two years later. Our results show that studies like this can provide marine life history, performance and survival information that supports management and recovery efforts for Columbia River Chinook salmon.

Long-term changes in length at maturity of Pacific salmon in Auke Creek, Alaska

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Oral

Abstract: A trend toward decreasing length at maturity has been observed in Alaskan salmon populations, but the generality of this trend is poorly understood. This study was undertaken to determine whether this pattern holds for several species of salmon from a small watershed in southeast Alaska (Auke Creek), and, if so, what abiotic and biotic factors are contributing to this phenomenon. We analyzed 32 years of data for Coho Salmon Oncorhynchus kisutch, Sockeye Salmon O. nerka, and Pink Salmon O. gorbuscha and observed significant decreases in mean length for Coho Salmon, as well as increases in mean length of saltwater age 2 Sockeye Salmon. Non-significant trends in length at maturity were observed in Coho Salmon jacks, Pink Salmon and saltwater age 3 Sockeye Salmon. Abiotic and biotic variables that were related to interannual variation in length include a combination of climate, harvest, and resource availability. These observed changes should be considered in future management decisions to ensure sustainable harvest for southeast Alaska's sport, commercial, and subsistence fisheries.

Response of juvenile Chinook salmon abundance to increasing temperatures in the Northern Bering Sea

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The northern Bering Sea supports many important commercial and subsistence fisheries including Chinook salmon. Chinook returns have declined over time, with significant restrictions placed on harvest (including subsistence harvests) in recent years. The early marine period for juvenile Chinook is known to be critical to their marine survival. Juvenile Chinook abundance estimates from August-October in the northern Bering Sea are correlated with adult returns, which emphasize the potential importance of initial marine habitat conditions on subsequent marine survival. Variable-coefficient generalized additive mixed effects models were used to examine habitat associations of juvenile Chinook salmon over the northeastern Bering Sea shelf from 2004 - 2016. Models indicated a positive relationship with temperature up to about 7 - 10 °C, above which juvenile abundance declined. This upper threshold is generally less than the optimal temperature ranges found for their lower latitude cousins where 10.8 °C is considered the midpoint of temperature growth ranges for juvenile Chinook. It is, however, logical that these northern Chinook would acclimate to lower temperatures considering their far north environment.

Norton Sound is one of the first nearshore marine habitats that out-migrating juveniles encounter upon leaving the Yukon River, and sea surface temperatures (SST) in the Sound may have a strong influence on early marine survival rates. SSTs in Norton Sound are generally warmer than the northeastern Bering Sea shelf, and the water column is usually well-mixed. Mean August SSTs over the northeastern Bering Sea shelf from 1982-2014 were relatively stable, with an increase of ~1 °C, over the past decade. Meanwhile, SSTs in Norton Sound have increased ~ 4 °C, beginning in the early 1990's. SST and other oceanographic changes will be further investigated for associations with juvenile abundance and returns, hoping to fill gaps in our knowledge of juvenile Chinook mortality rates.

A hyperiid amphipod trophically links a large scyphozoan jellyfish to juvenile Chinook Salmon in the Salish Sea

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Oral

The role of jellyfish in aquatic food webs includes the high consumption of lower trophic levels, which can mediate the flow of energy through food webs. Organisms that interact with jellyfish however remain understudied with regards to their role in these pathways. Here we examine the role of the parasitic amphipod Hyperia medusarum in mediating the energy transfer of its host Phacellophora camtschatica to juvenile Chinook salmon (Onchoryncus tshawytscha). Stomach contents from juvenile Chinook salmon were obtained through modified recreational trolling techniques and gastric lavage during the summer of 2015. Of 118 stomachs containing H. medusarum, 87% contained nematocysts from P. camtschatica confirming previous reports that suggest H. medusarum derives the majority of its nutrition from P. camtschatica. Here, we suggest that H. medusarum may represent a greater component of the modern diet of juvenile Chinook Salmon in the Salish Sea than historically. Further, we suggest that juvenile Chinook are utilizing energy derived from P. camtschatica indirectly by consuming H. medusarum. Mean cephalothorax length and sex ratios of H. medusarum differed significantly between jellyfish populations and Chinook stomach samples suggesting a feeding preference for large, female hyperiids. An increase in the biomass of P. camtschatica as well as H. medusarum in the Salish Sea, coincident with a higher frequency of observance of hyperiids in juvenile Chinook stomachs is discussed in the context of H. medusarum as a novel, opportunistic food source for juvenile Chinook salmon.

Juvenile salmon during the downstream migration in the Columbia River: more complicated that we expected!

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Oral

Most studies of juvenile salmon in marine waters start at ocean entry. However, salmon don't begin life at ocean entry, but have been alive for several months to over a year before entering marine waters. During this pre-ocean entry period, salmon occupy a variety of freshwater and estuarine habitats, which collectively determine their condition (e.g., size, timing) at ocean entry and therefore their marine ecology. However, our current understanding of this freshwater-estuary-ocean coupling is extremely limited. With funding from the U.S. Army Corps of Engineers, in 2016 we began sampling interior stocks of juvenile salmon at multiple locations in the Columbia River and estuary to document how salmon change as they move downstream. Our ultimate goal is to understand how conditions prior to ocean entry influences the ocean ecology of young salmon. Collection sites included hatcheries, mainstem dams, and locations spanning the Columbia estuary, in addition to ocean sampling, using a consistent set of fish performance metrics. Our results are both methodological and biological, given the uniqueness of the study. Methodologically, we successfully caught juvenile salmon in mainstem habitats of the Columbia River estuary, something which has not been attempted for at least 40 years (if ever). Biologically, we found the overall abundance and stocks of salmon differed greatly among sampling locations, including those that were geographically close and superficially appeared similar. Contrary the prevalent paradigm that migrating salmon don't feed or grow while migrating downstream through the estuary, several diverse metrics indicated that some Chinook salmon and steelhead stocks are actively feeding and growing. Overall, our results indicate that the downstream migration period may be much more complicated than we anticipated, with reach-, month-, and stock-specific variation in fish condition, all of which likely affect ocean ecology.

Spatial and temporal variation in ocean avian predation risk to Columbia River Chinook salmon

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Oral

Distinguishing natural variability in cohort survival from anthropogenic effects is a key component of ecosystem-based fisheries management. Ocean predation is hypothesized to be a natural mortality mechanism with strong effects on the early marine survival of several threatened and endangered Columbia River Basin Chinook salmon (*Oncorhynchus tshawytscha*) populations, yet there have been few direct investigations of predator overlap with salmon in the field. We present the first stock-specific analysis of spatial and temporal overlap between two numerically abundant seabird predators and six juvenile Columbia River Chinook salmon stocks during the period of initial ocean migration in May and June. Spatially-explicit models of predator-prey distributions from 2003-2012 demonstrate a high degree of predator overlap occurred for all Chinook salmon stocks examined but varied by predator type, salmon stock, month, and year. Common murres (*Uria aalge*) and sooty shearwaters (*Ardenna grisea*) exhibited the highest overlap with salmon during May. Spatial patterns in overlap indices show the area between the Columbia River mouth and Grays Harbor, Washington is the region with highest potential predation risk, and demonstrate that ocean avian predation may be a significant factor affecting early marine survival of Columbia River Chinook salmon.

From: David Welch

Sent: Fri Mar 10 12:01:10 2017

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

Subject: RE: CCR modification slowly

Importance: Normal

I did have an excellent time, Christine—[redacted]

Setting the end date later probably makes good sense, unless there is some downside that I am unaware of—as you indicate, the journal submission/revision cycle can be quite unpredictable. Do you want to set the date for two years out, or is that too far? (That date is obviously unrealistically long given current funding and what we need to accomplish, but also gives the opportunity for additional funding to be brought to bear on the other issues we had initially identified).

It's really your call as to what you think makes greatest sense—I don't see an issue from our end, because I am mainly concerned about getting the work products done to a high standard!

Regards, David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, March 10, 2017 9:53 AM
To: Erin Rechisky; David Welch
Subject: CCR modification slowly

Hi,

Let's see – this week we had several days of delay where I was unable to initiate the contract modification in Pisces because the initial contract has to be registered as 'issued' rather than 'pending' (as our procurement staff update the system after receiving the signed contract). This morning it looks like it has toggled over into 'issued' status, so I am starting the modification. The computer system only update overnight, so it should only be visible tomorrow or Monday.

Monday and Tuesday I will be in Seattle, but I will try to connect with you next week about modifying the SOW text and budget etc.

By the way – one question you could address right away is whether I should set the end date further ahead. It is currently at 1/31/2018 – for a 12 month contract. The primary reason why you might set it ahead could be to allow yourself flexibility to invoice time for journal revision and comments, if there are the predictable delays or turnaround time and this went into 2018.

(b)(6) [redacted] and also that you had a nice trip, David

Have a nice weekend

Christine Petersen

(503)230-4695

From: David Welch

Sent: Fri Mar 10 15:22:20 2017

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

Cc: Ben Zelinsky; Erin Rechisky

Subject: 2018 Spill test???

Importance: Normal

Attachments: Brosnan, Welch et al (Columbia R Plume Survival-MEPS 2014).pdf

Christine & Ben—

I just saw this comment in the Columba Basin Bulleting as, no doubt, did you:

"However, although in the opening remarks Simon said he was leaning towards ordering the federal agencies to begin maximum allowable spill to the gas cap at the dams beginning April 3 and continuing for two years to see what can be learned about salmon survivability with increased spill, by hearing's end his leaning was toward beginning the spill next year.

That would give both fisheries and dam managers time to devise a study design in order to learn if the spill will help or hinder salmon and steelhead."

(b)(5) [redacted]

David

David Welch, Ph.D.

kintamav_RGB

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Contribution to the Theme Section 'Tracking fitness in marine vertebrates'

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Evaluating the influence of environmental factors on yearling Chinook salmon survival in the Columbia River plume (USA)

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ABSTRACT: The impact of oceanographic processes on early marine survival of Pacific salmon is typically estimated upon adult return, 1 to 5 yr after ocean entry, and many 1000s of kilometers after initial exposure. Here, we use direct estimates of early marine survival obtained from acoustic-tagged yearling Chinook salmon *Oncorhynchus tshawytscha* that entered the Columbia River plume (USA) after migrating down the river and then north to the coastal waters off Willapa Bay, Washington. Plume residence time averaged 7 d, and was of such short duration that predation, rather than feeding and growth conditions, was the likely primary cause of mortality. Plume survival ranged from 0.13 to 0.86, but was stable when scaled by plume residence time, and we find that a simple exponential decay model adequately describes plume survival. Plume survival, and perhaps adult returns, could be improved by reducing plume residence time if the drivers controlling residence time were amenable to management control. However, we show that a statistical model of plume residence time that includes only sea-surface temperature far outperforms models that include river discharge and coastal upwelling. Timing hatchery releases using marine environmental forecasts could potentially improve smolt survival by minimizing their residence time in regions of poor survival. Acoustic telemetry may be used to evaluate the value and effectiveness of such approaches.

KEY WORDS: Juvenile salmon · Juvenile survival · Columbia River plume · Acoustic telemetry · Environmental factors

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INTRODUCTION

The Columbia River basin once supported large stocks of Pacific salmon, but their abundance has declined significantly under the combined effects of overfishing, damaging land-use practices, hydropower development, periodically unfavorable conditions for salmon survival in the North Pacific Ocean, and hatchery supplementation that accompanied the industrialization of the Pacific Northwest (National Research Council 1996, Mantua et al. 1997, Coronado & Hilborn 1998). Since the passage of the Endangered Species Act in 1973, 5 of the 7 evolutionarily significant units (ESUs) of Chinook salmon *Oncorhynchus tshawytscha* in the Columbia River basin have been listed as 'Threatened' or 'Endangered' and significant effort has been directed towards understanding the ocean ecology of salmon in the hopes of restoring depleted stocks (Brodeur et al. 2003, USNARA 2012).

Pearcy (1992) suggested that the number of juvenile salmon returning to spawn in their natal streams as adults may be established during the cohort's first month at sea, a 'critical period' of early marine survival. The possibility of predicting, and perhaps influencing, adult returns by elucidating the drivers of early marine survival has subsequently been an important focus for salmon ecologists. Numerous

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environmental variables have been examined for potential relationships with early marine survival. Although some variables lack clear mechanistic links to survival, they are generally related to feeding and growth opportunities, predation, and the effect of experiences in the river on subsequent fitness.

The annual transition to dominant northerly winds in spring, the 'spring transition', drives upwelling of cold nutrient-rich waters that support phytoplankton blooms and advect lipid-rich cold-water copepod species into the marine waters of Oregon and Washington, displacing relatively lipid-poor warm-water species and providing a food web input believed to be favorable for juvenile salmon growth (Huyer et al. 1979, Hickey & Banas 2003, Peterson & Keister 2003, Peterson & Schwing 2003, Schwing et al. 2006). The timing of ocean entry of juvenile salmon relative to the spring transition has been proposed as a driver of early marine survival (Logerwell et al. 2003, Scheuerell et al. 2009; but see Tomaro et al. 2012).

DeRobertis et al. (2005) and Morgan et al. (2005), in companion papers, directly examined the potential relationships between feeding and survival by sampling juvenile salmon and their prey at tidally driven Columbia River plume fronts and in the adjoining plume waters and coastal ocean. They found that the fronts aggregate salmon prey, but found little evidence that juvenile salmon take advantage of the feeding opportunities at the fronts, potentially due to their ephemeral nature. While juvenile salmon may not take advantage of unique feeding advantages presented by the fronts, field sampling and bioenergetics modeling have indicated that they are not food limited in the plume region (Brodeur et al. 1992, Morgan et al. 2005).

Although they may not be food limited, juvenile salmon are subject to predation. Emmett et al. (2006) describe the seasonal migration of predatory Pacific hake *Merluccius productus* into coastal waters off the Columbia River and note that improvements in marine survival of juvenile salmon beginning in 1999 were coincident with a decrease in predator fish abundance. Emmett & Sampson (2007) used a trophic model to demonstrate that high numbers of Pacific hake could account for high mortality of juvenile salmonids leaving the Columbia River. Collis et al. (2002) describe high and increasing proportions of juvenile salmonids in the diets of Caspian terns *Sterna caspia* and double-crested cormorants *Phalacrocorax auritus* from April into May. Colonies studied by Collis et al. (2002) on Rice Island in the mid-Columbia River were subsequently successfully encouraged to nest on East Sand Island (adjacent to the plume), reducing the proportion of their diet that consisted of juvenile salmon (Roby et al. 2002), but potentially increasing predation pressure in the plume. Turbidity in the plume may offer some relief as it has been shown to reduce predation on juvenile salmon (Gregory & Levings 1998, DeRobertis et al. 2003), despite reducing predator avoidance behavior (Gregory 1993).

There may also be latent effects of the river experience on early marine survival; Budy et al. (2002) and Schaller & Petrosky (2007) examined the effects of dam passage and concluded that there is evidence that the hydrosystem experience results in mortality that is delayed into early marine residence. Additionally, as a consequence of water being spilled over the dam faces (to reduce the physical and physiological stressors juveniles are exposed to during dam passage), air is entrained in the river, resulting in gas supersaturation below the dams. Exposure to supersaturated river water may result in gas bubble trauma in juvenile salmon (Bouck 1980), and, even when exposure is non-lethal, it may reduce their fitness and increase their susceptibility to predation (Mesa & Warren 1997).

Other environmental variables that have been associated with early marine survival do not have mechanistic explanations as clear as those described above. Ryding & Skalski (1999) and Cole (2000) linked survival with sea-surface temperature (SST), although when SST was examined in a suite of coastal oceanographic variables, including upwelling, wind mixing, mixed layer depth, sea level, and the timing of the spring transition, it was proven to be a dominant driver and is often an inconsistent predictor of adult returns (Hobday & Boehlert 2001, Koslow et al. 2002, Scheuerell & Williams 2005, Burke et al. 2013). Burla et al. (2010a) considered the effect of plume size and position, which are largely shaped by river discharge and wind-driven current, on juvenile survival and found no significant relationship with Chinook salmon returns and only a very weak relationship with steelhead salmon returns.

Here, we combine 2 novel approaches to gain insight into yearling Chinook survival in the Columbia River plume region, in their first period of marine residency. First, we use acoustic telemetry, which permits direct empirical measures of early marine survival to be evaluated against the environmental conditions experienced by tagged smolts (e.g. Rechisky et al. 2009, Moore et al. 2010, Welch et al. 2011, Thorstad et al. 2012, Melnychuk et al. 2013). This improves on the current approach to identifying critical environmental variables, which primarily

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relies on correlating them with smolt-to-adult return rates estimated over 1 to 5 yr and many 1000s of miles after exposure.

Second, we recognize that the plume is a region where occupancy is short and predators are rich, and thus it is conceivable that plume survival of telemetered smolts is regulated by their period of exposure (i.e. plume residence time) and that variables associated with survival, but lacking a direct link, may be acting on survival by influencing residence time. Therefore, in our analysis, we (1) evaluate the ability of a simple exponential decay model, equivalent to those used to model the decay of radioactive elements, to describe plume survival data for tagged yearling Chinook, (2) use the model residuals in survival analyses to examine whether measures of biological productivity or gas supersaturation levels, which may directly affect survival, would add additional predictive power to the model, and (3) evaluate the effect of 3 variables, potentially related to survival but lacking clear mechanistic links, on plume residence time. These variables are SST, river discharge and wind-driven surface currents, the latter reflected in the coastal upwelling index. Finally, in light of our findings, we briefly discuss manipulating the dynamics of the Columbia River plume through flow control as a potential mechanism for improving plume survival of salmon (Jacobson et al. 2012).

Fig. 1. Study region. The red lines mark the named telemetry sub-arrays. Contour lines mark the 200 m and 500 m isobaths

MATERIALS AND METHODS

Acoustic tagging and tracking

From 2008 to 2011, yearling Chinook *Oncorhynchus tshawytscha* from the Columbia River basin were surgically implanted with uniquely coded VEMCO V7-2L (7 × 20 mm, 1.6 g in air, 69 kHz transmission frequency) acoustic transmitters and then tracked as they migrated down the Columbia River and north along the continental shelf (Fig. 1). Yearling Chinook were used because several evolutionarily significant units in the Columbia River are listed as 'Threatened' or 'Endangered' under the USA Endangered Species Act and because their larger size reduces their tag burden. Although all groups of fish tagged and released for this study had a common migratory route in the lower river, estuary, plume, and coastal ocean, they followed 3 different migratory paths to the lower river, depending upon their origin and handling. They include Columbia run-of-the-river (CR) groups, Snake run-of-the-river (SR) groups, and Snake River transport (ST) groups (Table 1). In 2011, CR fish were identified as upper-Columbia (UC) or mid-Columbia (MC) using genetic stock identification (Table 1). Run-of-river groups were collected from hatcheries or at dams in their respective rivers, and then released to migrate to the ocean. Transported groups were collected from a hatchery or from Lower Granite Dam in the Snake River basin and then transported via truck or barge to below Bonneville Dam, the final dam on the Columbia River. With the exception of a unique early-April release of a group of transported fish in 2009, all releases occurred between late-April and late-May to minimize potential effects of emigration timing (Muir et al. 2006); release dates are reported in Table 1. The methods summarized here are also available in uncondensed reports to the Bonneville Power Administration (Porter et al. 2009b, 2010, 2011, 2012a,b) and in Rechisky & Welch (2010).

In 2008 and 2009, the CR groups were reared at the Cle Elum Supplementation and Research Facility on

Table 1. *Oncorhynchus tshawytscha*. Group names, release dates, sample sizes, fork length (FL) range, proportion (%) of the population represented by the size range tagged, and estimates of plume survival for acoustic-tagged Chinook smolts released in the Columbia (CR) and Snake Rivers (SR), or Snake River–sourced smolts that were transported and released below Bonneville Dam (ST). Chinook smolts released in the Columbia River in 2011 were identified as mid-Columbia (MC) or upper-Columbia (UC) using genetic stock identification. The ST_09ER (early release) group, shown for reference, was excluded from the analysis

Year	Group	Release dates	No. of fish	FL range (mm)	Percent of population	Median plume entry date	Plume survival (SE)
2008	SR_08	25 Apr & 2 May	395	130–159	10	28 May	0.41 (0.07)
	ST_08	17 & 23 May	199	131–159	10	26 May	0.52 (0.08)
	CR_08	15 & 21 May	378	129–158	72	29 May	0.38 (0.06)
2009	SR_09	4 & 11 May	389	130–164	68	30 May	0.53 (0.16)
	ST_09	27 May & 3 Jun	392	130–167	68	31 May	0.86 (0.14)
	ST_09ER	17 Apr	196			27 Apr	0.78 (0.15)
	CR_09	18 & 25 May	393	130–159	69	2 Jun	0.36 (0.12)
2010	SR_10	17–24 May	383	130–167	74	4 Jun	0.69 (0.11)
	ST_10	18–26 May	406	130–171	74	27 May	0.58 (0.07)
	CR_10	28 Apr–13 May	790	130–215	88	14 May	0.41 (0.05)
2011	SR_11	23 Apr–28 May	80	132–168	78	25 May	0.25 (0.07)
	ST_11	3–22 May	200	130–165	71	24 May	0.13 (0.03)
	UC_11	23 Apr–28 May	386	130–170	78	21 May	0.31 (0.04)
	MC_11	23 Apr–28 May	59	131–168	74	11 May	0.22 (0.07)

the Yakima River (a tributary of the Columbia River), but were captured, tagged, and re-released in 2 sub-groups 6 d (2008) and 7 d (2009) apart at the downstream Chandler Juvenile Monitoring Facility (CJMF). This was done to avoid the significant mortality, and thus reduced sample size, that occurs between these 2 facilities (Yakima Nation 2011). The SR and ST groups consisted of yearling Chinook reared at the Dworshak National Fish Hatchery (DNFH) on the Clearwater River (a Snake River tributary). The SR groups were released upstream of DNFH in 2 sub-groups 7 d apart. The ST groups were trucked to Lower Granite Dam and then placed in a barge for transport and release below Bonneville Dam in 2 sub-groups 6 d apart. There was also a single early transport release in 2009 (ST_09ER).

In 2010, the CR group consisted of hatchery- and wild-origin smolts (62% had fin clips) collected and tagged at the John Day Dam (Columbia River) before being released 42 km upstream in small sub-groups over 15 d. The Snake River groups consisted largely of hatchery-origin fish (97% had fin clips) that were collected and tagged at Lower Granite Dam and released in the tailrace over 8 d, or transported and released below Bonneville Dam in the lower Columbia River over 9 d. Unlike 2008, 2009, and 2011, the stocks of origin for fish tagged in 2010 are unknown. We have assumed that smolts collected at John Day Dam originated in the Columbia River (although some could be Snake River smolts) and those collected at Lower Granite Dam were of Snake River origin. We have also assumed that these fish are yearling Chinook, but since they were not known to be hatchery fish (as in 2008 to 2009) or genetically identified (as in 2011), it is possible that a proportion were hold-over fall type yearlings.

In 2011, juveniles in the CR and SR groups were captured and tagged at Bonneville Dam and then released in the tailrace over 14 and 7 d, respectively. Genetic stock identification was used to distinguish the spring Snake, mid- and upper-Columbia smolts used in the analysis (Porter et al. 2012b). The ST group fish were collected at Lower Granite Dam and transported for release below Bonneville Dam in 2 groups 8 d apart.

The surgical protocol for implanting the VEMCO V7-2L acoustic tag included sedation, anesthetic induction, tagging, and recovery. Briefly, fish captured for tagging were allowed to acclimate to their holding tank, and food was withheld for approximately 24 h prior to surgery. Fish were sedated with a 20 ppm dose of tricaine methane sulphonate (TMS or MS-222), and anesthetic induction was accomplished in a bath containing 70 ppm TMS. Once they reached Stage IV anesthesia, smolts were placed ventral side up, and their gills and mouths gently irrigated with a water tube. An incision to accommodate the tag was made on the mid-ventral line, and the tag was inserted into the abdominal cavity. Incisions were closed with sterile monofilament absorbable suture, and fish were transferred to a recovery tank for at least 24 h before release.

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Although this study focuses on survival in the plume region between the mouth of the Columbia River (Astoria, Oregon) and the coastal waters off Willapa Bay, Washington, the sub-arrays of acoustic receivers used to delineate the plume were part of a much larger array deployed within the Columbia River basin and eastern North Pacific coastal ocean. The Columbia River basin array elements were emplaced in 2006. However, we have used only the 2008 through 2011 data to build the models, as there was no sub-array at Astoria in 2006 to distinguish between survival in the lower river and the plume, and problems with smolt tagging precluded use of 2007 data (Porter et al. 2009a). Although lower river and plume survival were conflated in 2006 due to the lack of a sub-array at Astoria, we derived estimates of plume survival and residence time for 2006 using travel times and average survival between Bonneville Dam and Astoria from 2008 to 2011. The derived estimates were plotted against the exponential decay model output as an additional test of the model's adequacy.

Environmental data

Researchers have identified a number of environmental variables that may be related to the early marine survival of juvenile salmon. Using current literature as a guide, we identified 6 variables with publicly available datasets for exploratory analysis. These were timing of the biological spring transition (Koslow et al. 2002, Logerwell et al. 2003, Tomaro et al. 2012, Burke et al. 2013), cumulative upwelling prior to ocean entry (Schwing et al. 2006), turbidity (Gregory & Levings 1998, DeRobertis et al. 2003), SST (Ryding & Skalski 1999, Hobday & Boehlert 2001, Koslow et al. 2002, Logerwell et al. 2003, Burke et al. 2013), and upwelling and river discharge (Budy et al. 2002, Schaller & Petrosky 2007, Burla et al. 2010a). We lacked predator data, but hypothesized that if predation was the primary driver of survival, then survival could be related to period of exposure, i.e. plume residence time. Finally, flooding in the Columbia River basin in 2011 resulted in high levels of involuntary spill at Bonneville Dam, supersaturating the river below the dam with dissolved gas and raising our interest in the effect of physiological damage resulting from exposure to supersaturated water on subsequent plume survival (Mesa &Warren 1997, Mesa et al. 2000, USACOE 2011). We performed an initial exploration of the data with pairwise plots and used Pearson correlation coefficients to identify strongly collinear variables (Pearson correlation coefficient ≥ 0.95).

Coastal upwelling (UP), 2 and 4 wk cumulative upwelling (CU2, CU4). Daily upwelling index values at 48° N (cubic meters per second per 100 meters of coastline) were obtained from the NOAA Pacific Fisheries Environmental Laboratory (www.pfeg. noaa.gov/). Values were averaged over the period between plume entry and plume departure (see 'Analysis' section for how entry and departure dates were determined) for each salmon group in each year and cumulative upwelling was calculated for the 14 and 30 d periods prior to plume entry of each group in each year.

Biological spring transition (BST). We used transition dates for 2008 to 2011 that were calculated using the Peterson method and obtained through Columbia River Data Access in Real Time (DART; www.cbr. washington.edu/dart/). The Peterson method identifies the BST date as the day when cluster analysis of copepods sampled during biweekly research cruises at the hydrographic baseline station NH 05 off Newport, Oregon, indicates the transition from a southern, warm-water zooplankton assemblage to a northern, cold-water assemblage (Peterson & Keister 2003, Peterson & Schwing 2003, Hooff & Peterson 2006, Peterson et al. 2006). The timing of ocean entry of the tagged smolts in relation to the spring transition was calculated by subtracting the date of the transition from the date of entry into the plume by each group in each year.

Lower river gas saturation (PDG). We obtained gas saturation data, measured as percent dissolved gas (PDG), from an automated US Army Corp of Engineers water quality monitoring station located at Camas, Washington/Washougal, Oregon (CWMW), 40 km downstream of Bonneville Dam (Fig. 1; www. cbr.washington.edu/dart/). Hourly values were averaged over the period between median arrival date on the acoustic sub-array below Bonneville Dam or release date at Bonneville Dam and the plume entry date for each salmon group in each year.

Sea-surface temperature (SST). SST (°C) is measured hourly at several NOAA data buoys (NDB) off the Columbia River. NDB 46041, located approximately 111 km northwest of the mouth of the Columbia River (Fig. 1), had a complete SST data set for periods when tagged juvenile salmon were transiting the plume (www.ndbc.noaa.gov/). Hourly values collected at this buoy were averaged over the period between plume entry and plume departure for each salmon group in each year.

River discharge (DIS). River discharge data are recorded at Beaver Army Terminal near Quincy, Oregon, 150 km downstream of Bonneville Dam (Fig. 1). This is the last discharge recording station in the Columbia River. Daily mean discharge is recorded in cubic feet per second (converted to cubic meters per second) and was extracted from the National Water Information System (http://waterdata.usgs.gov/). Daily values were averaged over the period between plume entry and plume departure for each group in each year.

Turbidity (TB). River turbidity is measured daily at Bonneville Dam in units of Secchi-feet (converted to Secchi-meters), and the data were accessed through Columbia River DART (www.cbr.washington.edu/dart/). Bonneville Dam is located at River Mile 146.1, well upstream of the plume, but it is the closest continuous measurement of turbidity available. Turbidity in the plume should lag turbidity measured at Bonneville, with the lag time dependent on discharge levels. To estimate lag times for each group, we used the difference between their median arrival date at Astoria and median arrival, or release, date at Bonneville. Based on previous studies correlating juvenile travel time and discharge, we believe that using detection data to establish a lag time between turbidity measure and turbid water mass arrival in the plume is reasonable (Berggren & Filardo 1993). Lagged daily turbidity measurements were averaged over the period between plume entry and plume departure for each group.

ANALYSIS

Plume survival and occupancy

Estimates of yearling Chinook salmon *Oncorhynchus tshawytscha* survival in the plume were obtained using the data and analytical methods described in Porter et al. (2012b). Briefly, a total of 4646 acoustic tagged smolts were released in the Columbia River basin from 2008 to 2011 (Table 1). Detection data from the array components extending from the Snake River to Lippy Point, British Columbia, Canada (Fig. 1), were used to estimate apparent survival for each treatment group between each detection site in each year using a special case of the Cormack-Jolly-Seber (CJS) live-recapture modeling framework, implemented in the program MARK (Table 1; Lebreton et al. 1992, White & Burnham 1999). Unique detection probabilities (p) for each release group were estimated at each sub-array in the river; however, at the ocean sub-arrays, a common p for the groups was used each year. Eight of the 19 fish detected migrating upriver in their release year were detected at the river mouth, but not at Willapa Bay. We did not remove them from the analysis because they affect plume survival estimates by only a fraction of a percent and have no effect on the final results. However, all upstream migration detections were scrubbed prior to analysis.

In 2010 and 2011, an additional sub-array was placed at Sand Island, seaward and adjacent to the Astoria sub-array (Fig. 1). Porter et al. (2012a) report 2010 and 2011 plume survival in 2 segments: Astoria and Sand Island and Sand Island to Willapa Bay. To permit inter-year comparisons, the methods in Porter et al. (2012a) were modified by setting survival to Sand Island at 1 so that mortality was estimated from Astoria to Willapa Bay. Plume survival estimates in 2008 and 2009 are as reported in Porter et al. (2012a). Median $\hat{c}$ goodness-of-fit tests, carried out in the program MARK, of the 2008, 2009, and 2011 special-case CJS models used to estimate plume survival did not give evidence of extra-binomial variation (i.e. greater variability than would be expected under binomial sampling, which, if present, would result in underestimates of the variance of the CJS model parameters; Burnham & Anderson 2002). We made corrections to the 2010 survival estimates because there was evidence of minor overdispersion ($\hat{c} = 1.16$; Burnham & Anderson 2002).

Plume occupancy included the period between plume entry and plume departure. Entry and departure dates were calculated as the median of final detection dates on the Astoria sub-array (plume entry; Fig. 1) and the median of final detection dates on the Willapa Bay sub-array (plume departure; Fig. 1). Plume entry and departure were calculated for each group in each year. Median absolute deviation of the plume entry time (i.e. the spread) was calculated for each group in each year.

Modeling survival and plume residence time

If smolt survival was mediated by travel time through the plume, time-scaled survival, calculated as $S_{TS} = S_P{}^{1/T_P}$, should be nearly constant and survival could be explained as an exponential decay process, which is time dependent. We fit an exponential decay model to the survival estimates using the nls function in R (R Development Core Team 2011):

$$S_P = e^{-k\,T_P}$$

where S_P is plume survival, T_P is median residence time, k is the mortality rate constant, and e^{-k} is the

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apparent daily survival rate. The assumptions of non-linear regression — (1) correct function, (2) homoscedasticity, and (3) normally distributed error terms — were evaluated with a plot of the fitted regression curve, a plot of the model residuals against fitted values, and a quantile-quantile (QQ) plot, respectively (Kutner et al. 2005, Ritz & Streibig 2008). We obtained an estimate of the bias in k through bootstrap resampling (n = 10000; Kutner et al. 2005). We calculated the confidence intervals for the exponential decay model by log transforming the confidence intervals of the linear form of the exponential model ($\log S_P = -k\ T_P$).

We plotted logit-transformed survival estimates and residuals from the exponential decay model against the variables representing productivity (BST, CU2, CU4) and gas supersaturation (PDG) to evaluate the potential role of biological productivity and exposure to supersaturated river water on plume survival (Kutner et al. 2005). We also calculated the coefficients of determination (R^2) between logit-transformed survival estimates and each of the variables representing productivity and exposure.

We used linear regression models and information theoretic approaches to evaluate the environmental factors potentially governing plume residence time (Burnham & Anderson 2002, Johnson & Omland 2004, Kutner et al. 2005). Our general model of plume residence time, which included 3 covariates and 1 interaction term, was:

$$T_P \sim \mathrm{SST} + \mathrm{UP} + \mathrm{DIS} + \mathrm{UP{:}DIS}$$

We used corrected Akaike information coefficients (AICc), Akaike weights (w_i), and evidence ratios, implemented in R with the package MuMIn, to evaluate and rank the general model and 8 sub-models in our candidate set (Burnham & Anderson 2002, Barto 2012). We used diagnostic plots of the residuals to assess whether the assumptions of linear regression were met for the top ranked model. Additionally, the residuals of the top model were plotted against variables omitted from the general model to verify that they did not add descriptive or predictive power (Kutner et al. 2005).

Model evaluation with 2006 survival data

Although lower river and plume survival were conflated in 2006 due to the lack of a sub-array at Astoria, we derived estimates of plume survival and residence time for 2006 using travel times and average survival between Bonneville Dam and Astoria from 2008 to 2011. The derived estimates are plotted against the exponential decay model output as an additional test of the model's adequacy. We estimated plume survival in 2006 by dividing the 2006 estimates of combined lower river/plume survival (Bonneville Dam to Willapa Bay) by the average lower river survival (Bonneville Dam to Astoria) in 2008 to 2011 (average = 0.85). We used the range of lower river survival from 2008 to 2011 (0.71 to 0.99; Porter et al. 2012a) to estimate a 2006 maximum and minimum plume survival (Table 2). To estimate 2006 plume residence time, we first calculated the average proportion of time spent in the plume relative to the combined time in the lower river and plume for 2008 to 2011 (proportion = 0.64). This proportion was multiplied by the 2006 combined lower river/plume residence time to yield estimates of 2006 plume residence time for each group (Table 2).

ASSUMPTIONS AND TESTS

The use of acoustic telemetry and CJS modeling to estimate survival requires a number of assumptions, including that (1) there are no tag effects, (2) tags are not lost, (3) the size range of fish used in the study is representative of the source populations and there is no effect of fork length on survival, (4) every tagged smolt has the same probability of being detected, (5) sampling is instantaneous, (6) the offshore extent of the marine sub-arrays is sufficient to bound the early marine migratory path, and (7) smolts departing the Columbia River migrate north. Here, we summarize the results of tests of these assumptions, which are also available in uncondensed form in Porter et al. (2009b, 2010, 2011, 2012a,b).

Captive tag effects and tagging-induced mortality studies were conducted in 2008 to 2011 to study the

Table 2. *Oncorhynchus tshawytscha*. Estimates of combined lower river/plume survival and residence time and derived plume residence time and survival for acoustic-tagged Chinook smolts released in 2006 in the Snake River (SR_06) and Columbia (CR_06), or Snake River–sourced smolts that were transported and released below Bonneville Dam (ST_06)

Group	No. of fish	Combined residence time (d)	Combined survival (SE)	Derived plume residence time (d)	Derived plume survival (range)
SR_06	380	3.73	0.71 (0.19)	2.40	0.83 (0.72–1.00)
ST_06	203	8.10	0.56 (0.14)	5.22	0.66 (0.56–0.79)
CR_06	398	5.76	0.81 (0.20)	3.71	0.95 (0.82–1.00)

survival, tag retention, and growth of *Oncorhynchus tshawytscha* smolts implanted with V7-2L dummy acoustic tags (DATs) relative to PIT-tagged controls (Porter et al. 2009b, 2010, 2011, 2012b). Small initial effects on growth rates of DAT-tagged smolts were observed. Tag retention was high; no V7-2L DATs were shed in 2008. In 2009, 9 (of 210) DATs were shed, 2 (of 188) were shed in 2010, and 1 (of 87) was shed in 2011. In all years, there were no significant differences in survival or mean fork length between the DAT-tagged and control fish at the conclusion of the studies. To ensure that tag burdens were unlikely to impact survival, we restricted tagging in all years to smolts with a minimum fork length (FL) of 130 mm (one 129 mm smolt was tagged in 2008), which is below the ratio of tag size to smolt size where tag burdens have been found to be significant (Lacroix et al. 2004). Ninety-two percent of tagged smolts also had tag burdens <6.7% of their body weight, the level at which Brown et al. (2006) found that tag burdens may begin to exert an effect on survival.

The 130 mm FL minimum generally restricted tagging to the upper 68 to 88% of the study populations. In 2008, Snake River smolts collected at the Dworshak hatchery were small, and tagged smolts represented only the upper 10% of the population of smolts reared at Dworshak National Fish Hatchery. However, the fork length spectrum represented 76% of the population of hatchery Chinook sampled at the Lower Granite Dam smolt monitoring facility in 2008. Fork length ranges and the proportions of study populations they represent are reported in Table 1. Smolt size has been linked to adult returns and may influence early marine survival (Tomaro et al. 2012). We recorded fork lengths at tagging and compared the fork length frequency distributions of the released fish to those that survived to Willapa Bay. If larger size conferred a survival advantage to Willapa Bay, we would expect the size distribution of survivors to be right-skewed relative to the overall release group. However, the distributions were virtually identical, indicating that there was no size-selective effect (Fig. 2).

Violations of the assumption that every tagged smolt has the same probability of detection should be evident in a lack of fit of standard CJS models to the detection data (the standard CJS model has unique parameters for the probability of survival to, and detection at, each sub-array and thus contains more parameters than the special-case model used to estimate survival in this analysis). There was no evidence in median $\hat{c}$ tests, conducted in the program MARK, of a lack of fit to the 2008 through 2011 data, indicating that this assumption was not violated (Porter et al.

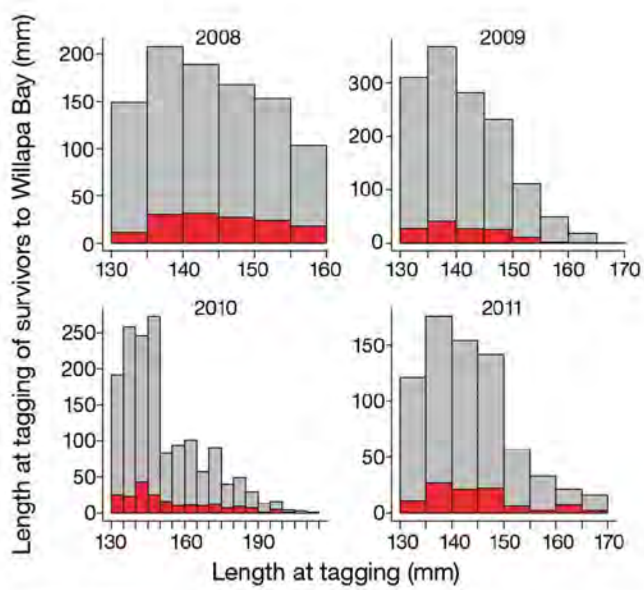

Fig. 2. *Oncorhynchus tshawytscha*. Frequency distributions of the fork lengths of all tagged smolts (gray) and smolts detected at the Willapa Bay sub-array (red). Fork length was measured at the time of tagging. The similarity in the distributions indicates that there was no size-selective effect on survival to the Willapa Bay sub-array

2012a). Instantaneous sampling is the assumption of demographic closure at each sampling period, and, in practice, sampling periods in mark-recapture studies are short, rather than truly instantaneous. From 2008 to 2011, individual fish crossed the arrays within hours of first detection, and the sampling periods at the lower river and Willapa Bay sub-arrays (i.e. the periods between arrival of the first and last smolts in each group) only lasted for several days.

Extensive ocean sampling of juvenile salmon off Oregon and Washington has shown that juveniles are generally confined to the shelf region (Bi et al. 2007, Peterson et al. 2010). From 2008 to 2010, the sub-array at Willapa Bay extended offshore to the 200 m isobath, but was extended to the 500 m isobath in 2011 because smolts continued to be detected on the outermost receivers. In 2011, 9 smolts were detected on the extended receivers, indicating a small number of smolts may have passed outside the detection range of the Willapa Bay sub-array in 2008 to 2010. No smolts were detected on the outermost receivers in 2011, although the receivers were lost, likely to fishing activity, sometime during the 2011 migration season (Porter et al. 2012a). Missed detections could result in a downward bias in plume survival estimates, although CJS modeling alleviates this problem by using subsequent detections at the

Lippy Point sub-array (which are heavily skewed towards the inner shelf) to adjust estimates of survival at Willapa Bay (Porter et al. 2012a).

Miller et al. (1983) demonstrated with north- and south-opening nets that juvenile salmon swim north after entering the ocean. In 2009 and 2011, a sub-array was deployed at Cascade Head, Oregon, to verify the assumption that fish swim north at ocean entry (Fig. 1). The small number of detections at Cascade Head (3 fish in 2009 [number released = 1370] and 6 in 2011 [number released = 725]), suggest the conclusion by Miller et al. (1983) was correct. One of the 6 tagged fish detected at Cascade Head in 2011 was subsequently detected at both Willapa Bay and Lippy Point, further supporting this conclusion. Fish detections at Cascade Head were included in the Willapa sub-array detections to reflect their survival in the plume. We have excluded a group of transport fish released in early-April 2009. This group was released much earlier in the season than the remaining groups (Porter et al. 2009b) and may have entered the plume before predators became abundant (see 'Discussion').

RESULTS

Initial exploration with pairwise plots of the variables and their Pearson correlation coefficients revealed that several variables potentially related to survival, but without clear mechanistic relationships, were also associated with plume residence time. Thus, we divided the variables into 2 categories, those that might affect survival of *Oncorhynchus tshawytscha* indirectly by influencing plume residence time (upwelling at ocean entry, discharge, SST), and those that might directly affect survival by way of feeding opportunities (timing of the biological spring transition, 2 and 4 wk cumulative upwelling prior to ocean entry) or reduced physiological fitness (dissolved gas levels). We excluded turbidity (measured at Bonneville Dam) due to its high correlation with discharge (Pearson correlation coefficient = 0.95) and the distance (146 km) between the dam and the plume. Similarly, we did not consider spill at Bonneville Dam (the final dam in the river) because it is correlated with discharge and does not reflect additional downstream freshwater inputs to the plume.

Plume survival varied widely, but the daily plume survival rate (S_{TS}) was similar among groups (Fig. 3). The estimated mortality rate constant, k, across the groups was 0.12 d^{-1}. There was no evidence of violation of homoscedasticity in the exponential decay

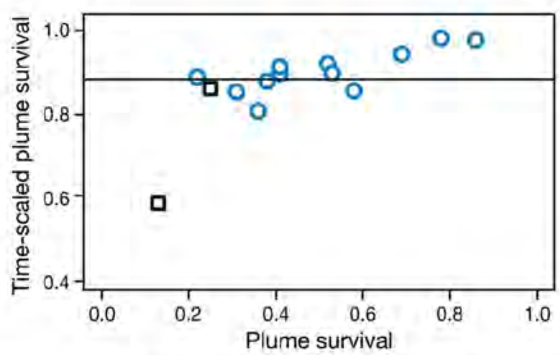

Fig. 3. *Oncorhynchus tshawytscha*. Comparison of plume survival with daily survival rates (open circles). Although plume survival varied widely, the daily survival rate was similar among groups, illustrating the potential effect of residence time on plume survival. The outlier with both low survival and low time-scaled survival was 1 of 2 groups (open squares), exposed to high total dissolved gas concentrations (TDG > 120 %) in the lower river. The gray line is the model estimated daily survival rate

model, the error terms appeared normal, and the bias of the estimate of k was low (bias = −0.003). However, the plot of the fitted regression curve suggests that the model performed well in predicting survival of the groups that migrate in-river, but did not perform as well for groups transported and released below Bonneville Dam (Fig. 4). In-river migrants entered the plume in a more continuous fashion, whereas transported fish entered in brief pulses; the median absolute deviation from the median plume entry date of transported juveniles was <1 d (mean = 0.56 d), but ranged from 1 to 7 d (mean = 3.39 d) for the in-river migrants (Fig. 4). The plume residence time of all groups was brief, averaging 7.29 d (Table 3).

The high variability in survival of the 2008 to 2011 transport groups limits further inference regarding these groups, and the remaining results pertain only to the in-river groups (transport group data are plotted in Fig. 5 for reference). Plots of logit-transformed survival estimates against timing of the biological spring transition relative to plume entry and 2 and 4 wk cumulative upwelling prior to plume entry did not provide evidence of any influence on plume survival (Fig. 5). Additionally, there were no strong patterns in the plots of the model residuals against these variables to suggest that incorporating them would improve the model (Fig. 5).

Survival appears lower at higher (>120 %) levels of dissolved gas supersaturation, which may be evidence of a threshold level of exposure at which gas supersaturation levels experienced in the lower river noticeably affect subsequent plume survival, al-

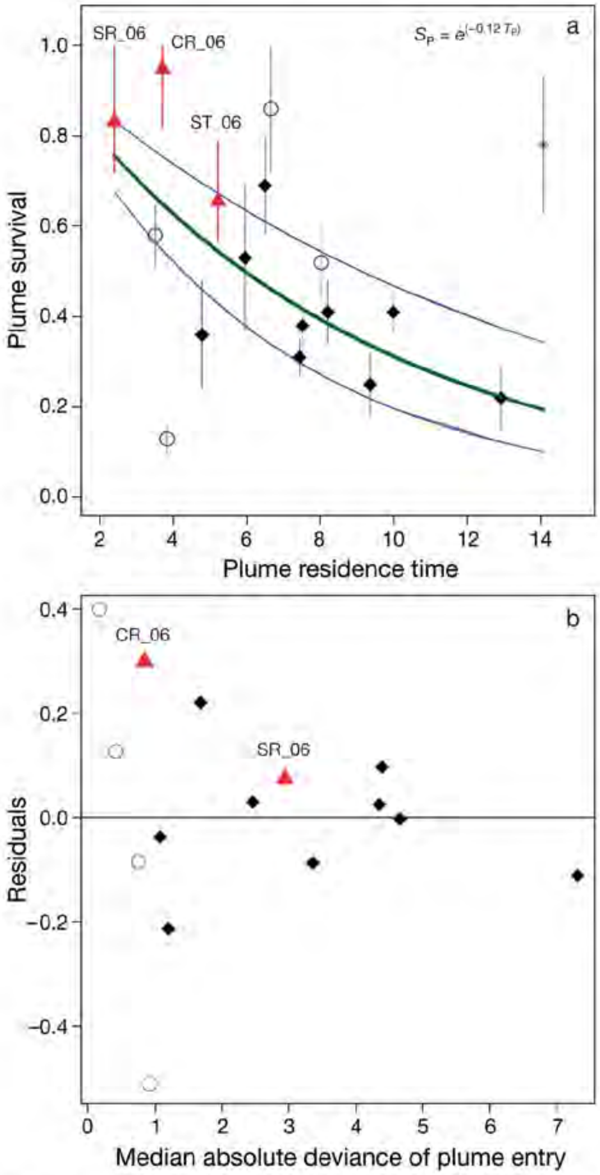

Fig. 4. *Oncorhynchus tshawytscha*. (a) Comparison of plume survival with plume residence time, showing the regression curve (thick green line) and 95% confidence intervals (thin blue lines). The model clearly fits the in-river migrant groups (black diamonds, ±95% CI) better than transported groups (open circles, ±95% CI). Derived estimates of 2006 plume survival and residence time (red triangles; vertical red lines show maximum and minimum estimates) also fit the pattern of a simple exponential decline in survival with residence time. The 2009 early-release transport group excluded in calculations is also shown (star, ±95% CI). (b) Residuals from the regression relationship exhibit greater variance when the spread in plume entry times is low (measured by median absolute deviation), as is also the case for all of the transport groups (open circles) in this study. Median absolute deviation at the Bonneville dam sub-array is shown for 2006 (triangles); there are no data for the 2006 transport group as they were released in the vicinity of Bonneville sub-array

though the evidence for this is weak (Fig. 5). The density of data points at high levels of dissolved gas is less than at lower levels, and the apparent relationship is determined by low survival in a single year, 2011, when dissolved gas levels below Bonneville Dam exceeded the 120% limit established under Oregon and Washington water quality law (USACOE 2011). We did not see evidence in the residual plot that this exposure should have been incorporated into the survival model (but see 'Discussion').

In 2006, smolt travel time between Bonneville Dam and Willapa Bay was short and survival was high, as are the derived estimates of plume residence time and survival (Table 2; Porter et al. 2012a). Additionally, the model performs better in predicting survival of the SR_06 group, which entered the lower river in a more continuous manner than the CR_06 group (Fig. 4). Refitting the exponential decay model to include the 2006 data only changes the decay constant slightly, from 0.12 to 0.11.

Among the 9 candidate models for predicting plume residence time, the model containing only SST outperformed all others, as measured by AICc distance and model weights (weight = 92%; Table 4 and Fig. 6). Diagnostic plots of the SST model did not show evidence of heteroscedasticity or non-normal error terms, and there were no patterns in the plots of the SST-model residuals against the omitted variables, upwelling and discharge, to indicate that that these variables should be included.

DISCUSSION

The Columbia River plume was once posited to benefit juvenile salmon by providing food and refuge while transporting them to safer environs (Casillas 1999). However, research has shown that juvenile salmon do not take advantage of feeding opportunities presented by the plume (DeRobertis et al. 2005, Morgan et al. 2005) and that the plume is rich in salmon predators (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005 Emmett et al. 2006). More recently, acoustic telemetry studies have shown that yearling Chinook *Oncorhynchus tshawytscha* survival in the plume is low in relation to river, estuary, and coastal ocean habitats (Porter et al. 2010, 2012a). Thus, the telemetry data suggest that reducing plume residency may increase yearling Chinook salmon productivity by allowing the smolts to move into regions with higher survival, which runs contrary to initial thinking that the plume might be a refuge where longer residence could increase adult return rates.

Table 3. *Oncorhynchus tshawytscha*. Plume residence time and environmental data summary. The ST_09ER group, shown for reference, was not included in the analysis. For explanation of group designations, see Table 1

Group	Plume residence time (d)	Days since biological spring transition	Cumulative upwelling ($m^3 s^{-1}$ 100 m^{-1}) 2 wk	4 wk	Percent dissolved gas	Sea-surface temperature (C°)	Upwelling ($m^3 s^{-1}$ 100 m^{-1})	Discharge ($m^3 s^{-1}$)
SR_08	8.21	84	243	233	118.1	11.46	8.22	13756.4
ST_08	8.03	82	32	48	118.0	11.42	12.44	13866.7
CR_08	7.52	85	267	332	118.3	11.44	10.44	13496.3
SR_09	5.96	84	286	−550	117.7	13.16	9.71	11194.7
ST_09	6.66	85	383	−527	117.9	13.49	3.57	11271.6
ST_09ER	14.08	51	470	445	113.3	9.95	−27.87	9551.8
CR_09	4.79	87	323	−424	118.3	13.82	2.80	11243.3
SR_10	6.50	−23	25	261	113.3	13.43	18.50	12461.1
ST_10	3.52	−31	128	297	113.4	11.02	14.00	8814.2
CR_10	9.99	−44	612	324	113.1	11.00	−34.55	8074.7
SR_11	9.36	62	57	16	124.6	12.33	2.00	16717.2
ST_11	3.84	61	−52	−98	123.7	11.49	−7.20	16419.6
UC_11	7.44	58	2	−71	116.8	11.47	1.75	14940.6
MC_11	12.92	48	35	−86	113.4	10.73	6.79	13781.0

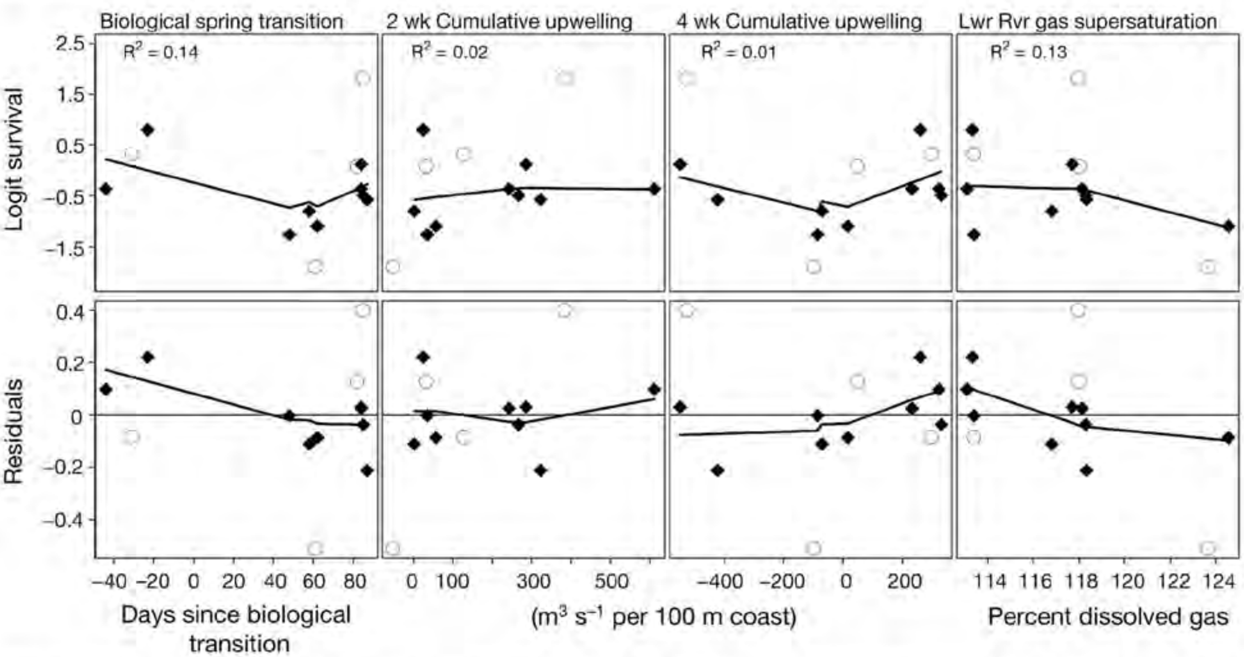

Fig. 5. *Oncorhynchus tshawytscha*. Upper panels: logit-transformed survival compared with measures of coastal productivity and lower river total dissolved gas levels; no clear relationships are evident. Lower panels: plots of residuals from the exponential decay model do not reveal patterns, indicating that the model would be improved by including biological productivity or exposure to gas supersaturated water. Coefficients of determination (R^2) and Friedman's supersmoother lines (R Development Core Team 2011) are fitted to the in-river groups (diamonds). Transport group data (open circles) are shown for reference

Although plume survival estimates in this study ranged from 0.13 to 0.86, they stabilized when scaled by residence time (Fig. 3). If mortality rates in the plume are consistent at comparable periods in the migratory season (groups used in this analysis were released at similar periods each year), then plume survival could be governed by residence time. Consistent with this idea, we find that a simple exponential decay model largely describes plume survival, although the model performs best when analysis is restricted to groups of yearling Chinook whose individuals enter the plume over a longer time period.

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Table 4. *Oncorhynchus tshawytscha.* AIC-based ranking of 9 candidate models of plume residence time containing hypothesized combinations of 3 predictor variables, sea-surface temperature (SST), upwelling (UP), and river discharge (DIS). Evidence is a measure of how many times less likely the model is the best model relative to the top ranked model. AIC_c: corrected Akaike's information criterion

Model	Parameters					AIC_c	ΔAIC_c	Model weight	Evidence
	Intercept	SST	UP	DIS	DIS:UP				
SST	29.06	−1.74	–	–	–	41.77	0	0.92	1.0
SST + DIS	27.83	−1.72	–	0.000078	–	48.81	7.034	0.027	33.7
SST + UP	29.12	−1.74	0.00094	–	–	48.97	7.19	0.025	36.6
UP	8.228	–	−0.053	–	–	50. 25	8.47	0.013	69.2
DIS	5.966	–	–	0.00016	–	51.0092	9.24	0.0091	101.3
UP + DIS	1.838	–	−0.10	0.00051	–	55.37	13.59	0.0010	894.6
SST + UP + DIS	25.89	−1.62	−0.016	0.00014	–	60.69	18.92	0.000071	12834.7
UP × DIS	−2.11	–	−0.66	0.00069	0.000058	65.056	23.28	0.0000081	113745.3
SST + UP × DIS	22.15	−1.45	−0.20	0.00023	0.000018	84.37	42.59	0.0000000052	1778441824.7

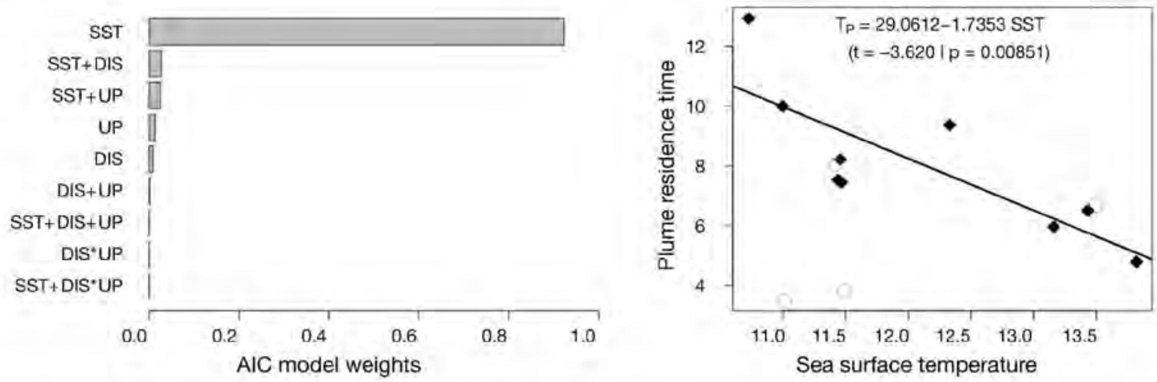

Fig. 6. *Oncorhynchus tshawytscha.* (a) Model ranking for the influence of environmental variables on plume survival; the sea-surface temperature (SST) model receives the greatest proportion of model weight. (b) The inverse relationship between SST and plume residence time suggests that most of the predictive power occurs because smolts do not remain in the plume for long when coastal temperatures are high, increasing survival to Willapa Bay. Diamonds: in-river migrants; open circles: transport groups. For explanation of model abbreviations, see Table 4

This scenario is also consistent with the hypothesis that predation is a key driver of survival in the plume region and provides a plausible bridge between survival and environmental variables, such as river discharge and SST, that have been hypothesized to influence early marine survival, but lack a clear link. The derived estimates of 2006 plume residence time and survival provide additional qualitative support to the idea that plume survival is negatively related to travel time.

The variability in plume survival of the 2008 to 2011 transport groups relative to the fitted regression line suggests that there may be substantial variation in mortality events around the average daily rate that we propose. Over short periods of time (<1 d), pulses of smolts travelling between the Astoria and Willapa Bay sub-arrays may or may not encounter significant numbers of foraging predators, resulting in groups experiencing either very high survival if they pass through the plume without encountering predator aggregations, or very low survival if they encounter substantial number of predator groups. In this scenario, survival of such groups would appear to be more variable than groups whose plume entry times are more dispersed over time, even though the same underlying mortality rate process may apply.

We believe that plume residence times (average: 7.29 d) were too short for starvation to have had an effect and that predation was the most likely cause of plume mortality. The density of piscivorous hake *Merluccius productus* in the plume generally increases in May and peaks in June and July (Agostini et al. 2006, Emmett et al. 2006), and, similarly, the contribution of salmonids to the diet of Caspian terns *Sterna caspia* and double-crested coromorants *Phalacrocorax auritus* that nest near the plume peaks in May (Collis et al.

2002, Lyons et al. 2005). Predation by these piscivorous birds and fish may exert significant top-down control on plume survival (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005, Emmett et al. 2006, Emmett & Sampson 2007), although this has not been conclusively demonstrated. We suspect that the high survival of the early-April 2009 release group, despite a long plume residence time, may be related to the May and June peaks in predation by piscivorous birds and fish (Collis et al. 2002, Anderson et al. 2004, Lyons et al. 2005, Emmett et al. 2006). This is consistent with an effect of emigration timing on early-marine survival (Muir et al. 2006) and the idea that the mortality rate may vary through the migration season. Unfortunately, with only a single data point and no predator data, any inference is severely restricted.

Although the temporal match, or mismatch, between juvenile salmon entering the plume and the timing of spring increases in marine productivity and advection of lipid-rich copepods into marine waters off Oregon and Washington (the biological spring transition) may affect feeding opportunities, plume survival of the groups used in this study does not appear to be related to biological productivity measures. However, biological productivity and the availability of higher quality prey is still potentially relevant to survival at larger temporal scales as it may affect whether juveniles obtain sufficient energy reserves to survive their first winter at sea (Beamish & Mahnken 2001, Tomaro et al. 2012).

The practice of spilling water over Columbia River dam faces (rather than through turbines) to reduce the physical and physiological stress on juvenile salmon can supersaturate the river below the dam with atmospheric gases, potentially leading to gas bubble trauma and, when exposure is non-lethal, reducing fitness (Bouck 1980, Mesa & Warren 1997). During the 2008 to 2011 period, percent dissolved gas levels recorded at the Camas/Washougal monitoring station below Bonneville Dam ranged from a relatively benign 113% to a potentially harmful 125% during flood conditions in 2011 (Bouck 1980, USACOE 2011). Although we found little evidence that dissolved gas exposure explains the variation in plume survival among the groups used in this analysis, an intra-year analysis of the smolts released in 2011 after total dissolved gas levels exceeded state legal limits at the Bonneville Dam release site suggests they may have experienced lower daily survival rates in the river and plume compared with their unexposed counterparts (I. G. Brosnan et al. unpubl. data).

Plume residence time may be affected by water temperature, which has been related to migration timing and speed (Brett et al. 1958, Sykes & Shrimpton 2010, Martin et al. 2012), and river discharge and wind-driven surface currents (reflected in the coastal upwelling index) that may affect travel time by changing the area and depth of the plume and adjusting its orientation between a northern, onshore configuration, or a southwestern, offshore configuration (Hickey et al. 2005, Burla et al. 2010b). The best model of plume residence, by a significant margin, included only SST. Models that included river discharge, which can be influenced by management action, or coastal upwelling, have little weight. This is consistent with Burla et al. (2010a), who found that the physical dynamics of the plume at the time of ocean entry do not affect adult returns of yearling Chinook (although it may affect steelhead returns). If our results are widely applicable, they also suggest that plume survival may not be amenable to improvement via management of the hydropower system, although it is conceivable that hatchery and fish transport releases could be timed to minimize plume residence. However, this would require detailed forecasts of conditions in the early marine environment that are not presently available.

Advances in marine acoustic telemetry have played an important role in addressing scientific questions and conservation problems in the Columbia River basin. Rechisky et al. (2009, 2012, 2013, 2014, this volume) and Welch et al. (2009, 2011) have measured directly the survival of juvenile salmon in key marine habitats and conducted direct experimental tests of survival hypotheses related to dam passage and the downriver transport of juvenile Chinook. Additional releases of telemetered yearling Chinook would provide greater clarity regarding the drivers of plume residence time and could better address the question of plume survival in relation to predator abundance and distribution. Nonetheless, we have shown here that a simple exponential decay model adequately described the survival of juvenile yearling Chinook in the Columbia River plume, and that the ability of resource managers to affect plume survival of yearling Chinook by altering residence time may be limited. If correct, this poses a potential problem, as survival in the plume is low relative to other habitats (Porter et al. 2010, 2012a). Survival might potentially be improved by the successful development of marine environmental forecasts to aid in release timing, and the telemetry data used in this analysis can be extended to a value-of-information analysis to determine what the maximum financial outlay should be for such forecasts (Raiffa & Schlaifer 1961, Williams et al. 2011).

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Submitted: March 13, 2013; Accepted: September 2, 2013

Proofs received from author(s): November 13, 2013

From: David Welch

Sent: Fri Mar 10 19:15:31 2017

To: Zelinsky,Benjamin D (BPA) - EWP-4

Subject: RE: 2018 Spill test???

Importance: Normal

Thanks for the update, Ben-

Have a good weekend, and I trust that things are working out for you as you hope.

Best, David

From: Zelinsky,Benjamin D (BPA) - EWP-4 [mailto:bdzelinsky@bpa.gov]
Sent: Friday, March 10, 2017 5:26 PM
To: David Welch; Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky
Subject: RE: 2018 Spill test???

Thanks David

[redacted] For starters I shared your email with Lydia and Jason.

We will keep you in mind as we develop an action plan.

Ben

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: David Welch <David.Welch@kintama.com>
Date: 3/10/17 3:22 PM (GMT-08:00)
To: "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Cc: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>, Erin Rechisky <Erin.Rechisky@kintama.com>
Subject: 2018 Spill test???

Christine & Ben—

I just saw this comment in the Columba Basin Bulleting as, no doubt, did you:

"However, although in the opening remarks Simon said he was leaning towards ordering the federal agencies to begin maximum allowable spill to the gas cap at the dams beginning April 3 and continuing for two years to see what can be learned about salmon survivability with increased spill, by hearing's end his leaning was toward beginning the spill next year.

That would give both fisheries and dam managers time to devise a study design in order to learn if the spill will help or hinder salmon and steelhead."

(b)(5) [redacted]

David

David Welch, Ph.D.

kintamav_RGB

President, Kintama Research Services Ltd.

Nanaimo, BC, Canada

Office: (250) 729-2600 Mobile: [redacted]

Skype: david.welch.kintama

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Browse animations of our

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

P Please consider the environment before printing this e-mail

From: chpetersen@bpa.gov

Sent: Fri Mar 10 19:47:32 2017

To: David Welch

Subject: RE: 2018 Spill test???

Importance: Normal

Hi

(b)(6) [redacted] I don't have copies of all the declarations but some sound worthwhile to read later.

(b)(5) [redacted]

Christine

Sent from my Verizon 4G LTE smartphone

-------- Original message --------
From: "Zelinsky,Benjamin D (BPA) - EWP-4" <bdzelinsky@bpa.gov>
Date: 3/10/17 5:25 PM (GMT-08:00)
To: David Welch <David.Welch@kintama.com>, "Petersen,Christine H (BPA) - EWP-4" <chpetersen@bpa.gov>
Cc: Erin Rechisky <Erin.Rechisky@kintama.com>
Subject: RE: 2018 Spill test???

Thanks David

We are still figuring out our next steps but I'll make sure folks are aware of the work you've done and the work you could do for us going forward. For starters I shared your email with Lydia and Jason.

We will keep you in mind as we develop an action plan.

Ben

Sent from my Verizon 4G LTE smartphone

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From: David Welch <David.Welch@kintama.com>
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That would give both fisheries and dam managers time to devise a study design in order to learn if the spill will help or hinder salmon and steelhead."

(b)(5) [redacted]

(b)(5) [redacted]

(b)(5) [redacted]

David

David Welch, Ph.D.

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Nanaimo, BC, Canada

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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: Thu Mar 16 12:05:44 2017

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

Cc: Erin Rechisky; Ben Zelinsky

Subject: RE: TMT Dworshak Update

Importance: Normal

Attachments: Cum_Survs_Chilko_CH_byDist_2016_labels.png

Interesting update… thanks! (I copy Erin and Ben Z for their info too).

I'm pretty sure that we have shared this survival graph from acoustic tagging work we did up in the Chilko (=upper Fraser River) last year. Chinook survival to the Fraser River mouth was similar to the work from the Thompson R (another upper Fraser River tributary) that was in our earlier 2008 Large Rivers comparison paper; as you can see, survival to the Fraser River mouth was "only" 50%, so the lack of dams doesn't mean that folks are going to get 80% survival, and suggests that survival in the Columbia River basin may already be exceeding what it is in other big river systems.

Obviously, having data makes it possible to have a debate that is less dependent on folks' expert opinions alone!

Just a quick note. I am here this week, but then gone until the end of the month [redacted]

[redacted]

Christine, we should perhaps touch base on the first invoice I will send in. It will not be for a substantial amount, but we can use it as a test case to see if there will be any hiccups in setting up international payments.

Is there a time that works to set up a brief phone call, preferably tomorrow morning?

David

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Thursday, March 16, 2017 8:58 AM
To: David Welch
Subject: FW: TMT Dworshak Update

Hi David,

This had a detail related to gas bubble trauma in the Dworshak hatchery. The TDG level probably did exceed 104.5%.

(b)(5) [redacted]

Christine

From: Norris,Tony (BPA) - PGPO-5
Sent: Wednesday, March 15, 2017 3:09 PM
To: ADL_DIR_ALL; ADL_PGB_ALL; ADL_PGL_ALL; ADL_PGPO_ALL; ADL_PGPW_ALL; ADL_PGSD_ALL; ADL_PGSP_ALL; ADL_PGST_ALL; Bettin,Scott W (BPA) - EWP-4; Bodi,Lorri (BPA) - E-4; Connolly,Kieran P (BPA) - PG-5; Cooper,Suzanne B (BPA) - PT-5; Dernovsek,David K (BPA) - PTF-5; Evans,Elizabeth A (BPA) - PB-6; Francis,Rose (BPA) - LN-7; Gendron,Mark O (BPA) - P-6; Grimm,Lydia T (BPA) - A-7; Johnson,Kimberly O (BPA) - PGA-6; Johnson,Robert C (BPA) - PTFR-5; Kerns,Steven R (BPA) - PGS-5; Kingsbury,Pamela A (BPA) - PGPL-5; Le,Nga (Dan) (BPA) - PTF-5; Leary,Jill C (BPA) - LN-7; Mercier,Bryan K (BPA) - EW-4; Pendergrass,Richard M (BPA) - PGP-5; Petersen,Christine H (BPA) - EWP-4; Petross,Dennis W (BPA) - PGAF-6; Rector,William Eric (BPA) - PBA-6; Smith,Gregory M (BPA) - EWP-4; Spain,Alex J (BPA) - PTF-5; Stier,Jeffrey K (BPA) - E-4; Sweet,Jason C (BPA) - PGB-5
Cc: Todd,Wayne A (BPA) - PGA-6
Subject: TMT Dworshak Update

The Corps will maintain the 22.5 kcfs outflow through Saturday in lieu of previous plan to increase discharge to 25 kcfs tonight. This delay in the increase is due to system flood control operations for the river stage at

Vancouver. It is expected when the system flood control conditions are ended that the discharge will increase to 25 kcfs at that time.

There will be a TMT meeting on Friday at 1:30 to discuss the potential for releasing the chinook from the hatchery next week (~1 week early). There is currently no plan to release the steelhead early. The Corps still plans on dropping discharge to 8 kcfs for 1-2 days to accommodate the fish release from the hatcheries. Currently, the chinook are experiencing significant gas bubble trauma with 9/10 fish observed with gas bubble in the gills. TDG in the hatchery is currently at 104.5% with TDG downstream of Dworshak at 125-126%. Variations are due to changes in temperature and barometric pressure.

Steve Hall, NWW Corps reported to the TMT about the adverse condition of the new unit 3 stator bars. Steve indicated that the impact to the schedule is unknown at this time.

Tony Norris, P.E.

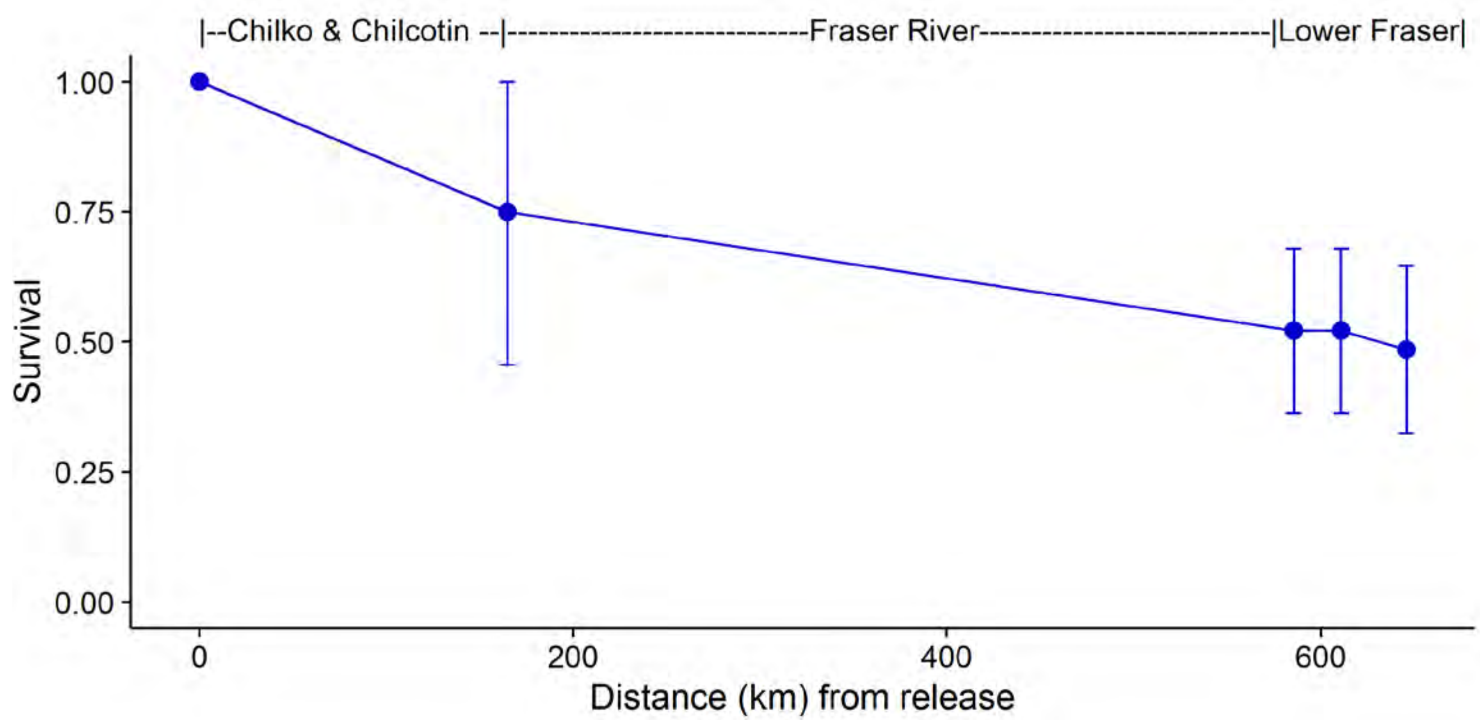
Operations Research Analyst

Operations Planning, PGPO-5

Bonneville Power Administration

503-230-3946 office

(b)(6) [redacted] mobile


|--Chilko & Chilcotin --|-----------------------------Fraser River----------------------------|Lower Fraser|
1.00
0.75
0.50
0.25
0.00
Survival
0
200
400
600
Distance (km) from release

From: David Welch

Sent: Fri Mar 17 09:36:44 2017

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

Subject: RE: TMT Dworshak Update

Importance: Normal

Works for me, and I know Erin is in.

From: Petersen,Christine H (BPA) - EWP-4 [mailto:chpetersen@bpa.gov]
Sent: Friday, March 17, 2017 9:36 AM
To: David Welch; Erin Rechisky
Subject: RE: TMT Dworshak Update

Thanks,

This is somewhat short notice, but would 10-11am work for a call this morning?

Christine

From: David Welch [mailto:David.Welch@kintama.com]
Sent: Thursday, March 16, 2017 12:06 PM
To: Petersen,Christine H (BPA) - EWP-4
Cc: Erin Rechisky; Zelinsky,Benjamin D (BPA) - EWP-4
Subject: RE: TMT Dworshak Update

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Operations Planning, PGPO-5

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(b)(6) [redacted] mobile

From: David Welch

Sent: Fri Mar 17 10:24:11 2017

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

Cc: Erin Rechisky

Subject: FW: BPA work

Importance: Normal

Attachments: Columbia_Chinook_SARS_FPC.xlsx; SurvivalRateStats_AllCWTChinookIndicatorStocks_ERA2014.xlsx

This is the list of stocks we have so far pulled together for the survival comparison; if you have any thoughts on added stocks we should go after, by all means let us know.

Also, feel free to share the Chilko (Fraser River) Chinook survival graph that I sent you yesterday… just mention that it is "in draft", although I think in reality the analysis is pretty well nailed down.

David

From: Aswea Porter
Sent: Thursday, March 16, 2017 9:01 AM
To: David Welch
Subject: RE: BPA work

For our talk this morning:

Col River CH and STHD SARS questions (see pivot tab in Columbia CH attachement)
1) Snake River: All calculated LGR-GRA and include jacks

Use Wild and Hatchery?

Use Spring, Summer, Fall?

2) Mid Columbia:

Yakima and Cl Elum have SARS available either MCN-to-BOA or MCN-to-MCA.

Deschutes STHD are only BON-to-BOA

Hanford Reach Wild Fall CH are MCN-to-BOA or Rel-to-BOA (but Rel to BOA is without jacks)

John Day stocks are JDA-to-BOA

Other 7 stocks are Bon-to-BOA or Rel-to BOA (but only BON-to-BOA has jacks)

3)Upper Columbia:

The combined hatchery and wild STHD and CH tagged at Rock Island dam are Rel-to-BOA

Entiat and Methow R STHD are RRE-to-BOA

Entiat and Methow CH and Upper Col Wild Summer CH are MCN-to-BOA or RRE-to-BOA

Eastbank and Chelan hatchery CH and Wenatchee ST and CH are MCN-to-BOA only

BC CH (see SurvivalRateStats_All CWTChinookIndicatorStocks...)

1) Review together. Confirm that we are using Column E TotalCWTSR from the Coh Anal Surv Rate Data sheet. How specifically were these calculated? How are these similar to or different from the Columbia estimates?

2) Notice that these contain some CWT results for stocks from Oregon to Alaska including West Coast Van Isle (but just a few stocks from each region).

3) There are no confidence intervals.

4) Year is to 2011 (incomplete since 2007?). Get updates?

Puget CH

1) The BC CH file contains estimates for 15 stocks of Puget Chinook

George Adams Fall Fingerling

Nisqually Fall Fingerling

Nooksack Spring Fingerling

Skagit Spring Fingerling

Skagit Spring Yearling

Skykomish Fall Fingerling

South Puget Sound Fall Fingerling

South Puget Sound Fall Yearling

Squaxin Pens Fall Yearling

Skagit Summer Fingerling

Stillaguamish Fall Fingerling

University of Washington Accelerated

White River Spring Yearling

Nooksack Spring Yearling

Samish Fall Fingerling

2) Pursue additional? Where?

BC STHD

1)Only Keogh. How specifically were these calculated? Used a mark-recapture model for adult returns. How are these similar to or different from the Columbia estimates? Keogh R is ~33 km long and the fence is 300 m from ocean.

2)Goes to 2012 (incomplete). Pursue update from who? Don?

Puget STHD

1)Neala was in the process of updating these estimates when she sent them June 2015. Get updates.

2) How specifically were these calculated? Similarity and differences to Columbia estimates?

From: Aswea Porter
Sent: March-14-17 17:26
To: David Welch
Cc: Erin Rechisky
Subject: BPA work

Hi D, Here's where I am at today:

One job from yesterday was to see if survival estimates are available in the CSS reports from hatchery release to LGR. BTW, the FPC website is slow (click wait wait wait wait wait wait etc)

- They do have these values calculated because all the SARS tables include a column "Smolts arriving at ---" where ---- is the upper dam where SARS are measured. These columns are footnoted to describe that they use CJS to calculate survival from release (or the trap I guess for wild) to the upper dam.

· The survival estimates themselves are available from the FPC website for hatchery Snake River spring Chinook and Snake R STHD (all but Sawtooth which comes up blank). *The survival estimates are not available for the other populations* that have SARS in the CSS report: wild Snake R Ch and STHD, Mid and Upper Col, or Snake subyearlings.

· It may be possible to calculate survivals for the missing groups using the "number of PIT Tag fish released" from Appendix C of the CSS report and the "number of smolts arriving at the upper dam". I tested if the ratio of these counts would equal the survival estimates for Dworshak fish and they matched to the second decimal for 8 of 9 years (1997-2005). For more recent years, the number arriving at the upper dam was based on the number in Group T rather than the number released. And I can't find the number in Group T. However this is not an issue for Mid and Upper Col stocks which are not transported.

· There are also survival estimates available online for trap to MCN for hatchery and wild Chinook with Grande Ronde, Inmaha, Salmon, and Snake River traps. However, this isn't much help since the SARS start at LGR not MCN.

Do BC SARS include mortality while in the river and swimming upstream? Recreational fisheries, tribal fisheries?

CSS 2016: Is this of interest as we try to compare SARS across decades?

To compare historical population productivity in the smolt-to-adult life stage necessitates accounting for changes in mainstem harvest rates and upstream passage success (Petrosky and Schaller 2010). Mainstem Columbia River harvest rates decreased markedly in the 1970s following construction of the FCRPS and the decline in abundance and productivity of upriver

Columbia and Snake River populations. Therefore, we also present a time series of SARs for Snake River wild spring/summer Chinook and steelhead based on smolts at the uppermost dam to adult returns to the Columbia River mouth for the 1964 to 2013 (steelhead) or 2014 (Chinook) smolt migration years; this time frame spans completion of the FCRPS, decreases in Columbia

River harvest rates, and a period of variable ocean conditions.

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These are Overall SARS for Zones in the Snake and Columbia Rivers. Accessed March 15th, 2017 from the fish passage

RiverZone	GroupDes	SpeciesCo	RearCode	RaceCode	MigrYr	SAR_Reacl	JuvPop	SARwoJac	SARwoJac	SARwoJac

center: http://www.fpc.org/survival/smol			
SARwJack:	SARwJack:	SARwJack:	Footnote

MCOL	Carson Ha	CH	H	Spr	2000	BON_to_E	12945	3.3	2.71	3.91
MCOL	Carson Ha	CH	H	Spr	2000	Rel_to_BC	14992	2.85	2.62	3.07
MCOL	Carson Ha	CH	H	Spr	2001	BON_to_E	12506	1.78	1.5	2.05
MCOL	Carson Ha	CH	H	Spr	2001	Rel_to_BC	14978	1.49	1.32	1.65
MCOL	Carson Ha	CH	H	Spr	2002	BON_to_E	12349	1.22	0.94	1.54
MCOL	Carson Ha	CH	H	Spr	2002	Rel_to_BC	14983	1.01	0.88	1.14
MCOL	Carson Ha	CH	H	Spr	2003	BON_to_E	12709	0.27	0.19	0.36
MCOL	Carson Ha	CH	H	Spr	2003	Rel_to_BC	14983	0.23	0.17	0.29
MCOL	Carson Ha	CH	H	Spr	2004	Rel_to_BC	14973	0.62	0.51	0.73
MCOL	Carson Ha	CH	H	Spr	2005	BON_to_E	14053	0.32	0.23	0.42
MCOL	Carson Ha	CH	H	Spr	2005	Rel_to_BC	14958	0.3	0.23	0.37
MCOL	Carson Ha	CH	H	Spr	2006	BON_to_E	10509	0.6	0.45	0.77
MCOL	Carson Ha	CH	H	Spr	2006	Rel_to_BC	14971	0.42	0.33	0.51
MCOL	Carson Ha	CH	H	Spr	2007	Rel_to_BC	14943	0.54	0.43	0.63
MCOL	Carson Ha	CH	H	Spr	2008	BON_to_E	12250	1.8	1.51	2.11
MCOL	Carson Ha	CH	H	Spr	2008	Rel_to_BC	14884	1.48	1.32	1.65
MCOL	Carson Ha	CH	H	Spr	2009	BON_to_E	11595	1.84	1.54	2.17
MCOL	Carson Ha	CH	H	Spr	2009	Rel_to_BC	14975	1.42	1.32	1.63
MCOL	Carson Ha	CH	H	Spr	2010	BON_to_E	11056	0.75	0.64	0.86
MCOL	Carson Ha	CH	H	Spr	2010	Rel_to_BC	14947	0.75	0.64	0.86
MCOL	Carson Ha	CH	H	Spr	2011	BON_to_E	10873	0.46	0.33	0.63

3.34	2.75	4	
1.81	1.51	2.09	
1.26	0.95	1.57	
0.27	0.19	0.36	
0.33	0.23	0.43	
0.63	0.48	0.79	
2.05	1.72	2.37	
1.91	1.6	2.23	
0.86	0.73	0.98	
0.48	0.35	0.66	

MCOL	Carson Ha	CH	H	Spr	2011	Rel_to_BC	14953	0.33	0.26	0.42
MCOL	Carson Ha	CH	H	Spr	2012	BON_to_B	13070	0.61	0.44	0.82
MCOL	Carson Ha	CH	H	Spr	2012	Rel_to_BC	14941	0.54	0.44	0.64
MCOL	Carson Ha	CH	H	Spr	2013	BON_to_B	13006	1.21	0.96	1.47
MCOL	Carson Ha	CH	H	Spr	2013	Rel_to_BC	14907	1.05	0.92	1.19
MCOL	Carson Ha	CH	H	Spr	2014	BON_to_B	10895	0.76	0.59	0.95
MCOL	Carson Ha	CH	H	Spr	2014	Rel_to_BC	14906	0.56	0.46	0.66
MCOL	Cle Elum H	CH	H	Spr	2000	MCN_to_I	14416	3.65	3.35	3.96
MCOL	Cle Elum H	CH	H	Spr	2001	MCN_to_I	9269	0.28	0.19	0.38
MCOL	Cle Elum H	CH	H	Spr	2002	MCN_to_I	11753	1.37	1.2	1.55
MCOL	Cle Elum H	CH	H	Spr	2002	MCN_to_I	11753	1.39	1.21	1.57
MCOL	Cle Elum H	CH	H	Spr	2003	MCN_to_I	11978	0.59	0.48	0.71
MCOL	Cle Elum H	CH	H	Spr	2003	MCN_to_I	11978	0.63	0.52	0.76
MCOL	Cle Elum H	CH	H	Spr	2004	MCN_to_I	7982	1.54	1.3	1.78
MCOL	Cle Elum H	CH	H	Spr	2004	MCN_to_I	7983	1.34	1.13	1.57
MCOL	Cle Elum H	CH	H	Spr	2005	MCN_to_I	5792	0.66	0.49	0.83
MCOL	Cle Elum H	CH	H	Spr	2005	MCN_to_I	5792	0.59	0.43	0.76
MCOL	Cle Elum H	CH	H	Spr	2006	MCN_to_I	10283	1.24	1.06	1.41
MCOL	Cle Elum H	CH	H	Spr	2006	MCN_to_I	12661	1.1	0.93	1.27
MCOL	Cle Elum H	CH	H	Spr	2007	MCN_to_I	12661	1.01	0.86	1.16
MCOL	Cle Elum H	CH	H	Spr	2007	MCN_to_I	12661	0.86	0.72	1
MCOL	Cle Elum H	CH	H	Spr	2008	MCN_to_I	11686	3.17	2.86	3.46
MCOL	Cle Elum H	CH	H	Spr	2008	MCN_to_I	11686	2.79	2.51	3.06
MCOL	Cle Elum H	CH	H	Spr	2009	MCN_to_I	15382	1.82	1.65	1.99
MCOL	Cle Elum H	CH	H	Spr	2009	MCN_to_I	15382	1.57	1.4	1.73
MCOL	Cle Elum H	CH	H	Spr	2010	MCN_to_I	12473	1.52	1.33	1.71
MCOL	Cle Elum H	CH	H	Spr	2010	MCN_to_I	12473	1.4	1.22	1.58
MCOL	Cle Elum H	CH	H	Spr	2011	MCN_to_I	11866	0.94	0.79	1.09
MCOL	Cle Elum H	CH	H	Spr	2011	MCN_to_I	11866	0.87	0.73	1
MCOL	Cle Elum H	CH	H	Spr	2012	MCN_to_I	15719	1.22	1.07	1.37
MCOL	Cle Elum H	CH	H	Spr	2012	MCN_to_I	15719	1.07	0.93	1.22
MCOL	Cle Elum H	CH	H	Spr	2013	MCN_to_I	13269	1.38	1.2	1.56
MCOL	Cle Elum H	CH	H	Spr	2013	MCN_to_I	13269	1.33	1.15	1.5
MCOL	Cle Elum H	CH	H	Spr	2014	MCN_to_I	12895	0.58	0.47	0.7
MCOL	Cle Elum H	CH	H	Spr	2014	MCN_to_I	12895	0.49	0.39	0.6
MCOL	Deschutes	CH	W	Fall	2011	BON_to_B	5860	2.3	1.48	3.22

0.67	0.48	0.89	
1.28	1.02	1.55	
0.84	0.67	1.05	
3.99	3.67	4.31	
0.29	0.2	0.39	
1.73	1.54	1.93	
1.77	1.58	1.98	
0.86	0.72	1.01	
0.94	0.8	1.09	
1.85	1.59	2.1	
1.64	1.41	1.88	
0.78	0.59	0.98	
0.73	0.54	0.92	
1.59	1.4	1.8	
1.47	1.27	1.67	
1.51	1.33	1.68	
1.32	1.16	1.49	
5.06	4.64	5.47	
4.64	4.27	5.01	
2.29	2.1	2.49	
2.03	1.84	2.22	
2.53	2.3	2.79	
2.31	2.07	2.55	
1.21	1.04	1.38	
1.12	0.96	1.28	
1.76	1.57	1.96	
1.57	1.4	1.76	
1.95	1.74	2.16	
1.87	1.66	2.07	
0.84	0.7	0.97	
0.73	0.6	0.85	
2.95	1.91	4.09	

MCOL	Deschutes	CH	W	Fall	2011	Rel_to_BC	9897	0.68	0.58	0.77
MCOL	Deschutes	CH	W	Fall	2012	BON_to_B	6696	0.7	0.41	0.78
MCOL	Deschutes	CH	W	Fall	2012	Rel_to_BC	20798	0.23	0.17	0.28
MCOL	Deschutes	CH	W	Fall	2013	BON_to_B	6069	0.31	0.17	0.47
MCOL	Deschutes	CH	W	Fall	2013	Rel_to_BC	26322	0.1	0.07	0.14
MCOL	Deschutes	ST	W	Sum	2006	BON_to_B	815			
MCOL	Deschutes	ST	W	Sum	2007	BON_to_B	942			
MCOL	Deschutes	ST	W	Sum	2008	BON_to_B	1277			
MCOL	Deschutes	ST	W	Sum	2009	BON_to_B	1830			
MCOL	Deschutes	ST	W	Sum	2010	BON_to_B	806			
MCOL	Deschutes	ST	W	Sum	2011	BON_to_B	1704			
MCOL	Deschutes	ST	W	Sum	2012	BON_to_B	1940			
MCOL	Hanford R	CH	W	Fall	2000	MCN_to_I	4521	2.68	2.27	3.11
MCOL	Hanford R	CH	W	Fall	2000	Rel_to_BC	10967	1.1	0.93	1.28
MCOL	Hanford R	CH	W	Fall	2001	MCN_to_I	3642	0.68	0.47	0.91
MCOL	Hanford R	CH	W	Fall	2001	Rel_to_BC	9973	0.25	0.17	0.33
MCOL	Hanford R	CH	W	Fall	2003	MCN_to_I	820	0.43	0.11	0.82
MCOL	Hanford R	CH	W	Fall	2003	Rel_to_BC	2975	0.13	0.03	0.27
MCOL	Hanford R	CH	W	Fall	2004	MCN_to_I	1000	0.2	0	0.44
MCOL	Hanford R	CH	W	Fall	2004	Rel_to_BC	2989	0.07	0	0.17
MCOL	Hanford R	CH	W	Fall	2005	MCN_to_I	6602	0.26	0.15	0.37
MCOL	Hanford R	CH	W	Fall	2005	Rel_to_BC	22634	0.08	0.04	0.11
MCOL	Hanford R	CH	W	Fall	2007	MCN_to_I	7790	0.35	0.24	0.46
MCOL	Hanford R	CH	W	Fall	2007	Rel_to_BC	21007	0.13	0.09	0.17
MCOL	Hanford R	CH	W	Fall	2008	MCN_to_I	5543	2	1.62	2.39
MCOL	Hanford R	CH	W	Fall	2008	Rel_to_BC	16651	0.67	0.56	0.77
MCOL	Hanford R	CH	W	Fall	2009	MCN_to_I	4614	0.72	0.51	0.96
MCOL	Hanford R	CH	W	Fall	2009	Rel_to_BC	13728	0.24	0.17	0.31
MCOL	Hanford R	CH	W	Fall	2010	MCN_to_I	1418	2.61	1.88	3.4
MCOL	Hanford R	CH	W	Fall	2010	Rel_to_BC	4850	0.76	0.56	0.97
MCOL	Hanford R	CH	W	Fall	2011	MCN_to_I	4045	3.19	2.61	3.8
MCOL	Hanford R	CH	W	Fall	2011	Rel_to_BC	10337	1.25	1.07	1.43
MCOL	Hanford R	CH	W	Fall	2012	MCN_to_I	1313	1.29	0.8	1.87
MCOL	Hanford R	CH	W	Fall	2012	Rel_to_BC	4885	0.35	0.23	0.49
MCOL	Hanford R	CH	W	Fall	2013	MCN_to_I	1416	0.64	0.3	1.01
MCOL	Hanford R	CH	W	Fall	2013	Rel_to_BC	4185	0.22	0.1	0.33

0.91	0.54	1.37	
0.65	0.39	0.95	
8.22	5.57	11.06	
7.54	5.07	9.98	
9.95	7.2	12.79	
8.47	6.84	10.21	
3.97	2.59	5.46	
6.45	4.68	8.49	
5.67	3.31	8.31	
2.88	2.45	3.32	
0.71	0.5	0.94	
0.43	0.11	0.82	
0.2	0	0.44	
0.29	0.18	0.4	
0.45	0.33	0.58	
2.27	1.88	2.71	
0.89	0.65	1.17	
2.96	2.15	3.88	
3.44	2.81	4.09	
1.37	0.84	2	
0.99	0.56	1.55	

MCOL	John Day I	CH	W	Spr	2000	JDA_to_B(	1310	10.91	9.32	12.55
MCOL	John Day I	CH	W	Spr	2001	JDA_to_B(	2743	3.86	3.25	4.5
MCOL	John Day I	CH	W	Spr	2002	JDA_to_B(	2513	3.78	3.13	4.52
MCOL	John Day I	CH	W	Spr	2003	JDA_to_B(	4388	2.8	2.38	3.26
MCOL	John Day I	CH	W	Spr	2004	JDA_to_B(	2805	3.14	2.46	3.88
MCOL	John Day I	CH	W	Spr	2005	JDA_to_B(	3817	1.86	1.51	2.22
MCOL	John Day I	CH	W	Spr	2006	JDA_to_B(	2237	2.06	1.55	2.59
MCOL	John Day I	CH	W	Spr	2007	JDA_to_B(	2726	4.33	3.65	5
MCOL	John Day I	CH	W	Spr	2008	JDA_to_B(	2973	5.48	4.69	6.27
MCOL	John Day I	CH	W	Spr	2009	JDA_to_B(	3219	6.77	5.95	7.63
MCOL	John Day I	CH	W	Spr	2010	JDA_to_B(	3095	3.55	2.99	4.14
MCOL	John Day I	CH	W	Spr	2011	JDA_to_B(	2569	0.9	0.59	1.24
MCOL	John Day I	CH	W	Spr	2012	JDA_to_B(	2528	3.4	2.7	4.2
MCOL	John Day I	CH	W	Spr	2013	JDA_to_B(	1151	4.08	3.06	5.18
MCOL	John Day I	CH	W	Spr	2014	JDA_to_B(	991	3.23	2.2	4.51
MCOL	John Day I	ST	W	Sum	2004	JDA_to_B(	2530			
MCOL	John Day I	ST	W	Sum	2005	JDA_to_B(	3571			
MCOL	John Day I	ST	W	Sum	2006	JDA_to_B(	1910			
MCOL	John Day I	ST	W	Sum	2007	JDA_to_B(	2874			
MCOL	John Day I	ST	W	Sum	2008	JDA_to_B(	3069			
MCOL	John Day I	ST	W	Sum	2009	JDA_to_B(	2556			
MCOL	John Day I	ST	W	Sum	2010	JDA_to_B(	2190			
MCOL	John Day I	ST	W	Sum	2011	JDA_to_B(	2252			
MCOL	John Day I	ST	W	Sum	2012	JDA_to_B(	3202			
MCOL	John Day I	ST	W	Sum	2013	JDA_to_B(	1483			
MCOL	Little Whit	CH	H	Fall	2008	BON_to_B	14393	1.74	1.52	1.99
MCOL	Little Whit	CH	H	Fall	2008	Rel_to_BC	24886	1.01	0.9	1.11
MCOL	Little Whit	CH	H	Fall	2009	BON_to_B	14805	0.84	0.7	1
MCOL	Little Whit	CH	H	Fall	2009	Rel_to_BC	24947	0.5	0.43	0.57
MCOL	Little Whit	CH	H	Fall	2010	BON_to_B	15140	2.69	2.35	3.06
MCOL	Little Whit	CH	H	Fall	2010	Rel_to_BC	24951	1.63	1.5	1.77
MCOL	Little Whit	CH	H	Fall	2011	BON_to_B	17626	3.3	2.75	3.9
MCOL	Little Whit	CH	H	Fall	2011	Rel_to_BC	24638	2.36	2.2	2.52
MCOL	Little Whit	CH	H	Fall	2012	BON_to_B	17502	0.58	0.43	0.75
MCOL	Little Whit	CH	H	Fall	2012	Rel_to_BC	24953	0.41	0.34	0.48
MCOL	Little Whit	CH	H	Fall	2013	BON_to_B	10547	0.66	0.52	0.82

11.14	9.51	12.77	
4.12	3.48	4.76	
3.98	3.29	4.75	
2.92	2.49	3.39	
3.32	2.6	4.07	
2.07	1.71	2.47	
2.15	1.63	2.7	
5.06	4.33	5.76	
6.22	5.36	7.08	
7.11	6.25	8.03	
4.85	4.18	5.49	
0.93	0.63	1.28	
4.27	3.49	5.15	
5.12	3.93	6.39	
3.53	2.4	4.9	
4.35	3.6	5.18	
2.77	2.31	3.28	
3.35	2.65	4.07	
8.8	7.73	9.89	
10.23	9.19	11.31	
7.67	6.63	8.65	
6.08	5.18	7.04	
1.95	1.46	2.51	
5.43	4.56	6.34	
10.38	8.39	12.62	
1.85	1.62	2.1	
0.95	0.8	1.12	
2.75	2.41	3.13	
3.38	2.82	3.99	
0.62	0.46	0.8	
0.78	0.62	0.95	

MCOL	Little Whit	CH	H	Fall	2013	Rel_to_BC	14960	0.47	0.38	0.56
MCOL	Yakima Riv	CH	W	Spr	2000	MCN_to_I	2581	6.9	6.1	7.73
MCOL	Yakima Riv	CH	W	Spr	2001	MCN_to_I	521	1.54	0.73	2.52
MCOL	Yakima Riv	CH	W	Spr	2002	MCN_to_I	2130	2.25	1.73	2.82
MCOL	Yakima Riv	CH	W	Spr	2002	MCN_to_I	2130	2.16	1.67	2.71
MCOL	Yakima Riv	CH	W	Spr	2003	MCN_to_I	2143	2.47	1.91	3.04
MCOL	Yakima Riv	CH	W	Spr	2003	MCN_to_I	2143	2.52	1.94	3.09
MCOL	Yakima Riv	CH	W	Spr	2004	MCN_to_I	1297	3.7	2.87	4.62
MCOL	Yakima Riv	CH	W	Spr	2004	MCN_to_I	1297	3.47	2.67	4.38
MCOL	Yakima Riv	CH	W	Spr	2005	MCN_to_I	519	1.35	0.57	2.2
MCOL	Yakima Riv	CH	W	Spr	2005	MCN_to_I	519	1.35	0.57	2.2
MCOL	Yakima Riv	CH	W	Spr	2006	MCN_to_I	565	1.59	0.76	2.65
MCOL	Yakima Riv	CH	W	Spr	2006	MCN_to_I	565	1.42	0.57	2.32
MCOL	Yakima Riv	CH	W	Spr	2007	MCN_to_I	362	1.93	0.86	3.26
MCOL	Yakima Riv	CH	W	Spr	2007	MCN_to_I	362	1.93	0.85	3.25
MCOL	Yakima Riv	CH	W	Spr	2008	MCN_to_I	512	6.84	4.93	8.96
MCOL	Yakima Riv	CH	W	Spr	2008	MCN_to_I	512	5.67	3.98	7.61
MCOL	Yakima Riv	CH	W	Spr	2009	MCN_to_I	990	4.95	3.78	6.21
MCOL	Yakima Riv	CH	W	Spr	2009	MCN_to_I	990	4.14	3.15	5.29
MCOL	Yakima Riv	CH	W	Spr	2011	MCN_to_I	411	0.97	0.24	1.79
MCOL	Yakima Riv	CH	W	Spr	2011	MCN_to_I	411	0.73	0	1.47
MCOL	Yakima Riv	CH	W	Spr	2012	MCN_to_I	826	2.79	1.85	3.85
MCOL	Yakima Riv	CH	W	Spr	2012	MCN_to_I	826	2.79	1.84	3.82
MCOL	Yakima Riv	CH	W	Spr	2013	MCN_to_I	704	1.42	0.75	2.25
MCOL	Yakima Riv	CH	W	Spr	2013	MCN_to_I	704	1.56	0.86	2.41
MCOL	Spring Cre	CH	H	Fall	2008	Rel_to_BC	3853	0.63	0.43	0.83
MCOL	Spring Cre	CH	H	Fall	2009	Rel_to_BC	8686	0.06	0.02	0.1
MCOL	Spring Cre	CH	H	Fall	2010	Rel_to_BC	8962	0.25	0.16	0.33
MCOL	Spring Cre	CH	H	Fall	2011	BON_to_E	8163	0.16	0.09	0.25
MCOL	Spring Cre	CH	H	Fall	2011	Rel_to_BC	8956	0.15	0.08	0.21
MCOL	Spring Cre	CH	H	Fall	2012	Rel_to_BC	8772	0.28	0.19	0.39
MCOL	Spring Cre	CH	H	Fall	2013	BON_to_E	8178	0.56	0.39	0.74
MCOL	Spring Cre	CH	H	Fall	2013	Rel_to_BC	8964	0.5	0.38	0.64
MCOL	Spring Cre	CH	H	Fall	2008	BON_to_E	5877	0.34	0.19	0.52
MCOL	Spring Cre	CH	H	Fall	2008	Rel_to_BC	7477	0.27	0.17	0.36
MCOL	Spring Cre	CH	H	Fall	2008	Rel_to_BC	2677	0.52	0.3	0.75

7.48	6.67	8.38	
1.92	0.98	3.04	
2.3	1.77	2.86	
2.21	1.7	2.76	
2.89	2.27	3.55	
2.89	2.28	3.52	
3.78	2.95	4.7	
3.62	2.83	4.54	
1.35	0.57	2.2	
1.35	0.57	2.2	
1.77	0.85	2.78	
1.59	0.72	2.51	
1.93	0.86	3.26	
1.93	0.85	3.25	
9.19	6.85	11.73	
8.01	5.91	10.38	
5.56	4.33	6.88	
4.65	3.59	5.82	
0.97	0.24	1.79	
0.73	0	1.47	
3.27	2.19	4.45	
3.27	2.23	4.43	
1.56	0.83	2.44	
1.71	0.94	2.61	
0.16	0.09	0.25	
0.68	0.48	0.89	
0.43	0.25	0.64	

MCOL	Spring Cre	CH	H	Fall	2009	Rel_to_BC	5950	0.22	0.13	0.32
MCOL	Spring Cre	CH	H	Fall	2010	BON_to_B	5908	0.2	0.11	0.31
MCOL	Spring Cre	CH	H	Fall	2010	Rel_to_BC	5971	0.2	0.12	0.3
MCOL	Spring Cre	CH	H	Fall	2011	Rel_to_BC	5983	0.23	0.13	0.33
MCOL	Spring Cre	CH	H	Fall	2012	Rel_to_BC	5978	0.23	0.13	0.35
MCOL	Spring Cre	CH	H	Fall	2013	BON_to_B	5402	0.56	0.37	0.75
MCOL	Spring Cre	CH	H	Fall	2013	Rel_to_BC	5976	0.5	0.35	0.65
MCOL	Warm Spr	CH	H	Spr	2007	Rel_to_BC	19698	0.3	0.24	0.38
MCOL	Warm Spr	CH	H	Spr	2008	Rel_to_BC	19936	0.84	0.73	0.94
MCOL	Warm Spr	CH	H	Spr	2009	Rel_to_BC	19924	0.65	0.56	0.74
MCOL	Warm Spr	CH	H	Spr	2010	BON_to_B	8361	0.37	0.26	0.48
MCOL	Warm Spr	CH	H	Spr	2010	Rel_to_BC	14907	0.21	0.15	0.27
MCOL	Warm Spr	CH	H	Spr	2011	BON_to_B	6164	0.45	0.29	0.65
MCOL	Warm Spr	CH	H	Spr	2011	Rel_to_BC	14924	0.19	0.13	0.25
MCOL	Warm Spr	CH	H	Spr	2012	BON_to_B	7802	1.26	0.92	1.63
MCOL	Warm Spr	CH	H	Spr	2012	Rel_to_BC	14806	0.66	0.56	0.77
MCOL	Warm Spr	CH	H	Spr	2013	BON_to_B	10595	1.65	1.3	2.03
MCOL	Warm Spr	CH	H	Spr	2013	Rel_to_BC	14877	1.18	1.04	1.32
MCOL	Warm Spr	CH	H	Spr	2014	BON_to_B	9537	1.36	1.04	1.69
MCOL	Warm Spr	CH	H	Spr	2014	Rel_to_BC	14818	0.88	0.75	0.99
MCOL	Yakima Riv	ST	W	Sum	2002	MCN_to_B	357			
MCOL	Yakima Riv	ST	W	Sum	2002	MCN_to_I	357			
MCOL	Yakima Riv	ST	W	Sum	2003	MCN_to_B	293			
MCOL	Yakima Riv	ST	W	Sum	2003	MCN_to_I	293			
MCOL	Yakima Riv	ST	W	Sum	2004	MCN_to_B	387			
MCOL	Yakima Riv	ST	W	Sum	2004	MCN_to_I	387			
MCOL	Yakima Riv	ST	W	Sum	2005	MCN_to_B	263			
MCOL	Yakima Riv	ST	W	Sum	2005	MCN_to_I	263			
MCOL	Yakima Riv	ST	W	Sum	2006	MCN_to_B	397			
MCOL	Yakima Riv	ST	W	Sum	2006	MCN_to_I	397			
MCOL	Yakima Riv	ST	W	Sum	2007	MCN_to_B	219			
MCOL	Yakima Riv	ST	W	Sum	2007	MCN_to_I	219			
MCOL	Yakima Riv	ST	W	Sum	2008	MCN_to_B	215			
MCOL	Yakima Riv	ST	W	Sum	2008	MCN_to_I	215			
MCOL	Yakima Riv	ST	W	Sum	2009	MCN_to_B	360			
MCOL	Yakima Riv	ST	W	Sum	2009	MCN_to_I	360			

0.24	0.14	0.36	
0.65	0.45	0.87	
0.63	0.47	0.79	
0.49	0.31	0.69	
1.64	1.23	2.1	
2	1.61	2.45	
1.58	1.22	1.95	
8.12	5.24	11.37	
6.16	3.72	8.83	
7.85	4.93	11.19	
6.49	4.05	9.29	
2.84	1.46	4.67	
2.58	1.26	4.29	
4.94	2.56	7.9	
4.56	2.29	7.36	
4.03	2.2	5.98	
3.27	1.7	4.97	
7.3	3.29	12.06	
6.39	2.87	10.55	
9.79	5.67	14.26	
8.85	4.93	13.24	
5.27	3.26	8.2	
4.72	2.79	7.28	

MCOL	Yakima Riv	ST	W	Sum	2010	MCN_to_I	331			
MCOL	Yakima Riv	ST	W	Sum	2010	MCN_to_I	331			
MCOL	Yakima Riv	ST	W	Sum	2011	MCN_to_I	213			
MCOL	Yakima Riv	ST	W	Sum	2011	MCN_to_I	213			
MCOL	Yakima Riv	ST	W	Sum	2012	MCN_to_I	381			
MCOL	Yakima Riv	ST	W	Sum	2012	MCN_to_I	381			
MCOL	Yakima Riv	ST	W	Sum	2013	MCN_to_I	240			
MCOL	Yakima Riv	ST	W	Sum	2013	MCN_to_I	240			

5.74	2.91	9.56	
4.53	2.13	7.71	
3.28	1.32	5.82	
2.34	0.88	4.57	
7.6	4.52	10.87	
5.24	2.99	7.91	
5.42	1.6	10.85	
4.17	1.18	8.78	

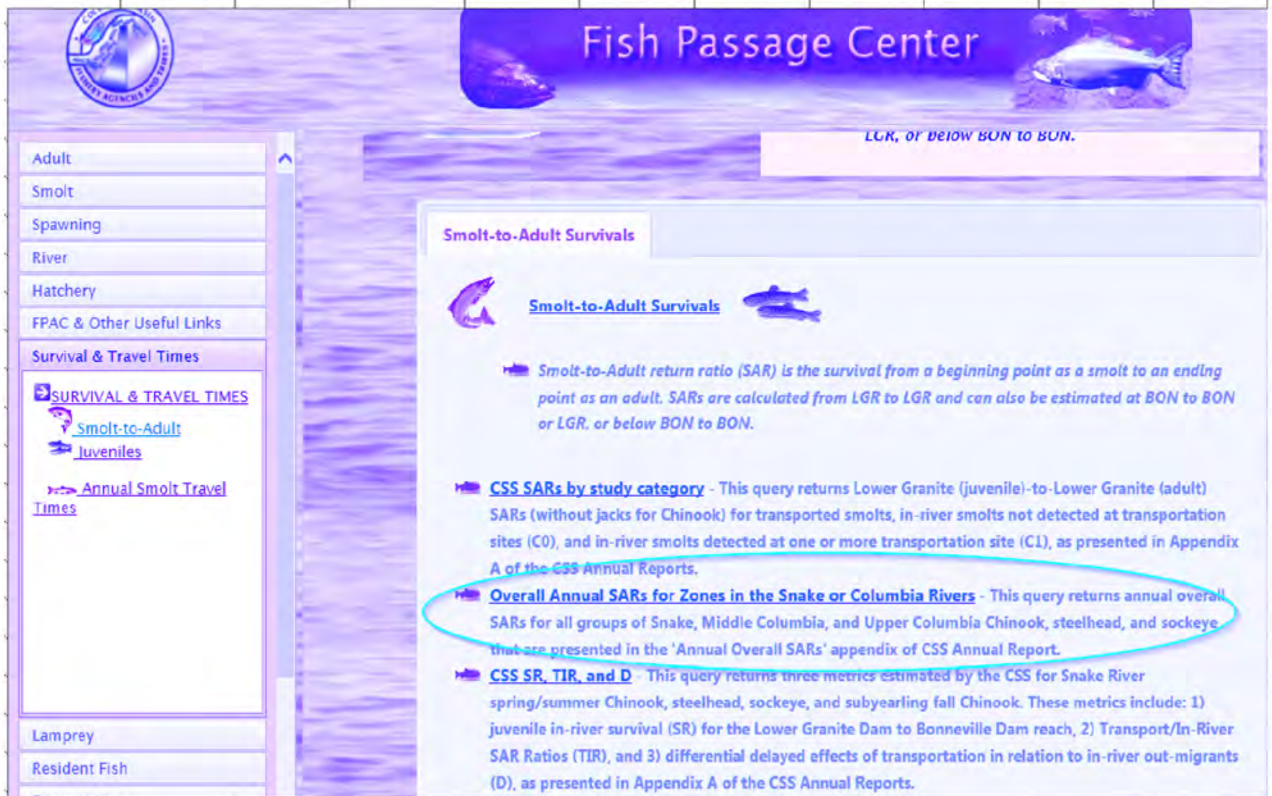
Count of SARwJacks							
						Total	Total is the Cc
MCOL	Carson Hatchery Spring Ch	CH	H	Spr	BON_to_BOA	13	
					Rel_to_BOA		
	Cle Elum Hatchery Spring (	CH	H	Spr	MCN_to_BOA	15	
					MCN_to_MCA	13	
	Deschutes River Wild Fall (	CH	W	Fall	BON_to_BOA	3	
					Rel_to_BOA		
	Deschutes River Wild Stee	ST	W	Sum	BON_to_BOA	7	
	Hanford Reach Wild Fall C	CH	W	Fall	MCN_to_BOA	12	
					Rel_to_BOA		
	John Day River Wild Spring	CH	W	Spr	JDA_to_BOA	15	
	John Day River Wild Steelh	ST	W	Sum	JDA_to_BOA	10	
	Little White Salmon Hatch	CH	H	Fall	BON_to_BOA	6	
					Rel_to_BOA		
	Spring Creek Hatchery Fall	CH	H	Fall	BON_to_BOA	1	
					Rel_to_BOA		
	Spring Creek Hatchery Fall	CH	H	Fall	BON_to_BOA	2	
					Rel_to_BOA		
	Spring Creek Hatchery Fall	CH	H	Fall	BON_to_BOA	2	
					Rel_to_BOA		
	Warm Springs Hatchery Sp	CH	H	Spr	BON_to_BOA	5	
					Rel_to_BOA		
	Yakima River Wild Spring (	CH	W	Spr	MCN_to_BOA	13	
					MCN_to_MCA	11	
	Yakima River Wild Steelhe	ST	W	Sum	MCN_to_BOA	12	
					MCN_to_MCA	12	
SNAK	Catherine Creek Hatchery	CH	H	Spr	LGR_to_GRA	14	
	Clearwater Hatchery Sprin	CH	H	Spr	LGR_to_GRA	9	
	Clearwater Hatchery Sumı	CH	H	Sum	LGR_to_GRA	4	
	Clearwater River Hatchery	ST	H	Sum	LGR_to_GRA	6	
	Clearwater River Wild Spri	CH	W	Spr	LGR_to_GRA	9	
	Clearwater River Wild Stee	ST	W	Sum	LGR_to_GRA	8	
	Dworshak Hatchery Fall Ch	CH	H	Fall	LGR_to_GRA	5	

unt with jacks.

	Dworshak Hatchery Spring	CH	H	Spr	LGR_to_GRA	18	
	Grande Ronde River Hatch	CH	H	Fall	LGR_to_GRA	6	
	Grande Ronde River Hatch	ST	H	Sum	LGR_to_GRA	6	
	Grande Ronde River Wild :	CH	W	Spr	LGR_to_GRA	9	
	Grande Ronde River Wild :	ST	W	Sum	LGR_to_GRA	8	
	Hells Canyon Hatchery Ste	ST	H	Sum	LGR_to_GRA	5	
	Imnaha Hatchery Summer	CH	H	Sum	LGR_to_GRA	18	
	Imnaha River Hatchery Ste	ST	H	Sum	LGR_to_GRA	6	
	Imnaha River Wild Steelhe	ST	W	Sum	LGR_to_GRA	8	
	Imnaha River Wild Summe	CH	W	Sum	LGR_to_GRA	9	
	Lyons Ferry Hatchery Fall (	CH	H	Fall	LGR_to_GRA	6	
	Lyons Ferry Hatchery Fall (	CH	H	Fall	LGR_to_GRA	5	
	Lyons Ferry Hatchery Fall (	CH	H	Fall	LGR_to_GRA	6	
	Lyons Ferry Hatchery Fall (	CH	H	Fall	LGR_to_GRA	6	
	McCall Hatchery Summer	CH	H	Sum	LGR_to_GRA	18	
	Middle Fork Salmon River	CH	W	SpSu	LGR_to_GRA	9	
	Nez Perce Hatchery Fall Ch	CH	H	Fall	LGR_to_GRA	3	
	Nez Perce Hatchery Fall Ch	CH	H	Fall	LGR_to_GRA	3	
	Oxbow Hatchery Fall Chin	CH	H	Fall	LGR_to_GRA	4	
	Oxbow Hatchery Sockeye	SK	H	Sum	LGR_to_GRA	3	
	Pahsimeroi Hatchery Sum	CH	H	Sum	LGR_to_GRA	7	
	Rapid River Hatchery Sprir	CH	H	Spr	LGR_to_GRA	18	
	Salmon River Hatchery Ste	ST	H	Sum	LGR_to_GRA	6	
	Salmon River Hatchery Ste	ST	H	Sum	LGR_to_GRA	6	
	Salmon River Wild Steelhe	ST	W	Sum	LGR_to_GRA	8	
	Sawtooth Hatchery Sockey	SK	H	Sum	LGR_to_GRA	5	
	Sawtooth Hatchery Spring	CH	H	Spr	LGR_to_GRA	8	
	Snake River Hatchery Stee	ST	H	Sum	LGR_to_GRA	1	
	Snake River Hatchery Stee	ST	H	Sum	LGR_to_GRA	17	
	Snake River Wild Fall Chin	CH	W	Fall	LGR_to_GRA	4	
	Snake River Wild Spring_S	CH	W	SpSu	LGR_to_GRA	21	
	Snake River Wild Steelhea	ST	W	Sum	LGR_to_GRA	17	
	Snake River Wild Steelhea	ST	W	Sum	LGR_to_GRA	8	
	Snake River Wild Steelhea	ST	W	Sum	LGR_to_GRA	8	
	South Fork Salmon River V	CH	W	SpSu	LGR_to_GRA	9	
	Umatilla_Irrigon Hatchery	CH	H	Fall	LGR_to_GRA	6	

	Upper Salmon River Wild :	CH	W	SpSu	LGR_to_GRA	9	
UCOL	Combined Hatch_Wild Spr	CH	HW	Spr	Rel_to_BOA	14	
	Combined Hatch_Wild Ste	ST	HW	Sum	Rel_to_BOA	13	
	Combined Hatch_Wild Summer Chinook tagged at Rock Island Dam					15	
	Eastbank and Chelan Hatc	ST	H	Sum	MCN_to_BOA	11	
	Entiat and Methow River \	CH	W	Spr	MCN_to_BOA	9	
					RRE_to_BOA	7	
	Entiat and Methow River \	ST	W	Sum	RRE_to_BOA	6	
	Leavenworth Hatchery Spr	CH	H	Spr	MCN_to_BOA	15	
	Upper Columbia River (ab	CH	W	Sum	MCN_to_BOA	3	
					RRE_to_BOA	3	
	Wenatchee Entiat and Me	ST	W	Sum	MCN_to_BOA	8	
	Wenatchee River Wild Spr	CH	W	Spr	MCN_to_BOA	8	

Data accessed from here:



Estimation of overall annual SARs in smolt migration year beginning 2006

With the approach of pre-assigning part of the PIT-tagged release gro mode group (called Group T) that follows the routing of the untagged popula collector dams, fewer parameters (than was the case before 2006) need to be intermediate steps before arriving at the final overall SAR estimate. The esti overall SAR is simply the number of returning adults in Group T divided by t number of smolts arriving LGR (both detected and undetected). The estimate tagged smolts arriving LGR is obtained by multiplying the release number in estimated S_1 (survival probability from release to LGR tailrace) obtained fro model on the total release. Group T reflects the untagged fish passage experi year's fish passage management actions. SARs for this report represent adult September 14, 2014.

Group T	PIT-tagged fish that have been pre-assig mode operations which routes the PIT-t pathways identical to the untagged run (e.g., back to river prior to the initiation and to raceways during transportation) a facilities (LGR, LGS, LMN, and MCN) entire migration season.

Methods

Overall SARs are based on PIT-tagged fish that experienced

up into a monitor-
tion through
estimated during
mation of the annual
he estimated
ed number of PIT-
Group T by the
n running the CJS
ence under a given
returns through

ned to the monitor-
agged fish to
of the river fish
of transportation
it all transportation
throughout the

the same conditions as

Methods

Overall SARs are based on PIT-tagged fish that experienced
untagged smolts under a given year's fish passage management scen
migration year 2006, this "run at large" group in the Snake River wa
Group T (Chapter 1 and Figure A.1). Prior to 2006 in the Snake Riv
proportion of run at large represented by each study group T_0, C_0 an
Report (Tuomikoski et al. 2009) found good agreement between ove
the pre-2006 and 2006 methods.

Overall SAR	The SAR that includes the survival of all smolts weighted across their different in-route experiences; the SAR of an entire b irrespective of their route of passage thro hydrosystem.

the same conditions as
ario. Beginning in
s represented by the
er, we estimated the
d C_1. The CSS 2009 Annual
rall SARs computed with

outmigrating
river and transport
rood of smolts,
ugh the