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

Refer to NMFS No.:
WCR-2013-76

November 3, 2015

Dennis McLerran
Regional Administrator
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

Re: Endangered Species Act Biological Opinion on the Environmental Protection Agency's Proposed Approval of Certain Oregon Water Quality Standards Including Temperature and Intergravel Dissolved Oxygen

Dear Mr. McLerran:

Enclosed is a joint conference and biological opinion (opinion) that we prepared pursuant to section 7(a)(2) of the Endangered Species Act (ESA) for the Environmental Protection Agency's proposed approval of certain Oregon water quality standards including temperature and intergravel dissolved oxygen.

In this opinion, we conclude that the proposed action is likely to jeopardize the continued existence of the following species, and result in the destruction or adverse modification of their designated critical habitats, with the exception of Southern Resident killer whales:

1. Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*)
2. Upper Willamette River Chinook salmon (*O. tshawytscha*)
3. Snake River sockeye salmon (*O. nerka*)
4. Lower Columbia River steelhead (*O. mykiss*)
5. Middle Columbia River steelhead
6. Upper Columbia River steelhead
7. Upper Willamette River steelhead
8. Snake River Basin steelhead
9. Southern Resident killer whale (*Orcinus orca*)

We also conclude that the proposed action is not likely to jeopardize the continued existence of the following species, or result in the destruction or adverse modification of their designated or proposed critical habitats (where applicable):

1. Snake River fall-run Chinook salmon
2. Snake River spring/summer-run Chinook salmon
3. Upper Columbia River Chinook salmon
4. Columbia River chum salmon (*O. keta*)
5. Lower Columbia River coho salmon (*O. kisutch*)
6. Oregon Coast coho salmon
7. Southern Oregon/Northern California Coast (SONCC) coho salmon
8. Southern distinct population segment of eulachon (*Thaleichthys pacificus*)
9. Southern distinct population segment of green sturgeon (*Acipenser medirostris*)

We conclude that the proposed action will have no effect on the following species or their designated critical habitats:

1. Blue whale (*Balaenoptera musculus*)
2. Fin whale (*B. physalus*)
3. Sei whale (*B. borealis*
4. Sperm whale (*Physeter macrocephalus*)
5. Humpback whale (*Megaptera novaeangliae*)
6. Stellar sea lion (*Eumetopias jubatus*)
7. Leatherback turtle (*Dermochelys coriacea*)

We have proposed critical habitat for Lower Columbia River coho salmon, but have not designated it. Therefore, our conclusion for the critical habitat of Lower Columbia River coho salmon will not be effective until that designation is final and we have adopted the conference opinion as a biological opinion.

Section 7(b)(3)(A) of the ESA requires that, if we reach a conclusion of jeopardy or destruction or adverse modification of critical habitat, we provide a reasonable and prudent alternative (RPA), which is an alternative action that the Federal agency could take that would not violate section 7(a)(2) of the ESA. The attached opinion contains one reasonable and prudent alternative to the proposed action. Implementing this RPA would change the proposed action such that we would conclude that it would not jeopardize the listed species or cause destruction or adverse modification of their critical habitats.

Please thank your staff for the many hours they spent with us working through the technical and policy issues that arose in this complex consultation. If you have any questions concerning this document, please call Jeff Lockwood at 503.231.2249.

Sincerely,

William W. Stelle, Jr.
Regional Administrator

cc: John Palmer, EPA

Jeopardy and Destruction or Adverse Modification of Critical Habitat Endangered Species Act Biological Opinion
for

The Environmental Protection Agency's Proposed Approval of Certain Oregon Water Quality Standards Including Temperature and Intergravel Dissolved Oxygen

NMFS Consultation Number: WCR-2013-76

Federal Action Agency: Environmental Protection Agency, Region 10

Affected Species and Determinations:

ESA-listed Species	ESA Status	Is the action likely to adversely affect this species or its critical habitat?	Is the action likely to jeopardize this species?	Is the action likely to destroy or adversely modify critical habitat for this species?
Lower Columbia River Chinook salmon	T	Yes	Yes	Yes
Upper Willamette River Chinook salmon	T	Yes	Yes	Yes
Upper Columbia River spring-run Chinook salmon	E	Yes	No	No
Snake River spring/summer run Chinook salmon	T	Yes	No	No
Snake River fall-run Chinook salmon	T	Yes	No	No
Columbia River chum salmon	T	Yes	No	No
Lower Columbia River coho salmon	T	Yes	No	No*
Oregon Coast coho salmon	T	Yes	No	No
Southern Oregon/Northern California coast coho salmon	T	Yes	No	No
Snake River sockeye salmon	E	Yes	Yes	Yes
Lower Columbia River steelhead	T	Yes	Yes	Yes
Upper Willamette River steelhead	T	Yes	Yes	Yes
Middle Columbia River steelhead	T	Yes	Yes	Yes
Upper Columbia River steelhead	T	Yes	Yes	Yes
Snake River Basin steelhead	T	Yes	Yes	Yes
Southern green sturgeon	T	Yes	No	No
Eulachon	T	Yes	No	No
Southern Resident killer whale *(Orcinus orca)*	E	Yes	Yes	No

*Critical habitat has been proposed for LCR coho salmon.

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

Issued by: William W. Stelle, Jr.
Regional Administrator

Date Issued: November 3, 2015

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1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554).

1.2 Consultation History

The Oregon Department of Environmental Quality (DEQ) completed a triennial review of the state's water quality standards (WQS) in January, 1996, and submitted revised standards for water temperature, dissolved oxygen and hydrogen ion concentration (pH) to the U.S. Environmental Protection Agency (EPA), Region 10, for approval under the Clean Water Act (CWA) on July 11, 1996. EPA initiated consultation on Oregon's proposed WQS for dissolved oxygen, temperature, and pH in January 1997. On September 18, 1998, EPA submitted a biological assessment (BE) (EPA 1998) for EPA's proposed approval of Oregon's revised WQS. We issued an opinion on EPA's proposed action on July 7, 1999 (NMFS 1999a). The opinion concluded that EPA's proposed approval of Oregon's WQS was not likely to jeopardize the continued existence of the listed, proposed, and candidate species named in the BA, or result in the destruction or adverse modification of their critical habitat.

To address issues raised in the ESA consultation on its 1999 approval action, EPA proposed an intergovernmental project to develop guidance for water temperature criteria for use in the Pacific Northwest. We also required completion of this project in our July, 1999 opinion. The goal for this project was to develop guidance that:

- Meets the biological requirements of native salmonid species for survival and recovery pursuant to ESA
- Provides for the restoration and maintenance of surface water temperature to support and protect native salmonids pursuant to the CWA
- Meets the salmon rebuilding needs of Federal trust responsibilities with treaty tribes
- Recognizes the natural temperature potential and limitations of water bodies
- Can be effectively incorporated by states and tribes in water quality standards programs
- Will be used by states and tribes to revise their temperature standards, if necessary

- Will be used by EPA, NMFS and U.S. Fish and Wildlife Service to evaluate state and tribal standard revisions[1]

We endorsed the final guidance document (April 23, 3002, letter from Robert Lohn, NMFS, to John Iani, EPA Region 10), and consider the Temperature Guidance to include the best scientific information available at the time on the thermal requirements of salmon and steelhead and on how to construct state or tribal water quality criteria for temperature.

The EPA's CWA approval document and NMFS' 1999 biological opinion were challenged by Northwest Environmental Advocates (NWEA), which filed a lawsuit in April 2001, challenging the Federal agencies' decision regarding Oregon's WQS. On March 31, 2003, the U.S. District Court for Oregon invalidated EPA's approval of Oregon's revised standards, and directed EPA to promulgate the following Federal WQS for Oregon waters:

- numeric criteria for the protection of salmonid rearing and bull trout rearing and spawning, accompanied by specific time and place use designations;
- a numeric temperature criterion for the lower Willamette River;
- a water quality criterion for intergravel dissolved oxygen (IGDO) for the protection of salmonid spawning; and
- a plan for implementing the antidegradation policy adopted by Oregon.

The March 31, 2003 court decision also invalidated the opinion issued by NMFS in 1999 on EPA's proposed approval of new and revised Oregon WQS. The court ordered NMFS to withdraw its opinion and reinitiate consultation with the EPA under the ESA. In accordance a stipulated schedule, the Court ordered NMFS to sign and transmit to EPA a final opinion within 53 days of receipt of a BE.

On December 10, 2003, Oregon revised its WQS to address the issues raised in the March, 31 2003 court order and subsequently submitted the WQS to EPA for approval. On January 12, 2003, NMFS received a letter requesting informal and formal consultation pursuant to section 7(a)(2) on a December 22, 2003 draft BE on EPA's proposed approval of Oregon's revised WQS. On February 2, 2004, NMFS received an EFH assessment and request for consultation on the subject action under section 305(b) of the MSA. We received a final version of EPA's BE on February 4, 2004.

On February 23, 2004, NMFS issued its opinion on EPA's proposed approval of Oregon's 2003 revised WQS. We concluded that EPA's approval of Oregon's 2003 WQS would not jeopardize listed species or result in the destruction or adverse modification of their critical habitat. On March 2, 2004, EPA approved Oregon's 2003 revised WQS.

On December 13, 2005 NWEA sued EPA on its approval of Oregon's 2003 revised standards and NMFS on the issuance of its opinion. On February 28, 2012, the court issued an opinion and order that found partially for EPA and NMFS, and partially for NWEA. The court found that

[1] EPA Region 10, Pacific NW Temperature Criteria Project goals and expected outcomes. Available at: http://yosemite.epa.gov/r10/water.nsf/6cb1a1df2c49e4968825688200712cb7/2cba8512381c21ae882569e400793772!OpenDocument (accessed April 28, 2015).

EPA's previous approval of the narrative natural conditions criteria (NCC) for temperature was arbitrary and capricious. However, the court also upheld EPA's approvals of the IGDO criteria (OAR 340-041-0016), the biologically-based numeric temperature criteria (OAR 340-041-0028(4)(a-f)), and Oregon's designated uses, among other aspects of Oregon's WQS. The court also found that NMFS failed to adequately consider cumulative effects, recovery, or the effects of the action on individual species, and therefore could not determine whether NMFS's consideration of criteria for the four following beneficial uses was reasonable:

- Salmon and steelhead spawning through fry emergence
- Steelhead smoltification
- Salmon and steelhead migration corridors
- IGDO

In an order dated January 7, 2013, the court set aside NMFS' 2004 opinion, required EPA to amend its BE and submit it to NMFS, and required NMFS to complete ESA consultation on the impacts of EPA's approval of Oregon's temperature standard on listed species and designated critical habitat and issue a revised opinion. On April 10, 2013, the court issued an order setting aside EPA's approval of the NCC and the statewide natural conditions (hereafter, "SNC") criteria and requiring EPA to take action on the NCC and SNC. On August 8, 2013, EPA disapproved Oregon's NCC (located at OAR 340-041-0028(8)) and SNC (located at OAR 340-041-0007(2)) in compliance with that court order.

On November 4, 2013, the EPA requested (1) initiation of formal consultation under section 7 of the ESA with NMFS for its proposed approval of certain provisions of the 2003 water quality standards (WQS) of the State of Oregon (hereafter, "Oregon") that the EPA determined are likely to adversely affect certain listed species and designated critical habitat, and (2) requested our concurrence with their determination that approval of certain other provisions of the 2003 WQS are not likely to adversely affect certain other listed species and designated critical habitat (Table 1). The request was accompanied by a biological evaluation (BE; EPA 2013). The EPA made separate determinations of effect for each numeric and narrative criterion for each species group (*e.g.*, Chinook salmon, steelhead), resulting in dozens of determinations. The EPA did not make an overall determination for their proposed action by species. However, the EPA determined that at least one criterion would adversely affect all of the ESA-listed species of salmon, steelhead, green sturgeon and eulachon that occur in the action area for this consultation; these species are listed in Table 1.

Table 1. Listing status, status of critical habitat designations and protective regulations, and relevant Federal Register (FR) decision notices for ESA-listed species considered in this opinion. Listing status: 'T' means listed as threatened; 'E' means listed as endangered; 'P' means proposed for listing or designation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Lower Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Columbia River spring-run	E 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	ESA section 9 applies
Snake River spring/summer-run	T 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Snake River fall-run	T 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Chum salmon *(O. keta)*			
Columbia River	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Coho salmon *(O. kisutch)*			
Lower Columbia River	T 6/28/05; 70 FR 37160	P 1/14/13; 78 FR 2726	6/28/05; 70 FR 37160
Oregon Coast	T 6/20/11; 76 FR 35755	2/11/08; 73 FR 7816	2/11/08; 73 FR 7816
Southern Oregon/Northern California Coast	T 6/28/05; 70 FR 37160	5/5/99; 64 FR 24049	6/28/05; 70 FR 37160
Sockeye salmon *(O. nerka)*			
Lake Ozette	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Snake River	E 8/15/11; 70 FR 37160	12/28/93; 58 FR 68543	ESA section 9 applies
Steelhead (*O. mykiss*)			
Lower Columbia River	T 1/5/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River	T 1/5/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Middle Columbia River	T 1/5/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Columbia River	T 1/5/06; 71 FR 834	9/02/05; 70 FR 52630	2/1/06; 71 FR 5178
Snake River Basin	T 1/5/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Green sturgeon (*Acipenser medirostris*)			
Southern DPS	T 4/07/06; 71 FR 17757	10/09/09; 74 FR 52300	6/2/10; 75 FR 30714
Eulachon *(Thaleichthys pacificus)*			
Southern DPS	T 3/18/10; 75 FR 13012	10/20/11; 76 FR 65324	Not applicable
Killer whale (*Orcinus orca*)			
Southern Resident	E 11/18/05; 70 FR 69903	11/29/06; 71 FR 69054	ESA section 9 applies

The EPA also made a determination that its proposed action "would not likely have an adverse effect" on the following species, but did not request that we concur with these determinations:

- Blue whale (*Balaenoptera musculus*)
- Fin whale (*B. physalus*)
- Humpback whale (*Megaptera novaeangliae*)
- Sei whale (*B. borealis*)
- Sperm whale (*Physeter macrocephalus*)
- Stellar sea lion (*Eumetopias jubatus*)
- Leatherback turtle (*Dermochelys coriacea*)

The EPA determined after submitting the BE that its proposed action is not likely to adversely affect Southern Resident killer whales (*Orcinus orca*), but did not request that we concur with this determination.[2] We listed this species as endangered on November 18, 2005 (USDC 2005), and designated critical habitat on November 29, 2006 (USDC 2006). On November 25, 2013, we sent a letter to EPA[3] requesting additional information needed to initiate consultation, including the following:

- Information supporting EPA's statement that in many rivers meeting the criterion for salmon and steelhead juvenile rearing and migration of 18°C (64°F), temperatures will be above 15°C for only short durations over the course of a summer, and thus, in many Oregon streams with this criterion, no adverse effects would be expected
- Information supporting EPA's statement that for the criterion for salmon and steelhead migration of 20°C (68°F) with sufficiently distributed cold water refugia (hereafter, "CWR"), the provision regarding the seasonal thermal pattern in the Columbia and Snake Rivers has ensured colder temperatures during other times of the year in these rivers since 2004
- Information supporting EPA's statement that Oregon mainly would use TMDLs to implement the narrative criterion for CWR, including (1) TMDLs Oregon has completed in waters subject to this criterion, (2) instances where Oregon identified existing CWR or designated additional refugia, and (3) identification of waters subject to the criterion that have not had TMDLs completed
- Information about how Oregon was implementing the narrative criterion for CWR in permits under the National Pollutant Discharge Elimination System (NPDES)
- Information supporting EPA's statement that Oregon's cold water protection provisions effectively maintain current summer maximum temperatures that are colder than the biologically-based criteria in waters where there are listed salmonid fishes or where critical habitat has been designated
- Information regarding Oregon's use of the provision to not list waters as temperature impaired when the temperature exceedance is attributed to unusually warm air temperatures
- Information about any new water temperature data since 2004 that could help rectify uncertainty about the extent of the designation of the beneficial use for "core cold water" in Oregon's South Coast Basin
- Any water temperature and fish migration data collected since 2004 that could help rectify uncertainty regarding the sufficiency of the spawning through fry emergence use designation in the John Day Basin for protecting smoltification in listed species.

The EPA responded to our information request on February 14, 2014.[4] We requested clarification in a March 3, 2014 conference call with EPA on the following topics related to their response:

- Thermal patterns in rivers meeting the criterion for rearing and migration
- Implementation of CWR
- Implementation of air temperature exception

[2] May 14, 2014 email from John Palmer, EPA, to Jeff Lockwood, NMFS.

[3] Letter from Kim Kratz, NMFS, to Christine Psyk, EPA.

[4] Letter from Christine Psyk, EPA, to Paul Henson, U.S. Fish and Wildlife Service, and Kim Kratz, NMFS.

- Core cold water designation in Oregon’s South Coast and Rogue Basins
- Spring water temperatures in the John Day River basin during steelhead smoltification.

The EPA responded with additional information in emails from John Palmer, EPA, to Jeff Lockwood, NMFS, on March 6, 11, 21, and 27 of 2014. We consider EPA to have initiated formal consultation on March 27, 2014.

In an October 27, 2015 letter from Christine Psyk, EPA to Kim Kratz, NMFS, the EPA committed to carrying out the following conservation measure as part of its proposed action to highlight to DEQ the importance of minimizing the adverse effects of future discharges on eulachon, as shown verbatim below:

> The EPA will send a letter to Oregon Department of Environmental Quality (ODEQ) within 6 months of the signing of this Opinion regarding thermal discharges permitted under the National Pollutant Discharge Elimination System (NPDES) in the Columbia, Umpqua, and Sandy Rivers and the protection of eulachon. EPA's letter will raise the importance of applying Oregon's mixing zone water quality standards in order to minimize adverse effects on eulachon, including reference to critical timeframes and temperature thresholds for eulachon identified in NMFS' Biological Opinion, and highlighting the importance of technologies to limit mixing zone sizes to the smallest extent practicable, including submerged ports and multi-port diffusers.
>
> In the letter, the EPA will request that the ODEQ issue an administrative order or re-issue the NPDES permit for Dyno-Nobel within two years from the issuance of this Opinion to address the current adverse effects on eulachon from the thermal plume associated with this discharge. Also, for the discharges in the Columbia River below Bonneville Dam and those in the lower 24.2 miles of the Umpqua River that exceed 1 million gallons per day inflow and 20°C in temperature, the EPA will request that ODEQ provide the EPA a copy of all draft NPDES permits, fact sheets and mixing zone analyses for the EPA’s review consistent with the NPDES- MOA with ODEQ. The EPA also will recommend that the ODEQ prioritize the NPDES permit for Georgia Pacific Wauna Mill for reissuance.
>
> The EPA will review all of the draft permit documents for the discharges described in the preceding paragraph subject to this conservation measure that are received over the next five years and use its CWA authorities, as necessary, to ensure Oregon's mixing zone water quality standards are applied to minimize adverse effects to eulachon. The EPA will notify NMFS of each draft permit it plans to review by email. The EPA also will provide an annual email status report to NMFS on the implementation of this measure that will include a summary of how each permit issued in the preceding year will minimize adverse effects on eulachon.

The docket for this consultation is on file at the Oregon Washington Coastal Area Office in Portland, Oregon.

1.3 Proposed Action

1.3.1 Overview of Water Quality Standards

The source for the information in this section is EPA's BE. A water quality standard defines the water quality goals for a waterbody by designating the use or uses to be made of the water, by setting criteria necessary to protect the uses, and by preventing or limiting degradation of water quality through antidegradation provisions. The CWA provides the statutory basis for the water quality standards program and defines broad water quality goals. For example, section 101(a) states, in part, that wherever attainable, waters achieve a level of quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water (*i.e.*, "fishable/swimmable uses").

Section 303(c) of the CWA requires that all states adopt water quality standards and that EPA review and approve these standards. In addition to adopting water quality standards, states are required to review and revise standards every 3 years. This public process, commonly referred to as the triennial review, allows for new technical and scientific data to be incorporated into the standards. The regulatory requirements governing water quality standards are established at 40 Code of Federal Regulations (CFR) Part 131.

The minimum requirements that must be included in the state standards are designated uses, criteria to protect the uses, and an antidegradation policy to protect existing uses, high-quality waters, and waters designated as "outstanding national resource waters." In addition to these elements, the regulations allow for states to adopt discretionary policies such as allowances for mixing zones and variances from water quality standards. These policies are also subject to EPA review and approval.

Section 303(c)(2)(B) of the CWA requires states to adopt numeric criteria for all toxic pollutants for which criteria have been published under section 304(a). The EPA publishes criteria documents as guidance to states. States consider these criteria documents, along with the most recent scientific information, when adopting regulatory criteria.

All standards officially adopted by each state are submitted to EPA for review and approval or disapproval. The EPA reviews the standards to determine whether the analyses performed are adequate and evaluates whether the designated uses are appropriate and the criteria are protective of those uses. The EPA then determines whether the standards meet the requirements of the CWA and EPA's water quality standards regulations. The EPA then formally notifies the state of these results. If EPA determines that any such revised or new water quality standard is not consistent with the applicable requirements of the CWA and EPA's implementing regulations, it is required to specify the disapproved portions and the changes needed to meet the requirements. The state is then given an opportunity to make appropriate changes. If the state does not adopt the required changes, EPA must promulgate Federal regulations to replace those disapproved portions.

1.3.2 Details of Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. According to the BE, the Federal action that is the subject of this consultation is EPA's proposed approval of portions of the following Oregon administrative rules (OAR) in effect for Clean Water Act purposes,[5] as listed below:

- Definitions, OAR 340-041-0002;
- Intergravel Dissolved Oxygen (IGDO) subsection of Dissolved Oxygen, OAR 340-041-0016;
- Temperature, OAR 340-041-0028;
- Mixing Zones, OAR 340-041-0053;
- Other Implementation of Water Quality Criteria, OAR 340-041-0061; and,
- Basin Specific Use Designations:
  - OAR 340-041-0101(2)
  - OAR 340-041-0120(2)
  - OAR 340-041-0130(2)
  - OAR 340-041-0140(2)
  - OAR 340-041-0151(2)
  - OAR 340-041-0160(2)
  - OAR 340-041-0170(2)
  - OAR 340-041-0180(2)
  - OAR 340-041-0190(2)
  - OAR 340-041-0201(2)
  - OAR 340-041-0220(2)
  - OAR 340-041-0250(2)
  - OAR 340-041-0260(2)
  - OAR 340-041-0271(2)
  - OAR 340-041-0286(2)
  - OAR 340-041-0300(2)
  - OAR 340-041-0310(2)
  - OAR 340-041-0320(2)
  - OAR 340-041-0330(2)
  - OAR 340-041-0340(2)

[5] EPA disapproved the natural conditions criteria (NCC; subsection 8 of Oregon's rule) on August 8, 2013, and thus it is not in effect for CWA purposes. Therefore, it is not part of the proposed action, and subsection 8 has been deleted from the temperature water quality standards included in this action.

Details of the above rules are discussed in Section 2.4 (Effects of the Action on Species and Designated Critical Habitat).

The BE explains that because EPA disapproved the NCC and the SNC, they are no longer part of EPA's proposed action. Further, the BE states that EPA has established a national policy that ESA consultation is not required for EPA approval of state and tribal antidegradation provisions that meet EPA's applicable regulations, because EPA lacks discretion to require measures that would benefit listed species. Therefore, EPA did not include the antidegradation provisions of Oregon's WQS that were included in the 2004 BE as part of its current proposed action. We did not include in this consultation any of the criteria or provisions that EPA did not include in its proposed action.

We did not identify any interdependent or interrelated actions for this proposed action.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this consultation, the action area consists of all streams and rivers in Oregon occupied by the ESA-listed species of fish listed in Table 1, including the Columbia River from the mouth to the Washington-Oregon border (river mile 292), and the Snake River from river mile 169 to river mile 247.5 (Figure 1). The Columbia River creates a plume of relatively low-salinity water that extends from the mouth of the river into the Pacific Ocean, and this water commonly is warmer than the ocean (Fiedler and Laurs 1990). Therefore, the action area includes an area of the Pacific Ocean that occurs within an arc measuring 35 km from the mouth of the Columbia River, as the plume commonly is 10 to 35 km wide (Jay et al. 2009). The action area also includes coastal areas occupied by Southern Resident killer whales (Figure 2), because the pathway of effect for this species is through its prey, which is migrating adult salmon and steelhead (primarily Chinook salmon).

The Klamath River originates in southwest Oregon. However, the Iron Gate dam at river mile 190.2 on the Klamath River in California prevents up-river migration of Southern Oregon/Northern California Coast (SONCC) coho salmon across the Oregon-California border. Because no SONCC coho salmon from the Klamath Strata occur in Oregon, NMFS determined that individuals of populations in the Klamath, Trinity, or central strata will not be exposed to the effects of approving the water quality standards that are the subject of this proposed action.

Figure 1. Overview of the of the action area (highlighted subbasins) for species other than Southern Resident killer whales.

Figure 2. Action area (light shading) for Southern Resident killer whales. Figure from Wiles (2004).

2. ENDANGERED SPECIES ACT

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

We do not expect that the proposed action will affect any of the following species, because the subject water quality criteria do not apply in marine waters where the subject species occur, nor will they affect any important prey species that spend part of their life history in fresh waters where the subject criteria do apply. Because NMFS does not anticipate that the proposed action will affect these species, we will not discuss them further:

- Blue whale (*Balaenoptera musculus*)
- Fin whale (*Balaenoptera physalus*)
- Humpback whale (*Megaptera novaeangliae*)
- Sei whale (*Balaenoptera borealis*)
- Sperm whale (*Physeter macrocephalus*)
- Leatherback turtle (*Dermochelys coriacea*)

There is no designated critical habitat for Southern Resident killer whales in the action area. Therefore, we will not discuss critical habitat for this species.

2.1 Analytical Approach

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

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action
- Describe the environmental baseline in the action area
- Analyze the effects of the proposed action on both species and their habitat using an “exposure-response-risk” approach
- Describe any cumulative effects in the action area

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat
- Reach jeopardy and adverse modification conclusions
- If necessary, define a reasonable and prudent alternative to the proposed action

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be affected by the proposed action. The status is the level of risk that the listed species face, based on parameters considered in documents such as listing decisions, recovery plans, and status reviews. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitats throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated areas, and discusses the current function of the essential physical and biological features that help to form that conservation value.

One factor affecting the status of listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance of listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Areas with elevations high enough to maintain temperatures well below freezing for most of the winter and early-spring will be less affected. Low-elevation areas are likely to be more affected.

During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. Warming is likely to continue during the next century as average temperatures increase another 3 to 10°F. Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009).

Precipitation trends during the next century are less certain than for temperature but more precipitation is likely to occur during October through March and less during summer months, and more of the winter precipitation is likely to fall as rain rather than snow (ISAB 2007; USGCRP 2009). Where snow occurs, a warmer climate will cause earlier runoff so stream flows in late spring, summer, and fall will be lower and water temperatures will be warmer (ISAB 2007; USGCRP 2009).

Higher winter stream flows increase the risk that winter floods in sensitive watersheds will damage spawning redds and wash away incubating eggs. Earlier peak stream flows will also flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and the risk of predation. Lower stream flows and warmer water temperatures during summer will degrade summer rearing conditions, in part by increasing the prevalence and virulence of fish diseases and parasites (USGCRP 2009). Other adverse effects are likely to include altered migration patterns, accelerated embryo development, premature emergence of fry, variation in quality and quantity of tributary rearing habitat, and increased competition and predation risk from warm-water, non-native species (ISAB 2007).

The earth's oceans are also warming, with considerable inter-annual and inter-decadal variability superimposed on the longer-term trend (Bindoff *et al.* 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances (Scheuerell and Williams 2005; Zabel *et al.* 2006; USGCRP 2009). Ocean conditions adverse to salmon and steelhead may be more likely under a warming climate (Zabel *et al.* 2006). Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Marine fish species have exhibited negative responses to ocean acidification conditions that include changes in growth, survivorship, and behavior. Marine phytoplankton, which are the base of the food web for many oceanic species, have shown varied responses to ocean acidification that include changes in growth rate and calcification (Feely *et al.* 2012).

2.2.1 Status of the Species − Fish

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

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

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

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

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

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

The summaries that follow describe the status of the 18 listed species, and their designated critical habitats, that occur within the geographic area of this proposed action and are considered in this opinion. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register (Table 1).

The status of species and critical habitat sections for salmon and steelhead are organized by recovery domains (Table 2) to better integrate into this consultation information in final and draft recovery plans on the conservation status of the listed species and their critical habitats. Recovery domains are the geographically-based areas within which we prepare recovery plans.

Table 2. Recovery domains identified by NMFS and their listed salmon and steelhead species.

Recovery Domain	Species
Willamette-Lower Columbia (WLC)	LCR Chinook salmon UWR Chinook salmon CR chum salmon LCR coho salmon LCR steelhead UWR steelhead
Interior Columbia (IC)	UCR spring-run Chinook salmon SR spring/summer-run Chinook salmon SR fall-run Chinook salmon SR sockeye salmon UCR steelhead MCR steelhead SRB steelhead
Oregon Coast (OC)	OC coho salmon
Southern Oregon/Northern California Coast (SONCC)	SONCC coho salmon

For each recovery domain, a technical review team (TRT) we appointed has developed, or is developing, criteria necessary to identify independent populations within each species, recommended viability criteria for those species, and descriptions of factors that limit species survival. Viability criteria are prescriptions of the biological conditions for populations, biogeographic strata, and evolutionarily significant units (ESU) that, if met, would indicate that an ESU will have a negligible risk of extinction over a 100-year time frame.[6]

Although the TRTs operated from the common set of biological principals described in McElhany *et al.* (2000), they worked semi-independently from each other and developed criteria suitable to the species and conditions found in their specific recovery domains. All of the criteria have qualitative as well as quantitative aspects. The diversity of salmonid species and populations makes it impossible to set narrow quantitative guidelines that will fit all populations in all situations. For this and other reasons, viability criteria vary among species, mainly in the number and type of metrics and the scales at which the metrics apply (*i.e.*, population, major population group (MPG), or ESU) (Busch *et al.* 2008).

Most TRTs included in their viability criteria a combined risk rating for abundance and productivity (A/P) and either an integrated spatial structure and diversity (SS/D) risk rating (*e.g.*, Interior Columbia TRT) or separate risk ratings for spatial structure and diversity (*e.g.*, Willamette/Lower Columbia TRT).

The boundaries of each population were defined using a combination of genetic information, geography, life-history traits, morphological traits, and population dynamics that indicate the extent of reproductive isolation among spawning groups. The overall viability of a species is a function of the VSP attributes of its constituent populations. Until a viability analysis of a species is completed, the VSP guidelines recommend that all populations should be managed to retain the potential to achieve viable status to ensure a rapid start along the road to recovery, and that no significant parts of the species are lost before a full recovery plan is implemented (McElhany *et al.* 2000).

Viability status or probability of population persistence is described below for each of the populations considered in this opinion. Although southern green sturgeon and the southern distinct population segment of eulachon (hereafter, “eulachon”) are part of more than one recovery domain structure, they are presented below for convenience as part of the Willamette Lower Columbia recovery domain.

Willamette-Lower Columbia Recovery Domain. Species in the Willamette-Lower Columbia (WLC) Recovery Domain include LCR Chinook salmon, UWR Chinook salmon, CR chum salmon, LCR coho salmon, LCR steelhead, UWR steelhead, southern green sturgeon, and eulachon. The WLC Technical Recovery Team (WLC-TRT) identified 107 demographically independent populations of Pacific salmon and steelhead (Myers *et al.* 2006). These populations were further aggregated into strata, groupings above the population level that are connected by some degree of migration, based on ecological subregions. All 107 populations use parts of the

[6] For Pacific salmon, NMFS uses its 1991 ESU policy, which states that a population or group of populations will be considered a DPS if it is an ESU. An ESU represents a DPS of Pacific salmon under the ESA that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species. The species *O. mykiss* is under the joint jurisdiction of NMFS and the U.S. Fish and Wildlife Service (USFWS), so in making its January 2006 ESA listing determinations, NMFS elected to use the 1996 joint USFWS-NMFS DPS policy for this species.

mainstem of the Columbia River and the Columbia River estuary for migration, rearing, and smoltification.

Persistence probabilities, which are provided here for Lower Columbia River salmon and steelhead, are the complement of a population's extinction risk (*i.e.*, persistence probability = 1 – extinction risk) (NMFS 2013a). Overall viability risk scores (high to low) and population persistence scores for species in this domain are based on combined ratings for the A&P and SS/D metrics (Table 3) (McElhany *et al.* 2006).

Table 3. Population persistence categories and probabilities from McElhany *et al.* (2006). A low or negligible risk of extinction is considered "viable" (Ford 2011). For population persistence categories, 4 = very low (VL), 3 = low (L), 2 = moderate (M), 1 = high (H), and 0 = very high (VH) in Oregon populations, and "extirpated or nearly so" (E) in Washington populations (Ford 2011).

Population Persistence Category	Probability of population persistence in 100 years	Probability of population extinction in 100 years	Description
0	0-40%	60-100%	Either extinct or "high" risk of extinction
1	40-75%	25-60%	Relatively "high" risk of extinction in 100 years
2	75-95%	5-25%	"Moderate" risk of extinction in 100 years
3	95-99%	1-5%	"Low" (negligible) risk of extinction in 100 years
4	>99%	<1%	"Very low" risk of extinction in 100 years

Status of LCR Chinook Salmon

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (NMFS 2013a). For spring Chinook salmon, all populations are affected by aspects of habitat loss and degradation. Four of the nine populations require significant reductions in every threat category. Protection and improvement of tributary and estuarine habitat are specifically noted.

For fall Chinook salmon, recovery requires restoration of the Coast and Cascade strata to high probability of persistence, to be achieved primarily by ensuring habitat protection and restoration. Very large improvements are needed for most fall Chinook salmon populations to improve their probability of persistence.

For late fall Chinook salmon, recovery requires maintenance of the North Fork Lewis and Sandy populations which are comparatively healthy, together with improving the probability of persistence of the Sandy population from its current status of "high" to "very high." Improving the status of the Sandy population depends largely on harvest and hatchery changes. Habitat improvements to the Columbia River estuary and tributary spawning areas are also necessary.

Spatial Structure and Diversity. This ESU includes naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls. Not included in this DPS are spring-run Chinook salmon originating from the Clackamas River or from five artificial propagation programs. Chinook salmon from 15 other artificial propagation programs are included in the DPS (USDC 2014). LCR Chinook populations exhibit three different life history types base on return timing and other features: fall-run (or "tules"), late-fall-run (or "brights"), and spring-run.

The WLC-TRT identified 32 historical populations of LCR Chinook salmon—seven in the coastal subregion, six in the Columbia Gorge, and 19 in the Cascade Range (Myers *et al.* 2006) (Table 4). Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers and other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (Lower Columbia Fish Recovery Board 2010; ODFW 2010; NMFS 2013a). Out of the 32 populations that make up this ESU, only the two late-fall runs, the North Fork Lewis and Sandy, are viable. Most populations (23 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so) (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a). Five of the six strata fall significantly short of the WLC-TRT criteria for viability; one stratum, Cascade late-fall, meets the WLC TRT criteria (NMFS 2013a).

Table 4. LCR Chinook salmon strata, ecological subregions, run timing, populations, and scores for the key elements (A&P, spatial structure, and diversity) used to determine overall net persistence probability of the population (NMFS 2013a). Persistence probability ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Stratum		Spawning Population (Watershed)	A&P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Cascade Range	Spring	Upper Cowlitz River (WA)	VL	L	M	VL
		Cispus River (WA)	VL	L	M	VL
		Tilton River (WA)	VL	VL	VL	VL
		Toutle River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		North Fork Lewis (WA)	VL	L	M	VL
		Sandy River (OR)	M	M	M	M
	Fall	Lower Cowlitz River (WA)	VL	H	M	VL
		Upper Cowlitz River (WA)	VL	VL	M	VL
		Toutle River (WA)	VL	H	M	VL
		Coweeman River (WA)	L	H	H	L
		Kalama River (WA)	VL	H	M	VL
		Lewis River (WA)	VL	H	H	VL
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas River (OR)	VL	VH	L	VL
		Sandy River (OR)	VL	M	L	VL
		Washougal River (WA)	VL	H	M	VL
	Late Fall	North Fork Lewis (WA)	VH	H	H	VH
		Sandy River (OR)	VH	M	M	VH
Columbia Gorge	Spring	White Salmon River (WA)	VL	VL	VL	VL
		Hood River (OR)	VL	VH	VL	VL
	Fall	Lower Gorge (WA & OR)	VL	M	L	VL
		Upper Gorge (WA & OR)	VL	M	L	VL
		White Salmon River (WA)	VL	L	L	VL
		Hood River (OR)	VL	VH	L	VL
Coast Range	Fall	Young Bay (OR)	L	VH	L	L
		Grays/Chinook rivers (WA)	VL	H	VL	VL
		Big Creek (OR)	VL	H	L	VL
		Elochoman/Skamokawa creeks (WA)	VL	H	L	VL
		Clatskanie River (OR)	VL	VH	L	VL
		Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
		Scappoose River (OR)	L	H	L	L

<u>Abundance and Productivity</u>. A&P ratings for LCR Chinook salmon populations are currently "low" to "very low" for most populations, except for spring Chinook salmon in the Sandy River, which are "moderate" and late-fall Chinook salmon in North Fork Lewis River and Sandy River, which are "very high" (NMFS 2013a). Low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of

hatchery-origin spawners. Particularly for tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (Ford 2011).

Limiting Factors. Limiting factors for all Lower Columbia River species are given in Table 5.

Table 5. Limiting factors for Lower Columbia River species by life history type within species (NMFS 2013a). Some limiting factors vary by stratum and population; for additional information see NMFS (2013a), particularly Appendices A, B, C, and H.

Limiting Factor	Spring Chinook Salmon	Fall Chinook Salmon	Late-Fall Chinook Salmon	Chum Salmon	Coho Salmon	Winter Steelhead	Summer Steelhead
Tributary Habitat							
Habitat Quantity (Small Dams)					√		
Riparian Condition	√	√	√[7]	√	√	√	√
Channel Structure and Form	√	√	√	√	√	√	√
Side Channel and Wetland Conditions	√	√	√	√	√	√	√
Floodplain Conditions	√	√	√	√	√	√	√
Sediment Conditions	√	√	√	√	√	√	√
Water Quality (Temperature)	√	√	√	√	√	√	√
Water Quantity (Flow)	√	√	√	√	√	√	√
Toxic Contaminants						√	√
Estuary Habitat							
Toxic Contaminants		√	√	√	√	√	√
Food (Shift from Macro- to Microdetrital-Based)		√	√	√	√	√	√
Estuary Condition	√	√	√	√	√	√	√
Channel Structure and Form	√	√	√	√	√	√	√
Sediment Conditions	√	√	√	√	√	√	√
Water Quality (Temperature)	√	√	√	√	√	√	√
Water Quantity (Flow)	√	√	√	√	√	√	√
Hydropower Factors							
Habitat Quantity (Access) – Bonneville Dam	√	√	√	√	√	√	√
Habitat Quantity (Inundation) – Bonneville Dam	√	√			√	√	√
Habitat Quantity (Access) – Tributary dams	√	√	√		√	√	√
Water Quantity (Flow) – Mainstem Dams				√			
Harvest Factors							
Direct Mortality	√	√	√		√	√	√
Hatchery Factors							
Food (Competition)	√	√	√		√	√	√

[7] The recovery plan for LCR species (NMFS 2013a) lists riparian condition as a limiting factor for one of the two populations of late-fall Chinook salmon (Sandy).

Limiting Factor	Spring Chinook Salmon	Fall Chinook Salmon	Late-Fall Chinook Salmon	Chum Salmon	Coho Salmon	Winter Steelhead	Summer Steelhead
Population Diversity (Interbreeding)	√	√	√	√	√	√	√
Predation Factors							
Direct Mortality (Land Use)	√	√	√	√	√	√	√
Direct Mortality (Dams)	√	√		√	√	√	√

Status of UWR Chinook Salmon

A recovery plan is available for this species (ODFW and NMFS 2011).

Spatial Structure and Diversity. This species includes all naturally spawned populations of spring-run Chinook salmon originating from the Clackamas River, from the Willamette River and its tributaries above Willamette Falls, and from six artificial propagation programs (USDC 2014). All seven historical populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the western Cascade Range (Table 6). The McKenzie River population has a "low" risk of extinction and the Clackamas population has a "moderate" risk. (Ford 2011). Data collected since the 2005 status review has confirmed a high fraction of hatchery origin fish in all of the populations of this species (even the Clackamas and McKenzie rivers have hatchery fractions above WLC-TRT viability thresholds). All of the UWR Chinook salmon populations have "moderate" or "high" risk ratings for diversity. Clackamas River Chinook salmon have a "low" risk rating for spatial structure (Ford 2011).

Table 6. Scores for the key elements (A&P, diversity, and spatial structure) used to determine current overall viability risk for UWR Chinook salmon (ODFW and NMFS 2011). All populations are in the Western Cascade Range ecological subregion. Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Population (Watershed)	A&P	Diversity	Spatial Structure	Overall Extinction Risk
Clackamas River	M	M	L	M
Molalla River	VH	H	H	VH
North Santiam River	VH	H	H	VH
South Santiam River	VH	M	M	VH
Calapooia River	VH	H	VH	VH
McKenzie River	VL	M	M	L
Middle Fork Willamette River	VH	H	H	VH

Abundance and Productivity. The Clackamas and McKenzie river populations currently have the best risk ratings for A&P, spatial structure, and diversity. Data collected since the BRT status update in 2005 highlighted the substantial risks associated with pre-spawning mortality. Although recovery plans are targeting key limiting factors for future actions, there have been no significant on-the-ground actions since the 2005 status review to resolve the lack of access to historical habitat above dams nor have there been substantial actions removing hatchery fish from the spawning grounds (Ford 2011).

Limiting Factors. Limiting factors for this species include (ODFW and NMFS 2011):

- Degraded freshwater habitat, including floodplain connectivity and function, channel structure and complexity, riparian areas, and large wood recruitment
- Degraded water quality including elevated water temperature and toxins

- Increased disease incidence
- Altered stream flows
- Reduced access to spawning and rearing habitats
- Altered food web due to reduced inputs of microdetritus
- Predation by native and non-native species, including hatchery fish
- Competition related to introduced races of salmon and steelhead
- Altered population traits due to fisheries and by-catch

Status of CR Chum Salmon

Columbia River chum salmon are included in the Lower Columbia River recovery plan (NMFS 2013a). Recovery targets for this species focus on improving tributary and estuarine habitat conditions, and re-establishing populations where they may have been extirpated, in order to increase all four viability parameters. Specific recovery goals are to restore Coast and Cascade chum salmon strata to high probability of persistence, and to improve persistence probability of the two Gorge populations by protecting and restoring spawning habitat, side channel, and off channel habitats alcoves, wetlands, floodplains, *etc.*

Spatial Structure and Diversity. This species includes all naturally-spawned populations of chum salmon originating from the Columbia River and its tributaries in Washington and Oregon, and from two artificial propagation programs (USDC 2014). The WLC-TRT identified 17 historical populations of CR chum salmon and aggregated these into four strata (Myers *et al.* 2006) (Table 7). CR chum salmon spawning aggregations identified in the mainstem Columbia River were included in the population associated with the nearest river basin.

Table 7. CR chum salmon strata, ecological subregions, run timing, populations, and scores for the key elements (A&P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013a). Persistence probability ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Stratum		Spawning Population (Watershed)	A&P	Diversity	Spatial Structure	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Coast Range	Fall	Young's Bay (OR)	*	*	*	VL
		Grays/Chinook rivers (WA)	VH	M	H	M
		Big Creek (OR)	*	*	*	VL
		Elochoman/Skamakowa rivers (WA)	VL	H	L	VL
		Clatskanie River (OR)	*	*	*	VL
		Mill, Abernathy and Germany creeks (WA)	VL	H	L	VL
		Scappoose Creek (OR)	*	*	*	VL
Cascade Range	Summer	Cowlitz River (WA)	VL	L	L	VL
	Fall	Cowlitz River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		Lewis River (WA)	VL	H	L	VL
		Salmon Creek (WA)	VL	L	L	VL
		Clackamas River (OR)	*	*	*	VL
		Sandy River (OR)	*	*	*	VL
		Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Fall	Lower Gorge (WA & OR)	VH	H	VH	H
		Upper Gorge (WA & OR)	VL	L	L	VL

* No data are available to make a quantitative assessment.

The very low persistence probabilities or possible extirpations of most chum salmon populations are due to low abundance, productivity, spatial structure, and diversity. Although, hatchery production of chum salmon has been limited and hatchery effects on diversity are thought to have been relatively small, diversity has been greatly reduced at the ESU level because of presumed extirpations and the low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (Lower Columbia Fish Recovery Board 2010; NMFS 2013a). The Lower Gorge population meets abundance and productivity criteria for very high levels of viability, but the distribution of spawning habitat (*i.e.*, spatial structure) for the population has been significantly reduced (Lower Columbia Fish Recovery Board 2010); spatial structure may need to be improved, at least in part, through better performance from the Oregon portion of the population (NMFS 2013a).

Abundance and Productivity. Of the 17 populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a). All three strata in the ESU fall significantly short of the WLC-TRT criteria for viability. Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge. The Grays/Chinook population has a moderate persistence probability, and the Lower Gorge population has a high probability of persistence (Lower Columbia Fish Recovery Board 2010; NMFS 2013a).

Limiting Factors. Limiting factors for this species are given in Table 5 above.

Status of LCR Coho Salmon

This species is included in the Lower Columbia River recovery plan (NMFS 2013a). Specific recovery goals are to improve all four viability parameters to the point that the Coast, Cascade, and Gorge strata achieve high probability of persistence. Protection of existing high functioning habitat and restoration of tributary habitat are noted needs, along with reduction of hatchery and harvest impacts. Large improvements are needed in the persistence probability of most populations of this ESU.

Spatial Structure and Diversity. This species includes naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the Big White Salmon and Hood Rivers (inclusive), any such fish originating from the Willamette River and its tributaries below Willamette Falls, and coho salmon from 21 artificial propagation programs (USDC 2014). Spatial diversity is “moderate” to “very high” for all the populations, except the North Fork Lewis River, which has a “low” rating for spatial structure.

Out of the 24 populations that make up this ESU (Table 8), 21 have a “very low” probability of persisting for the next 100 years, and none of them are viable (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a).

Table 8. LCR coho salmon strata, ecological subregions, run timing, populations, and scores for the key elements (A&P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013a). Persistence probability ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Ecological Subregions	Population (Watershed)	A&P	Spatial Structure	Diversity	Overall Persistence Probability
Coast Range	Young's Bay (OR)	VL	VH	VL	VL
	Grays/Chinook rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L
	Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
	Scappoose River (OR)	M	H	M	M
Cascade Range	Lower Cowlitz River (WA)	VL	M	M	VL
	Upper Cowlitz River (WA)	VL	M	L	VL
	Cispus River (WA)	VL	M	L	VL
	Tilton River (WA)	VL	M	L	VL
	South Fork Toutle River (WA)	VL	H	M	VL
	North Fork Toutle River (WA)	VL	M	L	VL
	Coweeman River (WA)	VL	H	M	VL
	Kalama River (WA)	VL	H	L	VL
	North Fork Lewis River (WA)	VL	L	L	VL
	East Fork Lewis River (WA)	VL	H	M	VL
	Salmon Creek (WA)	VL	M	VL	VL
	Clackamas River (OR)	M	VH	H	M
	Sandy River (OR)	VL	H	M	VL
	Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Lower Gorge Tributaries (WA & OR)	VL	M	VL	VL
	Upper Gorge/White Salmon (WA)	VL	M	VL	VL
	Upper Gorge Tributaries/Hood (OR)	VL	VH	L	VL

Abundance and Productivity. In Oregon, the Clatskanie Creek and Clackamas River populations have "low" and "moderate" persistence probability ratings for A&P, while the rest are rated "very low." All of the Washington populations have "very low" A&P ratings. The persistence probability for diversity is "high" in the Clackamas population, "moderate" in the Clatskanie, Scappoose, Lower Cowlitz, South Fork Toutle, Coweeman, East Fork Lewis, and Sandy populations, and "low" to "very low" in the rest (NMFS 2013a). Uncertainty is high because of a lack of adult spawner surveys. Smolt traps indicate some natural production in Washington populations, though given the high fraction of hatchery origin spawners suspected to occur in these populations it is not clear that any are self-sustaining (Ford 2011; NMFS 2011a; NMFS 2013a).

Limiting Factors. Limiting factors for this species are given in Table 5 above.

Status of LCR Steelhead

This species is included in the Lower Columbia River recovery plan (NMFS 2013a). For this species, threats in all categories must be reduced, but the most crucial elements are protecting favorable tributary habitat and restoring habitat in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama and Sandy subbasins (for winter steelhead), and the East Fork Lewis, and Hood, subbasins (for summer steelhead). Protection and improvement is also need among the South Fork Toutle and Clackamas winter steelhead populations.

Spatial Structure and Diversity. This species includes naturally spawned steelhead originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive); it excludes such fish originating from the upper Willamette River basin above Willamette Falls (USDC 2014). Four strata and 23 historical populations of LCR steelhead occur within the DPS: 17 winter-run populations and six summer-run populations, within the Cascade and Gorge ecological subregions (Table 9).[8] The DPS also includes steelhead from seven artificial propagation programs (USDC 2014). Summer steelhead return to freshwater long before spawning. Winter steelhead, in contrast, return from the ocean much closer to maturity and spawn within a few weeks. Summer steelhead spawning areas in the Lower Columbia River are found above waterfalls and other features that create seasonal barriers to migration. Where no temporal barriers exist, the winter-run life history dominates.

[8] The White Salmon and Little White Salmon steelhead populations are part of the Middle Columbia steelhead DPS and are addressed in a separate recovery plan, the Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009).

Table 9. LCR steelhead strata, ecological subregions, run timing, populations, and scores for the key elements (A&P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013a). Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Stratum: Ecological Subregion	Stratum: Run Timing	Population (Watershed)	A&P	Spatial Structure	Diversity	Overall Persistence Probability
Cascade Range	Summer	Kalama River (WA)	H	VH	M	M
		North Fork Lewis River (WA)	VL	VL	VL	VL
		East Fork Lewis River (WA)	VL	VH	M	VL
		Washougal River (WA)	M	VH	M	M
	Winter	Lower Cowlitz River (WA)	L	M	M	L
		Upper Cowlitz River (WA)	VL	M	M	VL
		Cispus River (WA)	VL	M	M	VL
		Tilton river (WA)	VL	M	M	VL
		South Fork Toutle River (WA)	M	VH	H	M
		North Fork Toutle River (WA)	VL	H	H	VL
		Coweeman River (WA)	L	VH	VH	L
		Kalama River (WA)	L	VH	H	L
		North Fork Lewis River (WA)	VL	M	M	VL
		East Fork Lewis River (WA)	M	VH	M	M
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas River (OR)	M	VH	M	M
		Sandy River (OR)	L	M	M	L
		Washougal River (WA)	L	VH	M	L
Columbia Gorge	Summer	Wind River (WA)	VH	VH	H	H
		Hood River (OR)	VL	VH	L	VL
	Winter	Lower Gorge (WA & OR)	L	VH	M	L
		Upper Gorge (OR & WA)	L	M	M	L
		Hood River (OR)	M	VH	M	M

It is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 have a "low" or "very low" probability of persisting over the next 100 years, and six populations have a "moderate" probability of persistence (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a). All four strata in the DPS fall short of the WLC-TRT criteria for viability (NMFS 2013a).

Baseline persistence probabilities were estimated to be "low" or "very low" for three out of the six summer steelhead populations that are part of the LCR DPS, moderate for two, and high for one, the Wind, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have "low" or "very low" baseline probabilities of persistence, and the remaining four are at "moderate" probability of persistence (Table 9) (Lower Columbia Fish Recovery Board 2010; ODFW 2010; NMFS 2013a).

Abundance and Productivity. The "low" to "very low" baseline persistence probabilities of most Lower Columbia River steelhead populations reflect low abundance and productivity

(NMFS 2013a). All of the populations increased in abundance during the early 2000s, generally peaking in 2004. Most populations have since declined back to levels within one standard deviation of the long term mean. Exceptions are the Washougal summer-run and North Fork Toutle winter-run, which are still higher than the long term average, and the Sandy, which is lower. In general, the populations have not shown any sustained, dramatic changes in abundance or fraction of hatchery origin spawners since the 2005 status review (Ford 2011). Although current LCR steelhead populations are depressed compared to historical levels and long-term trends show declines, many populations are substantially healthier than their salmon counterparts, typically because of better habitat conditions in core steelhead production areas (Lower Columbia Fish Recovery Board 2010; NMFS 2013a).

Limiting Factors. Limiting factors for this species are given in Table 5 above.

Status of UWR Steelhead

A recovery plan is available for this species (ODFW and NMFS 2011).

Spatial Structure and Diversity. This species includes naturally spawned anadromous winter-run steelhead originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to and including the Calapooia River (USDC 2014). One stratum and four extant populations of UWR steelhead occur within the DPS (Table 10). Historical observations, hatchery records, and genetics suggest that the presence of UWR steelhead in many tributaries on the west side of the upper basin is the result of recent introductions. Nevertheless, the WLC-TRT recognized that although west side UWR steelhead does not represent a historical population, those tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance.

Table 10. Scores for the key elements (A&P, diversity, and spatial structure) used to determine current overall viability risk for UWR steelhead (ODFW and NMFS 2011). All populations are in the Western Cascade Range ecological subregion. Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Population (Watershed)	A&P	Diversity	Spatial Structure	Overall Extinction Risk
Molalla River	VL	M	M	L
North Santiam River	VL	M	H	L
South Santiam River	VL	M	M	L
Calapooia River	M	M	VH	M

Abundance and Productivity. Since the last status review in 2005, UWR steelhead initially increased in abundance but subsequently declined and current abundance is at the levels observed in the mid-1990s when the DPS was first listed. The DPS appears to be at lower risk than the UWR Chinook salmon ESU, but continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The elimination of winter-run hatchery release in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity.

Limiting Factors. Limiting factors for this species include (ODFW and NMFS 2011):

- Degraded freshwater habitat, including floodplain connectivity and function, channel structure and complexity, riparian areas, and large wood recruitment
- Degraded water quality including elevated water temperature and toxins
- Increased disease incidence
- Altered stream flows
- Reduced access to spawning and rearing habitats
- Altered food web due to reduced inputs of microdetritus
- Predation by native and non-native species, including hatchery fish
- Competition related to introduced races of salmon and steelhead
- Altered population traits due to fisheries and by-catch

Status of Southern DPS Green Sturgeon

We have released a recovery outline for this species (NMFS 2010). This preliminary document identifies important threats to abate, including exposure to contaminants, loss of estuarine and delta function, and other activities that impact spawning, rearing and feeding habitats. Key recovery needs are restoring access to suitable habitat, improving potential habitat, and establishing additional spawning populations.

Spatial Structure and Diversity. Two DPSs have been defined for green sturgeon — a northern DPS (with spawning populations in the Klamath and Rogue rivers) and a southern DPS (with spawning populations in the Sacramento River). The southern green sturgeon DPS includes all naturally-spawned populations of green sturgeon that occur south of the Eel River in Humboldt County, California. When not spawning, this anadromous species is broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Although it is commonly observed in bays, estuaries, and sometimes the deep riverine mainstem in lower elevation reaches of non-natal rivers along the west coast of North America, the distribution and timing of estuarine use are poorly understood.

In addition to the PS recovery domain, southern green sturgeon occur in the WLC, OC, and SONCC recovery domains. We are developing a recovery plan for this species.

Limiting Factors. The principal factor for the decline of southern green sturgeon is the reduction of its spawning area to a single known population limited to a small portion of the Sacramento River. It is currently at risk of extinction primarily because of human-induced ‘‘takes’’ involving elimination of freshwater spawning habitat, degradation of freshwater and estuarine habitat quality, water diversions, fishing, and other causes (USDC 2010). Adequate water flow and temperature are issues of concern. Water diversions pose an unknown but potentially serious threat within the Sacramento and Feather Rivers and the Sacramento River Delta. Poaching also poses an unknown but potentially serious threat because of high demand for sturgeon caviar. The effects of contaminants and nonnative species are also unknown but potentially serious. Retention of green sturgeon in both recreational and commercial fisheries is now prohibited within the western states, but the effect of capture/release in these fisheries is unknown. There is evidence of fish being retained illegally, although the magnitude of this activity likely is small (NOAA Fisheries 2011).

Status of Eulachon

On June 21, 2013, NMFS announced a Federal recovery plan outline, which is to serve as interim guidance for recovery efforts (USDC 2013b). The target month for completion of a recovery plan for eulachon is December, 2016. The major threats to eulachon are impacts of climate change on oceanic and freshwater habitats (species-wide), fishery by-catch (species-wide), dams and water diversions (Klamath and Columbia subpopulations) and predation (Fraser River and British Columbia sub-populations) (NMFS 2013b). Preliminary key recovery actions in the recovery outline include maintaining conservative harvest, reducing by-catch, restoring more natural flows and water quality in the Columbia River, maintaining dredging best management practices, removing Klamath River dams, and completing research on life history and genetics, climate effects, and habitat effects (NMFS 2013b).

Spatial Structure and Diversity. Listed eulachon occur in three salmon recovery domains in Oregon: the Willamette and Lower Columbia, Oregon Coast, and Southern Oregon/Northern California Coast. The listed population of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Core populations for this species include the Fraser River, Columbia River and (historically) the Klamath River. Eulachon leave saltwater to spawn in their natal streams late winter through early summer, and typically spawn at night in the lower reaches of larger rivers fed by snowmelt. After hatching, larvae are carried downstream and widely dispersed by estuarine and ocean currents. Eulachon movements in the ocean are poorly known, although the amount of eulachon by-catch in the pink shrimp fishery seems to indicate that the distribution of these organisms overlap in the ocean.

Abundance and Productivity. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River (Drake *et al.* 2008). Persistent low returns and landings of eulachon in the Columbia River from 1993 to 2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan in 2001 that provides for restricted harvest management when parental run strength, juvenile production, and ocean productivity forecast a poor return (WDFW and ODFW 2001). Despite a brief period of improved returns in 2001 to 2003, the returns and associated commercial landings evenually declined to the low levels observed in the mid-1990s (Joint Columbia River Management Staff 2009). Starting in 2005, the fishery has operated at the most conservative level allowed in the management plan (Joint Columbia River Management Staff 2009). Large commercial and recreational fisheries have occurred in the Sandy River in the past. The most recent commercial harvest in the Sandy River was in 2003. No commercial harvest has been recorded for the Grays River from 1990 to the present, but larval sampling has confirmed successful spawning in recent years (USDC 2011). Starting in 2011, returns in the Columbia River have rebounded by up to two orders of magnitude (Figure 3). We have not identified an abundance or productivity target for eulachon recovery, as sufficient data does not exist to parameterize a population viability analysis.[9]

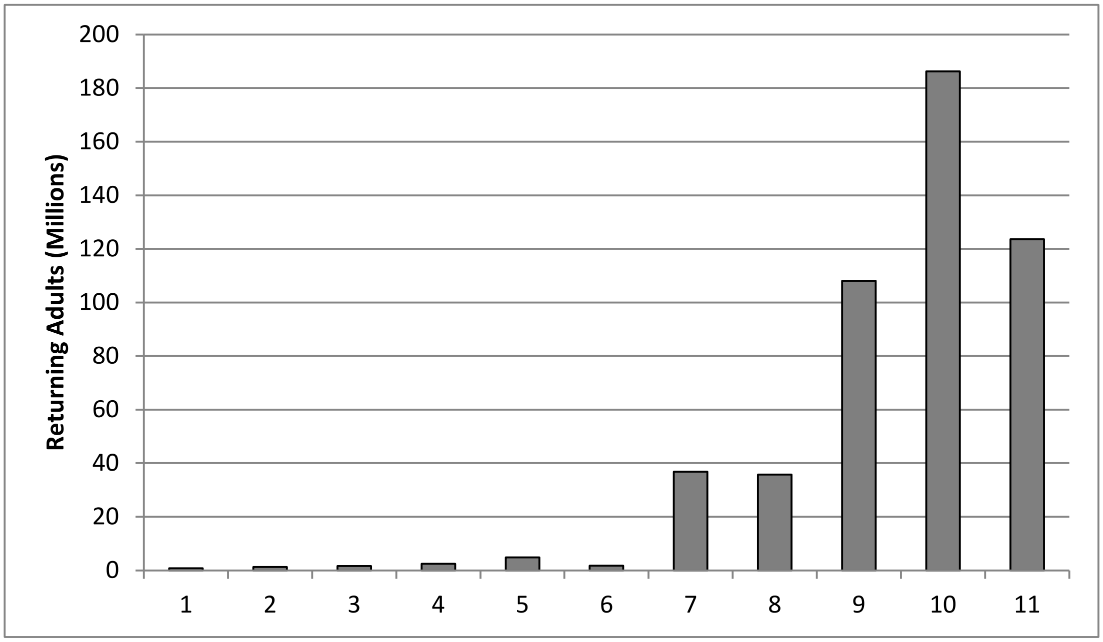

Figure 3. Annual Columbia River eulachon run size from 2000 to 2015 (mean of bootstrap estimates; pounds converted to numbers of fish at 11.16 fish pound^{-1}; [WDFW 2015]). The estimates were calculated based on methods developed by Parker (1985), Jackson and Cheng (2001), and Hay *et al.* (2002) to estimate spawning biomass of pelagic fishes. For 2000 through 2010, estimates were back-calculated using historical larval density data.

Threats. We have not identified limiting factors for this species. However, our status review for this species (Gustafson *et al.* 2010) listed threats to this species (Table 11).

[9] September 1, 2015 email from Robert Anderson, Eulachon Recovery Coordinator, NMFS, to Jeffrey Lockwood, Fishery Biologist, NMFS, regarding a eulachon recovery question from EPA.

Table 11. Threats to eulachon populations with the most severe threat ranked number 1. Statutory listing factors (ESA section 4(a)(1)(A)–(C), and (E)) include (A): the present or threatened destruction, modification, or curtailment of its habitat or range; (B): overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; and (E) other natural or man-made factors affecting its continued existence. Source: Gustafson *et al.* (2010), p. 160-170.

Threat	Klamath River	Columbia River	Fraser River	British Columbia	Listing Factor
	Ranking				
Climate change impacts on ocean conditions	1	1	1	1	A
Dams/water diversions	2	4	8	11	A
Eulachon by-catch	3	2	2	2	E
Climate change impacts on freshwater habitats	4	3	4	4	A
Predation	5	7	3	3	C
Water quality	6	5	5	8	A
Catastrophic events	7	8	10	5	A
Disease	8	11	11	7	C
Competition	9	12	12	9	E
Shoreline construction	10	10	9	6	A
Tribal/First Nation fisheries	11	14	13	10	B
Nonindigenous species	12	15	15	13	E
Recreational harvest	13	13	14	14	B
Scientific monitoring	-	16	16	15	B
Commercial harvest	-	9	6	-	A
Dredging	-	6	7	12	A

(-) = no ranking due to insufficient data.

The likely effects of climate change on eulachon were summarized by Gustafson et al. (2010). Many populations of eulachon spawn in rivers fed by snowmelt or glacial runoff well before the peak of water inputs so that their eggs will have time to incubate before hatching during the peak spring discharge of the rivers. If peak runoff and river flows occur earlier due to warmer air temperatures, eulachon may spawn earlier or be flushed out to the ocean at an earlier date. Earlier emigration of eulachon from spawning areas, together with an anticipated delay in the onset of coastal upwelling, may result in a mismatch between entry of larval eulachon into the ocean and the peak of coastal upwelling, which could reduce marine survival of the larvae. Gustafson et al. (2010) also summarized anecdotal and quantitative data suggesting that, perhaps due to warming conditions or altered stream flow timing, adult eulachon are returning earlier in the season to several rivers within the southern DPS.

Interior Columbia Recovery Domain. Species in the Interior Columbia (IC) recovery domain include UCR spring-run Chinook salmon, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, UCR steelhead, MCR steelhead, and SRB steelhead (IC-TRT 2003; McClure *et al.* 2005) . The IC-TRT aggregated populations into “major groupings” based on dispersal distance and rate, and drainage structure, primarily the location and distribution of large tributaries. All IC populations use the mainstem of the Columbia River and the Columbia River estuary for migration, rearing, and smoltification.

The IC-TRT recommended viability criteria that follow the VSP framework (IC-TRT 2007). The criteria include biological and physical performance conditions that, when met, indicate a population or species has a 5% or less risk of extinction over a 100-year period.

Status of UCR Spring-run Chinook Salmon

A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

Spatial Structure and Diversity**.** This species includes all naturally-spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River), the Columbia River upstream to Chief Joseph Dam, and progeny of six artificial propagation programs (USDC 2014). The IC-TRT identified four independent populations of UCR spring-run Chinook salmon in the upriver tributaries of the Wenatchee, Entiat, Methow, and Okanogan Rivers (one of which, the Okanogan, is extirpated), but no major groups due to the relatively small geographic area affected (IC-TRT 2003; McClure *et al.* 2005) (Table 12).

Table 12. Scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for spring-run UCR Chinook salmon (Ford 2011). Risk ratings included very low (VL), low (L), moderate (M), high (H), very high (VH), and extirpated (E).

Population	A&P	Diversity	Integrated SS/D	Overall Viability Risk
Wenatchee River	H	H	H	H
Entiat River	H	H	H	H
Methow River	H	H	H	H
Okanogan River				E

The composite SS/D risks are "high" for all three of the extant populations in this MPG. The spatial processes component of the SS/D risk is "low" for the Wenatchee River and Methow River populations and "moderate" for the Entiat River (loss of production in lower section increases effective distance to other populations). All three of the extant populations in this MPG are at "high" risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and lack of genetic diversity among the natural-origin spawners (Ford 2011).

Increases in natural origin abundance relative to the extremely low spawning levels observed in the mid-1990s are encouraging; however, average productivity levels remain extremely low. Overall, the viability of Upper Columbia Spring Chinook salmon ESU likely improved somewhat since the 2005 status review, but the ESU is still clearly at "moderate-to-high" risk of extinction (Ford 2011).

Abundance and Productivity. UCR spring-run Chinook salmon is not currently meeting the viability criteria (adapted from the IC-TRT) in the Upper Columbia recovery plan. A&P remains at "high" risk for each of the three extant populations in this MPG/ESU (Ford 2011). The 10-year geometric mean abundance of adult natural origin spawners has increased for each population relative to the levels for the 1981-2003 series, but the estimates remain below the corresponding IC-TRT thresholds. Estimated productivity (spawner to spawner return rate at low to moderate escapements) was on average lower over the years 1987-2009 than for the previous period. The combinations of current abundance and productivity for each population result in a "high" risk rating for all extant populations (Ford 2011).

Limiting Factors. Limiting factors for this species include (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

- Effects related to hydropower system in the mainstem Columbia River , including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species
- Harvest in Columbia River fisheries

Status of SR Spring/summer-run Chinook Salmon

We are developing a recovery plan for this species.

Muir and Williams (2012) summarized the current status of fish passage for SR spring/summer Chinook salmon, which must pass eight dams on the mainstem Snake and Columbia Rivers as follows:

1. Structural and operational improvements to mainstem Snake and Columbia River hydropower dams in recent years have substantially improved Chinook salmon smolt survival, reduced travel time, and increased connectivity between rearing areas and the Pacific Ocean by restoring entry timing closer to that prior to hydropower development.
2. Despite substantial gains in direct downstream smolt survival and improved upstream passage success through the hydropower system, SAR (smolt-to-adult) return rates have not shown the same improvement in most years. However, variable ocean conditions and increased hatchery production confound comparisons with historical SARs.
3. Factors that may contribute to depressed and variable SARs include changes in ocean productivity, increased hatchery production, and the reduction in volume and turbidity of the Columbia River plume due to increased water storage in the basin.

Spatial Structure and Diversity. This species includes all naturally-spawned populations of spring/summer-run Chinook salmon originating from the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, and from 11 artificial propagation programs (USDC 2014). The IC-TRT recognized 27 extant and four extirpated populations of SR spring/summer-run Chinook salmon, and aggregated these into five MPGs that correspond to ecological subregions (Table 13) (IC-TRT 2003; McClure *et al.* 2005). All extant populations face a "high" risk of extinction (Ford 2011).

Table 13. MPGs, populations, and scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for SR spring/summer-run Chinook salmon (Ford 2011). Risk ratings included very low (VL), low (L), moderate (M), high (H), very high (VH), and extirpated (E).

Major Population Groups	Spawning Populations (Watershed)	A&P	Diversity	Integrated SS/D	Overall Viability Risk
Lower Snake River	Tucannon River	H	M	M	H
	Asotin River				E
Grande Ronde and Imnaha rivers	Wenaha River	H	M	M	H
	Lostine/Wallowa River	H	M	M	H
	Minam River	H	M	M	H
	Catherine Creek	H	M	M	H
	Upper Grande Ronde R.	H	M	H	H
	Imnaha River	H	M	M	H
	Big Sheep Creek				E
	Lookingglass Creek				E
South Fork Salmon River	Little Salmon River	*	*	*	H
	South Fork mainstem	H	M	M	H
	Secesh River	H	L	L	H
	EF/Johnson Creek	H	L	L	H
Middle Fork Salmon River	Chamberlin Creek	H	L	L	H
	Big Creek	H	M	M	H
	Lower MF Salmon	H	M	M	H
	Camas Creek	H	M	M	H
	Loon Creek	H	M	M	H
	Upper MF Salmon	H	M	M	H
	Sulphur Creek	H	M	M	H
	Bear Valley Creek	H	L	L	H
	Marsh Creek	H	L	L	H
Upper Salmon River	N. Fork Salmon River	H	L	L	H
	Lemhi River	H	H	H	H
	Pahsimeroi River	H	H	H	H
	Upper Salmon-lower mainstem	H	L	L	H
	East Fork Salmon River	H	H	H	H
	Yankee Fork	H	H	H	H
	Valley Creek	H	M	M	H
	Upper Salmon main	H	M	M	H
	Panther Creek				E

* Insufficient data.

Abundance and Productivity. Population level status ratings remain at "high" risk across all MPGs within the ESU, although recent natural spawning abundance estimates have increased, all populations remain below minimum natural origin abundance thresholds (Ford 2011). Spawning escapements in the most recent years in each series are generally well below the peak returns but above the extreme low levels in the mid-1990s. Relatively low natural production rates and spawning levels below minimum abundance thresholds remain a major concern across the ESU.

The ability of SR spring/summer-run Chinook salmon populations to sustain themselves through normal periods of relatively low ocean survival remains uncertain. Factors cited by Good *et al.* (2005) remain as concerns or key uncertainties for several populations.

Limiting Factors. Limiting factors for this species include (NOAA Fisheries 2011):

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality. Effects related to the hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality
- Harvest-related effects
- Predation

Status of SR Fall-run Chinook Salmon

We are developing a recovery plan for this species.

Spatial Structure and Diversity. This species includes all naturally-spawned populations of fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam; from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins; and from four artificial propagation programs (USDC 2014).

The IC-TRT identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon and Tucannon rivers. The extant population of Snake River fall-run Chinook salmon is the only remaining population from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex (IC-TRT 2003; McClure *et al.* 2005). The population is at moderate risk for diversity and spatial structure (Ford 2011).

Abundance and Productivity. The recent increases in natural origin abundance are encouraging. However, hatchery origin spawner proportions have increased dramatically in recent years – on average, 78% of the estimated adult spawners have been hatchery origin over the most recent brood cycle considered by Ford (2011). The apparent leveling off of natural returns in spite of the increases in total brood year spawners may indicate that density dependent habitat effects are influencing production or that high hatchery proportions may be influencing natural production rates. The A&P risk rating for the population is "moderate." Given the combination of current A&P and SS/D ratings summarized above, the overall viability rating for SR fall-run Chinook salmon is "maintained" (Ford 2011).[10]

Limiting Factors. Limiting factors for this species include (NOAA Fisheries 2011):

- Degradation of floodplain connectivity and function and channel structure and complexity
- Harvest-related effects
- Loss of access to historical habitat above Hells Canyon and other Snake River dams
- Impacts from mainstem Columbia River and Snake River hydropower systems
- Hatchery-related effects
- Degraded estuarine and nearshore habitat.

Status of SR Sockeye Salmon

We released a final recovery plan for this species on June 8, 2015 (NMFS 2015a).

Spatial Structure and Diversity**.** This species includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (USDC 2014). The IC-TRT identified historical sockeye salmon production in at least five Stanley Basin and Sawtooth Valley lakes and in lake systems associated with Snake River tributaries currently cut off to anadromous access (*e.g.*, Wallowa and Payette Lakes). Current returns of SR sockeye salmon are extremely low and limited to Redfish Lake (IC-TRT 2007).

Abundance and Productivity. This species is at extremely high risk across all four basic risk measures (abundance, productivity, spatial structure and diversity. Although the captive brood program has been successful in providing substantial numbers of hatchery produced *O. nerka* for use in supplementation efforts, substantial increases in survival rates across all life history stages must occur to re-establish sustainable natural production (Hebdon *et al.* 2004; Keefer *et al.* 2008). Overall, although the risk status of Snake River sockeye salmon appeared to improve between 2005 and 2011, we determined, in our 2011 5-year review, that this ESU should retain its "endangered" classification.

Limiting Factors. The key factor limiting recovery of SR sockeye salmon ESU is survival outside of the Stanley Basin. Portions of the migration corridor in the Salmon River are impaired by reduced water quality and elevated temperatures (Idaho Department of Environmental Quality 2011). The natural hydrological regime in the upper mainstem Salmon River Basin has been altered by water withdrawals. Survival rates from Lower Granite dam to the spawning grounds are low in some years (*e.g.*, average of 31%, range of 0-67% for 1991-1999) (Keefer *et al.* 2008). Keefer *et al.* (2008) conducted a radio tagging study on adult SR sockeye salmon passing upstream from Lower Granite Dam in 2000 and concluded that high in-river mortalities could be explained by "a combination of high migration corridor water temperatures and poor initial fish condition or parasite loads." Keefer *et al.* (2008) also examined current run timing of SR sockeye

[10] "Maintained" population status is for populations that do not meet the criteria for a viable population but do support ecological functions and preserve options for ESU/DPS recovery.

salmon versus records from the early 1960s, and concluded that an apparent shift to earlier run timing recently may reflect increased mortalities for later migrating adults. In the Columbia and lower Snake River migration corridor, predation rates on juvenile sockeye salmon are unknown, but terns and cormorants consume 12% of all salmon smolts reaching the estuary, and piscivorous fish consume an estimated 8% of migrating juvenile salmon (NOAA Fisheries 2011).

Status of MCR Steelhead

A recovery plan is available for this species (NMFS 2009a).

Spatial Structure and Diversity. This species includes all naturally-spawned steelhead populations originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River; excluding steelhead originating from the Snake River basin. This DPS does include steelhead from seven artificial propagation programs (USDC 2014). The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project in the Deschutes River Basin, Oregon (USDC 2013a). The IC-TRT identified 17 extant populations in this DPS (IC-TRT 2003; McClure *et al.* 2005). The populations fall into four MPGs: Cascade eastern slope tributaries (five extant and two extirpated populations), the, the John Day River (five extant populations), the Walla Walla and Umatilla rivers (three extant and one extirpated populations), and the Yakima River (four extant populations) (Table 13) (IC-TRT 2003; McClure *et al.* 2005). Viability ratings for these populations range from extirpated to viable (Table 14) (NMFS 2009a; Ford 2011).

Table 14. MPGs, populations, and scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for MCR steelhead (NMFS 2009a; Ford 2011). Risk ratings included very low (VL), low (L), moderate (M), high (H), very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS.

Major Population Group	Population (Watershed)	A&P	Diversity	Integrated SS/D	Overall Viability Risk
Cascade Eastern Slope Tributaries	Fifteenmile Creek	L	L	L	Viable
	Klickitat River	M	M	M	MT?
	Eastside Deschutes River	L	M	M	Viable
	Westside Deschutes River	H	M	M	H*
	Rock Creek	H	M	M	H?
	White Salmon				E*
	Crooked River				E*
John Day River	Upper Mainstem	M	M	M	MT
	North Fork	VL	L	L	Highly Viable
	Middle Fork	M	M	M	MT
	South Fork	M	M	M	MT
	Lower Mainstem	M	M	M	MT
Walla Walla and Umatilla rivers	Umatilla River	M	M	M	MT
	Touchet River	M	M	M	H
	Walla Walla River	M	M	M	MT
Yakima River	Satus Creek	M	M	M	Viable (MT)
	Toppenish Creek	M	M	M	Viable (MT)
	Naches River	H	M	M	H
	Upper Yakima	H	H	H	H

* Re-introduction efforts underway (NMFS 2009a).

Straying frequencies into at least the Lower John Day River are high. Out-of-basin hatchery stray proportions, although reduced, remain very high in the Deschutes River basin.

<u>Abundance and Productivity</u>. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the MCR steelhead DPS is not currently meeting the viability criteria (adopted from the IC-TRT) in the MCR steelhead recovery plan (NMFS 2009a). In addition, several of the factors cited by Good *et al.* (2005) remain as concerns or key uncertainties. Natural origin spawning estimates of populations have been highly variable with respect to meeting minimum abundance thresholds.

<u>Limiting Factors.</u> Limiting factors for this species include (NMFS 2009a; NOAA Fisheries 2011):

- Degradation of floodplain connectivity and function, channel structure and complexity,

riparian areas, fish passage, stream substrate, stream flow, and water quality
- Mainstem Columbia River hydropower-related impacts
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Harvest-related effects
- Effects of predation, competition, and disease.

Status of UCR Steelhead

A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

Spatial Structure and Diversity**.** This species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, and progeny of six artificial propagation programs (USDC 2014). Four independent populations of UCR steelhead were identified by the IC-TRT in the same upriver tributaries as for UC spring-run Chinook salmon (*i.e.*, Wenatchee, Entiat, Methow, and Okanogan; Table 15) and, similarly, no major population groupings were identified due to the relatively small geographic area involved (IC-TRT 2003; McClure *et al.* 2005). All extant populations are at high risk of extinction (Ford 2011). With the exception of the Okanogan population, the Upper Columbia populations rated as "low" risk for spatial structure. The "high" risk ratings for SS/D are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations.

Table 15. Summary of the key elements (A&P, diversity, and SS/D) and scores used to determine current overall viability risk for UCR steelhead populations (Ford 2011). Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Population (Watershed)	A&P	Diversity	Integrated SS/D	Overall Viability Risk
Wenatchee River	H	H	H	H
Entiat River	H	H	H	H
Methow River	H	H	H	H
Okanogan River	H	H	H	H

Abundance and Productivity. Upper Columbia steelhead populations have increased in natural origin abundance in recent years, but productivity levels remain low. The modest improvements in natural returns in recent years are probably primarily the result of several years of relatively good natural survival in the ocean and tributary habitats.

Limiting Factors. Limiting factors for this species include (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality
- Hatchery-related effects
- Predation and competition
- Harvest-related effects

Status of SRB Steelhead

We are developing a recovery plan for this species.

Spatial Structure and Diversity**.** This species includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, and progeny of six artificial propagation programs (USDC 2014). The IC-TRT identified 24 populations in five major groups (Table 16) (IC-TRT 2003; McClure *et al.* 2005). The IC-TRT has not assessed the viability of this species. The relative proportion of hatchery fish in natural spawning areas near major hatchery release sites is highly uncertain. There is little evidence for substantial change in ESU viability relative to the previous BRT and IC-TRT reviews.

Table 16. MPGs, populations, and scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for SRB steelhead (Ford 2011; NMFS 2011b). Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS.

Major Population Group	Spawning Populations (Watershed)	A&P	Diversity	Integrated SS/D	Overall Viability Risk*
Lower Snake River	Tucannon River	**	M	M	H
	Asotin Creek	**	M	M	MT
Grande Ronde River	Lower Grande Ronde	**	M	M	Not rated
	Joseph Creek	VL	L	L	Highly viable
	Upper Grande Ronde	M	M	M	MT
	Wallowa River	**	L	L	H
Clearwater River	Lower Clearwater	M	L	L	MT
	South Fork Clearwater	H	M	M	H
	Lolo Creek	H	M	M	H
	Selway River	H	L	L	H
	Lochsa River	H	L	L	H
Salmon River	Little Salmon River	**	M	M	MT
	South Fork Salmon	**	L	L	H
	Secesh River	**	L	L	H
	Chamberlain Creek	**	L	L	H
	Lower MF Salmon	**	L	L	H
	Upper MF Salmon	**	L	L	H
	Panther Creek	**	M	H	H
	North Fork Salmon	**	M	M	MT
	Lemhi River	**	M	M	MT
	Pahsimeroi River	**	M	M	MT
	East Fork Salmon	**	M	M	MT
	Upper Main Salmon	**	M	M	MT
Imnaha	Imnaha River	M	M	M	MT

* There is uncertainty in these ratings due to a lack of population-specific data.
** Insufficient data.

Abundance and Productivity. The level of natural production in the two populations with full data series and the Asotin Creek index reaches is encouraging, but the status of most populations in this DPS remains highly uncertain. Population-level natural origin abundance and productivity inferred from aggregate data and juvenile indices indicate that many populations are below the minimum combinations defined by the IC-TRT viability criteria.

Limiting Factors. Limiting factors for this species include (NMFS 2011b; NMFS 2011c):

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality

- Increased water temperature
- Harvest-related effects, particularly for B-run steelhead
- Predation
- Genetic diversity effects from out-of-population hatchery releases

Oregon Coast Recovery Domain. The OC recovery domain includes OC coho salmon, southern green sturgeon, and eulachon, covering Oregon coastal streams south of the Columbia River and north of Cape Blanco. Streams and rivers in this area drain west into the Pacific Ocean, and vary in length from < 1 mile to more than 210 miles in length. We covered the status of green sturgeon and eulachon earlier in this document, and cover the status of OC coho salmon below.

Status of OC Coho Salmon

We have completed a draft recovery plan for this species (NMFS 2015b).

Spatial Structure and Diversity**.** This species includes populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. The Cow Creek Hatchery Program (South Umpqua population) is included as part of the ESU because the original brood stock was founded from the local, natural origin population and natural origin coho salmon have been incorporated into the brood stock on a regular basis. The OC-TRT identified 56 populations, including 21 independent and 35 dependent populations in five biogeographic strata (Table 17) (Lawson *et al.* 2007). Independent populations are populations that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years and are rated as functionally independent or potentially independent. Dependent populations (D) are populations that historically would not have had a high likelihood of persisting in isolation for 100 years. These populations relied upon periodic immigration from other populations to maintain their abundance (McElhany *et al.* 2000; Lawson *et al.* 2007).

Table 17. OC coho salmon populations. Population types included functionally independent (FI), potentially independent (PI) and dependent populations (D) (McElhany *et al.* 2000; Lawson *et al.* 2007).

Stratum	Population	Type	Stratum	Population	Type
North Coast	Necanicum River	PI	Mid-Coast (cont.)	Alsea River	FI
	Ecola Creek	D		Big Creek (Alsea)	D
	Arch Cape Creek	D		Vingie Creek	D
	Short Sands Creek	D		Yachats River	D
	Nehalem River	FI		Cummins Creek	D
	Spring Creek	D		Bob Creek	D
	Watseco Creek	D		Tenmile Creek	D
	Tillamook Bay	FI		Rock Creek	D
	Netarts Bay	D		Big Creek (Siuslaw)	D
	Rover Creek	D		China Creek	D
	Sand Creek	D		Cape Creek	D
	Nestucca River	FI		Berry Creek	D
	Neskowin Creek	D		Siuslaw River	FI
Mid-Coast	Salmon River	PI	Lakes	Siltcoos Lake	PI
	Devils Lake	D		Sutton Creek	D
	Siletz River	FI		Tahkenitch Lake	PI
	Schoolhouse Creek	D		Tenmile Lakes	PI
	Fogarty Creek	D	Umpqua	Lower Umpqua River	FI
	Depoe Bay	D		Middle Umpqua River	FI
	Rocky Creek	D		North Umpqua River	FI
	Spencer Creek	D		South Umpqua River	FI
	Wade Creek	D	Mid-South Coast	Threemile Creek	D
	Coal Creek	D		Coos River	FI
	Moolack Creek	D		Coquille River	FI
	Big Creek (Yaquina)	D		Johnson Creek	D
	Yaquina River	FI		Twomile Creek	D
	Theil Creek	D		Floras Creek	PI
	Beaver Creek	PI		Sixes River	PI

A 2010 BRT noted significant improvements in hatchery and harvest practices have been made (Stout *et al.* 2012). However, harvest and hatchery reductions have changed the population dynamics of the ESU. Current concerns for spatial structure focus on the Umpqua River. Of the four populations in the Umpqua stratum, the North Umpqua and South Umpqua are of particular concern. The North Umpqua is controlled by Winchester Dam and has historically been dominated by hatchery fish. Hatchery influence has recently been reduced, but the natural productivity of this population remains to be demonstrated. The South Umpqua is a large, warm system with degraded habitat. Spawner distribution appears to be seriously restricted in this population, and it is probably the most vulnerable of any population in this ESU to increased temperatures.

Current status of diversity shows improvement through the waning effects of hatchery fish on populations of OC coho salmon. In addition, recent efforts in several coastal estuaries to restore lost wetlands should be beneficial. However, diversity is lower than it was historically because of the loss of both freshwater and tidal habitat loss coupled with the restriction of diversity from very low returns over the past 20 years.

Abundance and Productivity. It has not been demonstrated that productivity during periods of poor marine survival is now adequate to sustain the ESU. Recent increases in adult escapement do not provide strong evidence that the century-long downward trend has changed. The ability of the OC coho salmon ESU to survive another prolonged period of poor marine survival remains in question. Wainwright (2008) determined that the weakest strata of OC coho salmon were in the North Coast and Mid-Coast of Oregon, which had only "low" certainty of being persistent. The strongest strata were the Lakes and Mid-South Coast, which had "high" certainty of being persistent. To increase certainty that the ESU as a whole is persistent, they recommended that restoration work should focus on those populations with low persistence, particularly those in the North Coast, Mid-Coast, and Umpqua strata.

Limiting Factors. Information about limiting factors at the species scale can be gleaned from the discussion of factors for decline and threats in Stout *et al.* (2012). Also, Oregon provided "population bottlenecks" (*i.e.*, limiting factors at the population scale) in its coastal coho assessment (State of Oregon 2005). Based on these two sources, limiting factors for this species include:

- Degraded stream complexity
- Reduced recruitment of wood to streams
- Increased fine substrate sediment
- Loss of beaver dams
- Increased water temperature
- Reduced stream flow
- Human disturbance of the landscape
- Loss of wetlands and estuarine habitat
- Fish passage barriers
- Effects of global climate change
- Periodic reduction in marine productivity
- Hatchery effects
- Effects from exotic fish species

Southern Oregon and Northern California Coast Recovery Domain. The SONCC recovery domain includes coho salmon, green sturgeon, and eulachon (we covered the status of green sturgeon and eulachon earlier in this document). The SONCC recovery domain extends from Cape Blanco, Oregon, to Punta Gorda, California. This area includes many small-to-moderate-sized coastal basins, where high quality habitat occurs in the lower reaches of each basin, and three large basins (Rogue, Klamath and Eel) where high quality habitat is in the lower reaches, little habitat is provided by the middle reaches, and the largest amount of habitat is in the upper reaches.

Status of SONCC Coho Salmon

A recovery plan is available for this species (NMFS 2014).

Spatial Structure and Diversity. This species includes all naturally-spawned populations of coho salmon in coastal streams from the Elk River near Cape Blanco, Oregon, through and including the Mattole River near Punta Gorda, California, and progeny of three artificial propagation programs (NMFS 2014). Williams *et al.* (2006) designated 45 populations of coho salmon in the SONCC coho salmon ESU as dependent or independent based on their historical population size. Independent populations are populations that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years and are rated as functionally independent or potentially independent. Dependent populations historically would not have had a high likelihood of persisting in isolation for 100 years. These populations relied upon periodic immigration from other populations to maintain their abundance. Two populations are both small enough and isolated enough that they are only intermittently present (McElhany *et al.* 2000; Williams *et al.* 2006a; NMFS 2014). These populations were further grouped into seven diversity strata based on the geographical arrangement of the populations and basin-scale genetic, environmental, and ecological characteristics (Table 18).

NMFS (2014b) determined the role each of the independent populations will serve in recovery (Table 18). Independent populations likely to respond to recovery actions and achieve a low risk of extinction most quickly are designated "Core" populations. We based this designation on current condition, geographic location in the ESU, a low risk threshold compared to the number of spawners needed for the entire stratum, and other factors. Independent populations with little to no documentation of coho salmon presence in the last century, and poor prospects for recovery were designated as non-core 2. All other independent populations are designated non-core 1. With improved data from 2006, NMFS (2014b) determined five of the 45 populations are ephemeral.

Table 18. Independent and dependent SONCC coho salmon populations by stratum and role of each population in recovery (Williams *et al.* 2006a). Ephemeral populations per NMFS (2014b) not listed.

Diversity Stratum	Independent Population	Population Role
Northern Coastal Basins	Elk River	Independent - Core
	Brush Creek	Dependent
	Mussel Creek	Dependent
	Lower Rogue River	Independent - Non-Core 1
	Hunter Creek	Dependent
	Pistol River	Dependent
	Chetco River	Independent - Core
	Winchuck River	Independent - Non-Core 1
Interior Rogue River	Illinois River	Independent - Core
	Middle Rogue and Applegate rivers	Independent - Non-Core 1
	Upper Rogue River	Independent - Core
Central Coastal Basins	Smith River	Independent - Core
	Elk Creek	Dependent
	Wilson Creek	Dependent
	Lower Klamath River	Independent - Core
	Redwood Creek	Independent - Core
	Maple Creek/Big Lagoon	Independent - Non-Core 2
	Little River	Independent - Non-Core1
	Strawberry Creek	Dependent
	Norton/Widow White Creek	Dependent
	Mad River	Independent - Non-Core 1
Interior Klamath River	Middle Klamath River	Independent - Non-Core 1
	Upper Klamath River	Independent - Core
	Salmon River	Independent - Non-Core 1
	Scott River	Independent - Core
	Shasta River	Independent - Core
Interior Trinity River	Lower Trinity River	Independent - Core
	Upper Trinity River	Independent - Core
	South Fork Trinity River	Independent - Non-Core 1
Southern Coastal Basins	Humboldt Bay tributaries	Independent - Core
	Lower Eel and Van Duzen rivers	Independent - Core
	Guthrie Creek	Dependent
	Bear River	Independent - Non-Core 2
	Mattole River	Independent - Non-Core 1

Diversity Stratum	Independent Population	Population Role
Interior Eel River	South Fork Eel River	Independent - Core
	Mainstem Eel River	Independent - Core
	Middle Fork Eel River	Independent - Non-Core 2
	North Fork Eel River	Independent - Non-Core 2
	Middle Mainstem Eel River	Independent - Core
	Upper Mainstem Eel River	Independent - Non-Core 2

We established biological recovery objectives and criteria for each population role (Table 19) in our recovery plan for this species (NMFS 2014).

Table 19. Biological recovery objectives and criteria to measure whether recovery objectives are met for SONCC coho salmon (NMFS 2014).

VSP Parameter	Population Role	Biological Recovery Objective	Biological Recovery Criteria[1]
Abundance	Core	Achieve a low risk of extinction	The geometric mean of wild adults over 12 years meets or exceeds the "low risk threshold" of spawners for each core population[2]
	Non-Core 1	Achieve a moderate or low risk of extinction	The annual number of wild adults is greater than or equal to four spawners per IP-km for each non-core population[2]
Productivity	Core and Non-Core 1	Population growth rate is not negative	Slope of regression of the geometric mean of wild adults over the time series ≥ zero[2]
Spatial Structure	Core and Non-Core 1	Ensure populations are widely distributed	Annual within-population distribution ≥ 80%[4] of habitat[3,4] (outside of a temperature mask[5])
	Non-Core 2 and Dependent	Achieve inter- and intra-stratum connectivity	≥ 80% of accessible habitat[3] is occupied in years[6] following spawning of cohorts that experienced high marine survival[7]
Diversity	Core and Non-Core 1	Achieve low or moderate hatchery impacts on wild fish	Proportion of hatchery-origin adults (pHOS) < 0.05
	Core and Non-Core 1	Achieve life-history diversity	Variation is present in migration timing, age structure, size, and behavior. The variation in these parameters,[8] is retained.

[1]All applicable criteria must be met for each population in order for the ESU to be viable.
[2]Assess for at least 12 years, striving for a coefficient of variation (CV) of 15% or less at the population level (Crawford and Rumsey 2011).
[3]Based on available rearing habitat within the watershed (Wainwright *et al.* 2008). For purposes of these biological recovery criteria, "available" means accessible. 70% of habitat occupied relates to a truth value of approximately 0.60, providing a "high" certainty that juveniles occupy a high proportion of the available rearing habitat (Wainwright *et al.* 2008).
[4]The average for each of the three year classes over the 12 year period used for delisting evaluation must each meet this criterion. Strive to detect a 15% change in distribution with 80% certainty (Crawford and Rumsey 2011).
[5]Williams *et al.* (2008) identified a threshold air temperature, above which juvenile coho salmon generally do not occur, and identified areas with air temperatures over this threshold. These areas are considered to be within the temperature mask.
[6]If young-of-year are sampled, sampling would occur the spring following spawning of the cohorts experiencing high marine survival. If juveniles are sampled, sampling would occur approximately 1.5 years after spawning of the cohorts experiencing high marine survival, but before juveniles outmigrate to the estuary and ocean.
[7]High marine survival is defined as 10.2% for wild fish and 8% for hatchery fish (Sharr *et al.* 2000). If marine survival is not high, then this criterion does not apply.
[8]This variation is documented in the population profiles in Volume II of the recovery plan (NMFS 2014).

Abundance and Productivity. Although long-term data on abundance of SONCC coho salmon are scarce, available evidence from shorter-term research and monitoring efforts indicates that the population abundance of most independent populations is below the depensation threshold, and therefore SONCC coho salmon are at high risk of extinction and not viable (Williams *et al.* 2011).

Limiting Factors. Threats from natural or man-made factors have worsened in recent years, primarily due to four factors: small population dynamics, climate change, multi-year drought, and poor ocean conditions (NOAA Fisheries 2011; NMFS 2014). Limiting factors for this species include:

- Lack of floodplain and channel structure

- Impaired water quality
- Altered hydrologic function (timing of volume of water flow)
- Impaired estuary/mainstem function
- Degraded riparian forest conditions
- Altered sediment supply
- Increased disease/predation/competition
- Barriers to migration
- Fishery-related effects
- Hatchery-related effects

2.2.2 Status of the Species - Marine Mammals

The Southern Resident killer whale DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). Southern Residents are designated as “depleted” and “strategic” under the Marine Mammal Protection Act (MMPA) (68 FR 31980, May 29, 2003). NMFS issued the final recovery plan for Southern Residents in January 2008 (NMFS 2008a). This section summarizes information taken largely from the recovery plan and recent 5-year status review (NMFS 2011d), as well as new data that became available more recently.

Range and Distribution

Southern Residents occur throughout the coastal waters of Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as southeast Alaska (one sighting occurred in Chatham Strait, Alaska; NMFS 2008a; Hanson *et al.* 2013; Figure 4). Figure 4 does not reflect the recent sighting in Alaska. There is limited information on the distribution and habitat use of Southern Residents along the outer Pacific Coast.

Figure 4. Geographic Range (light shading) of the Southern Resident killer whale DPS. Figure from Wiles (2004).

Southern Residents are highly mobile and can travel up to 86 miles in a single day (Erickson 1978; Baird 2000). Although the entire Southern Resident DPS has potential to occur in coastal waters at any time during the year, occurrence is more likely from November to May (Hanson and Emmons 2010). Southern Residents spend a substantial amount of time from late spring to early autumn in inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford *et al.* 2000; Krahn *et al.* 2002; Hanson and Emmons 2010). Typically, J, K and L pods are increasingly present in May or June and spend considerable time in the core area of Georgia Basin and Puget Sound until at least September. During this time, pods (particularly K and L) make frequent trips from inland waters to the outer coasts of Washington and southern Vancouver Island, which typically last a few days (Ford *et al.* 2000). During their forays to the outer coast the whales typically travel along the southern coast of Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound.

Late summer and early fall movements of Southern Residents in the Georgia Basin are consistent, with strong site fidelity shown to the region as a whole and high occurrence in the San Juan Island area (Hanson and Emmons 2010; Hauser *et al.* 2007). There is inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present during spring in recent years potentially related to weak returns of spring and early summer Chinook salmon to the Fraser River (Hanson and Emmons 2010). Similarly, recent high occurrence in late summer may relate to greater than average Chinook salmon returns to South Thompson tributary of the Fraser River (Hanson and Emmons 2010). During fall and early winter, Southern Resident pods, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Hanson *et al.* 2010a, Osborne 1999). During late fall, winter, and early spring, the ranges and movements of the Southern Residents are less known. Sightings through the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts of Vancouver Island and Washington (Krahn *et al.* 2002).

The Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg *et al.* 1990) or the mouth of the Columbia River (Ford *et al.* 2000). In recent years several sightings or acoustic detections have been obtained off the Washington and Oregon coasts for these pods in the winter and spring (NWFSC unpubl. data, Hanson *et al.* 2013). Even fewer sightings/acoustic detections are available for J pod on the outer coast in the winter and spring, but the limited range of the sighting/acoustic detections and a lack of coincident occurrence during the K and L pods sightings suggest a much more restricted coastal range.

Sightings in Monterey Bay, California coincided with occurrence of salmon, with feeding witnessed in 2000 (Black *et al.* 2001). Southern Residents were also sighted in Monterey Bay during 2008, when salmon runs from California were expected to be near record lows (PFMC 2010). L pod was also seen feeding on unidentified salmon off Westport, Washington, in March 2004 during the spring Chinook salmon run in the Columbia River (M. B. Hanson, personal observation as cited in Krahn *et al.* 2004). In March, 2005 L pod was sighted working a circuit across the Columbia River plume from the North Jetty across to the South Jetty during the spring Chinook salmon run in the Columbia River (Zamon *et al.* 2007). Also in March of 2006, K and L pods were encountered off the Columbia River (Hanson *et al.* 2008). L pod was again seen feeding off Westport, Washington in March 2009, and genetic analysis of prey remains collected from two predation events identified one fish as spring Chinook salmon and the other as a summer/fall Chinook salmon from Columbia River stocks (Hanson *et al.* 2010b). Recent evidence shows K and L pods are spending significantly more time off of the Columbia River in March than previously recognized, suggesting the importance of Columbia River spring Chinook salmon in their diet (Hanson *et al.* 2013).

The Northwest Fisheries Science Center (NWFSC) also deploys and collects data from remote autonomous acoustic recorders from seven sites off Washington, Oregon, and California (Emmons *et al.* 2009; Hanson *et al.* 2013). In 2009, they documented 52 Southern Resident killer whale detections from this acoustic system (Emmons *et al.* 2009). Between 2006 and 2011, the whales were detected on 131 days (Hanson *et al.* 2013). The data suggest that J, K, and L spend a relatively large amount of time off of Washington, with K and L pods only detected off California in February (Hanson *et al.* 2013). J pod spent most of their time in the northeastern part of Washington, whereas K and L pods were detected off the southern part of the state. The Department of Fisheries and Oceans (DFO), Canada also maintains acoustic recorders in British Columbia. When the DFO analyze these data, more information will be available about the seasonal distribution, movements and habitat use of Southern Resident killer whales, specifically in coastal waters off British Columbia.

<u>Abundance and Productivity</u>

Southern Resident killer whales are a long-lived species with late onset of sexual maturity (review in NMFS 2008a). Females produce a low number of surviving calves over the course of their reproductive life span (Bain 1990; Olesiuk *et al.* 1990). Southern Resident females appear to have reduced fecundity relative to Northern Residents; the average interbirth interval for reproductive Southern Resident females is 6.1 years, which is longer than that of Northern Resident killer whales (Olesiuk *et al.* 2005). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Baird 2000; Bigg *et al.* 1990; Ford *et al.* 2000). Groups of related matrilines form pods. Three pods – J, K, and L – make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of J clan.

The historical abundance of Southern Resident killer whales is estimated from 140 to an unknown upper bound. The minimum historical estimate (~140) included whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time the captures ended. Several lines of evidence (*i.e.*, known kills and removals [Olesiuk *et al.* 1990], salmon declines [Krahn *et al.* 2002] and genetics [Krahn *et al.* 2002; Ford *et al.* 2011a]) all indicate that the population used to be much larger than it is now, but there is currently no reliable estimate of the upper bound of the historical population size. When faced with developing a population viability analysis for this population, NMFS' biological review team found it reasonable to assume an upper bound of as high as 400 whales to estimate carrying capacity (Krahn *et al.* 2004).

At present, the Southern Resident population has declined to essentially the same size that was estimated during the early 1960s, when it was considered likely to be depleted (Olesiuk *et al.* 1990) (Figure 5). The population suffered an almost 20% decline from 1996-2001 (from 97 whales in 1996 to 81 whales in 2001), largely driven by lower survival rates in L pod. Since then, the overall population has fluctuated but remained fairly consistent from 2002 to present (from 83 whales in 2002 to 81 whales on July 1, 2015). Over the last 32 years (1983-2014), population growth has been variable, with an average annual population growth rate of 0.1% and standard deviation of ± 3.2%. Seasonal mortality rates among Southern and Northern Resident whales may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk *et al.* (2005) identified high neonate mortality that occurred outside of the summer season. At least 12 newborn calves (nine in the southern community and three in the northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman *et al.* 2004). Between 1925 and 2011, data were collected on a total of 371 killer whales that stranded in the North Pacific (Barbieri *et al.* 2013). Since the beginning of the annual census in 1974, 19 confirmed Southern Resident killer whale carcasses were found, suggesting a carcass recovery rate of approximately 20% (Barbieri *et al.* 2013). Several of these stranding events occurred in the waters off of Washington and British Columbia, Canada (*e.g.*, 1995 and 1996 off of Northern Vancouver Island and the Queen Charlotte Islands; 2002 offshore of Long Beach, WA; 2006 in Nootka Sound British Columbia; 2008 off Henry Island, San Juan County, WA; 2012 Long Beach WA; and 2013 Dungeness Spit) (NMFS 2008a; Gaydos *et al.* 2013). On an annual basis, approximately 10 stranded killer whales are observed in the region. Most of the causes of death are unknown.

As of July 1, 2015, there were 27 whales in J pod, 19 whales in K pod, and 35 whales in L pod.. The age distribution is similar to that of the Northern Resident population, which is stable and increasing (Olesiuk *et al.* 2005). However, there are several demographic factors of the Southern Resident population that are cause for concern, namely the small number of breeding males (particularly in J and K pods), reduced fecundity, sub-adult survivorship in L pod, and the total number of individuals in the population (review in NMFS 2008a). The current population abundance of 81 whales is small — at most, it is 58% of the low end of its likely previous abundance range (140 to an unknown upper bound that could be as high at 400 whales, as discussed above). The estimated effective size of the population (based on the number of breeders under ideal genetic conditions) is very small at approximately 26 whales, or roughly 1/3 of the current population size (Ford *et al.* 2011a). The problem of a small effective population size and the absence of gene flow from other populations is that it may elevate the risk from inbreeding and other issues associated with genetic deterioration, as evident from documented breeding within pods (Ford *et al.* 2011a). As well, the small effective population size may contribute to the lower growth rate of the Southern Resident population in contrast to the Northern Resident population (Ford *et al.* 2011a; Ward *et al.* 2009).

Because of this population's small abundance, it is also susceptible to demographic stochasticity — randomness in the pattern of births and deaths among individuals in a population. Several other sources of stochasticity can affect small populations and contribute to variance in a population's growth and extinction risk. Other sources include environmental stochasticity, or fluctuations in the environment that drive fluctuations in birth and death rates, and demographic heterogeneity, or variation in birth or death rates of individuals because of differences in their individual fitness. In combination, these and other sources of random variation combine to amplify the probability of extinction, known as the extinction vortex (Gilpin and Soule 1986; Fagen and Holmes 2006; Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks. A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3% for 28 years (NMFS 2008a). In light of the current average annual growth rate of 0.1%, this recovery criterion reinforces the need to allow the population to grow quickly.

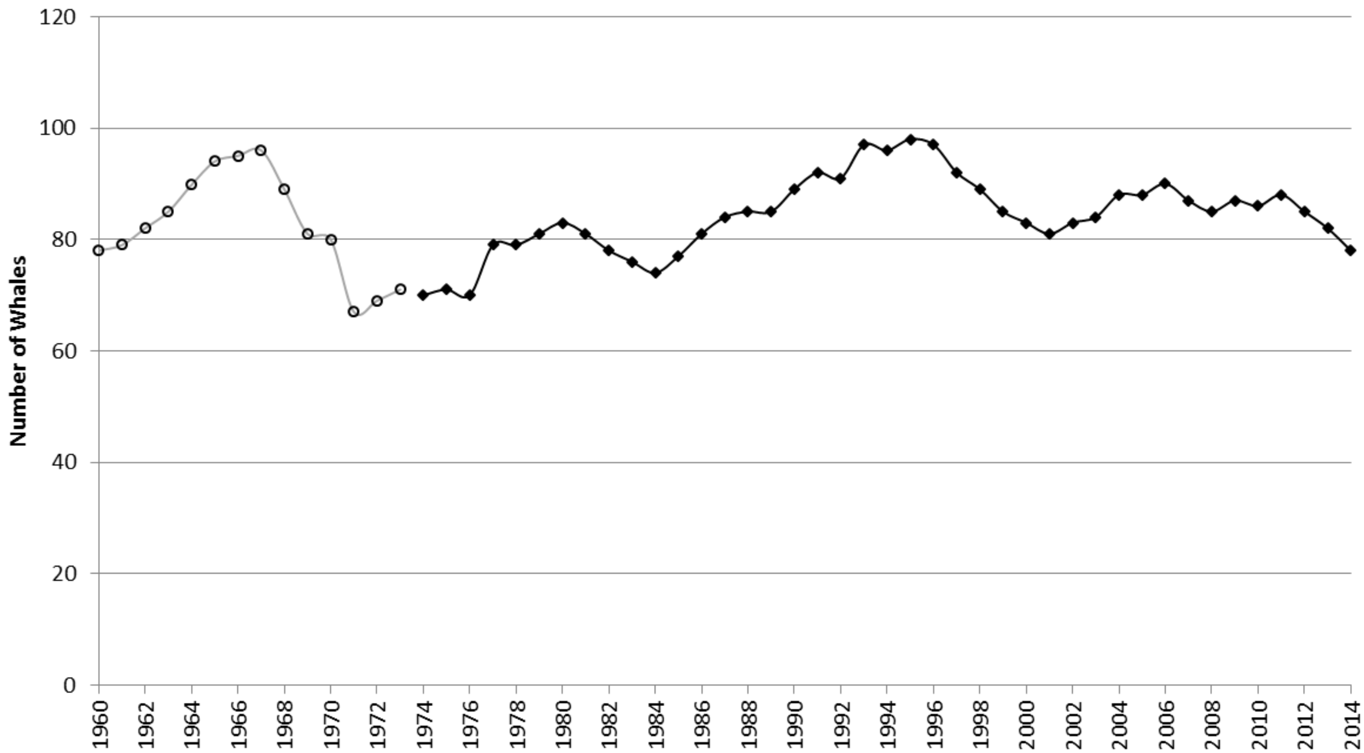

Figure 5. Population size and trend of Southern Resident killer whales, 1960-2014. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk *et al.* (1990). Data from 1974-2014 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpubl. data) and NMFS (2008). Data for these years represent the number of whales present at the end of each calendar year, except for 2014, when data only extend to July.

Population growth is also important because of the influence of demographic and individual heterogeneity on a population's long-term viability. Population-wide distribution of lifetime reproductive success can be highly variable, such that some individuals produce more offspring than others, and male variance in reproductive success can be greater than that of females (*i.e.*, Clutton-Brock 1988; Hochachka 2006). For long-lived vertebrates such as killer whales, some females in the population might contribute less than the number of offspring required to maintain a constant population size (n = 2), while others might produce more offspring. The smaller the population, the more weight an individual's reproductive success has on the population's growth or decline (*i.e.*, Coulson *et al.* 2006). This further illustrates the risk of demographic stochasticity for a small population like Southern Resident killer whales – the smaller a population, the greater the chance that random variation will result in too few successful individuals to maintain the population.

<u>Limiting Factors and Threats</u>

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting in concert to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008a). Here we focus on the quantity and quality of prey,because these are affected by the proposed action. The discussions in the Environmental Baseline and Cumulative Effects sections contain thorough evaluations of all threats in the action area.

Prey Availability. Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Scheffer and Slipp 1948; Ford *et al.* 1998, 2000; Ford and Ellis 2006; Saulitis *et al.* 2000; Hanson *et al.* 2010c), but salmon are identified as their primary prey (*i.e.*, a high percentage of prey consumed during spring, summer and fall, from long-term studies of resident killer whale diet; Ford and Ellis 2006; Hanson *et al.* 2010c). Feeding records for Southern and Northern Residents show a predominant consumption of Chinook salmon during late spring to fall (Ford and Ellis 2006). Chum salmon are also taken in significant amounts, especially in fall. Other salmon eaten include coho, pink, steelhead, and sockeye. The non-salmonid fishes included Pacific herring, sablefish, Pacific halibut, quillback and yelloweye rockfish (*Sebastes maliger*), lingcod (*Ophiodon elongates*), and Dover sole (*Microstomus pacificus*) (Ford *et al.* 1998; Hanson *et al.* 2010c). Chinook salmon were the primary prey despite the much lower abundance of Chinook salmon in the study area in comparison to other salmonid fishes (primarily sockeye salmon), for mechanisms that remain unknown but factors of potential importance include the species' large size, high fat and energy content, and year-round occurrence in the area. Killer whales also captured older (*i.e.*, larger) than average Chinook salmon (Ford and Ellis 2006). Recent research suggests that killer whales are capable of detecting, localizing and recognizing Chinook salmon through their ability to distinguish Chinook salmon echo structure as different from other salmon (Au *et al.* 2010).

Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. A recent publication by Hanson *et al.*

(2010c) provides the best available scientific information on diet composition of Southern Residents in inland waters during summer months. The results provide information on (1) the percentage of Chinook salmon in the whales' diet, and (2) the predominant river of origin of those Chinook salmon. Other research and analysis provides additional information on the age of prey consumed (Hanson, unpubl. data, as summarized in Ward *et al.* 2010), indicating that the whales are consuming mostly larger (*i.e.*, older) Chinook salmon.

Scale and tissue sampling in inland waters from May to September indicate that the Southern Residents' diet consists of a high percentage of Chinook salmon, with an overall average of 88% Chinook across the timeframe and monthly proportions as high as >90% Chinook salmon (*i.e.*, July: 98% and August: 92%, see S/T sample type in Table 2 of Hanson *et al.* 2010c). Fecal samples are also available in Hanson *et al.* (2010c) but were not used to estimate proportion of the Southern Residents' diet, because the data from these samples represents presence or absence of prey species, but not proportion of diet. DNA quantification methods can be used to estimate the proportion of diet from fecal samples (*i.e.*, Deagle *et al.* 2005). This technique is still in the developmental stages. However, preliminary DNA quantification results from Hanson *et al.* (2010c) samples indicate that Chinook salmon make up the bulk of the prey DNA in the fecal samples (Ford *et al.* 2011b).

Genetic analysis of the Hanson *et al.* (2010c) samples indicate that when Southern Resident killer whales are in inland waters from May to September, they consume Chinook stocks that originate from the Fraser River (including Upper Fraser, Mid Fraser, Lower Fraser, N. Thompson, S. Thompson and Lower Thompson), Puget Sound (N. and S. Puget Sound), the Central British Columbia Coast and West and East Vancouver Island. Hanson *et al.* (2010c) find that the whales are likely consuming Chinook salmon stocks at least roughly proportional to their local abundance, as inferred by Chinook run-timing pattern and the stocks represented in killer whale prey for a specific area of inland waters, the San Juan Islands. Ongoing studies also confirm a shift to chum salmon in fall (Ford *et al.* 2010a; Hanson *et al.* 2010a).

Although less is known about the diet of Southern Residents off the Pacific coast, the available information indicates that salmon, and Chinook salmon in particular, are also important when the whales occur in coastal waters. There are few direct observations of predation events (where the prey were identified to species and stock from genetic analysis of prey remains) when the whales were in coastal waters. Two of these observations were identified as Columbia River Chinook stocks and at least one was identified from the Snake River (Hanson *et al.* 2010b; NWFSC unpubl. data). More recently, the researchers observed several predation events and collected prey and fecal samples during the winter 2013 cruise (NWFSC unpubl. data). Preliminary results indicate the whales are consuming primarily Chinook salmon (potentially from the Klamath River, Lower Columbia Springs, Middle Columbia Tule, Upper Columbia Summer/Fall, and north and south Puget Sound (NWFSC unpubl. data), and also steelhead and chum. Chemical analyses also support the importance of salmon in the year round diet of Southern Resident killer whales (Krahn *et al.* 2002; 2007; 2009). Krahn *et al.* (2002) examined the ratios of DDT (and its metabolites) to various PCB compounds in the whales, and concluded that the whales feed primarily on salmon throughout the year rather than other fish species. The predominance of Chinook salmon in their diet in inland waters, even when other species are more abundant, combined with information to date about prey in coastal waters (above), makes it reasonable to expect that Chinook salmon is equally predominant in the whales' diet when available in coastal waters. It is also reasonable to expect that the diet of Southern Residents is predominantly larger Chinook when available in coastal waters. The diet of Southern Residents in coastal waters is a subject of ongoing research.

Human influences have had profound impacts on the abundance of many prey species in the northeastern Pacific during the past 150 years, including salmon. The health and abundance of wild salmon stocks have been negatively affected by altered or degraded freshwater and estuarine habitat, including numerous land use activities, from hydropower systems to urbanization, forestry, agriculture and development. Harmful artificial propagation practices and overfishing have also negatively affected wild salmon stocks. Predation also contributes to natural mortality of salmon. Salmonid fishes are prey for pelagic fish, birds, and marine mammals including killer whales.

While wild salmon stocks have declined in many areas, hatchery production has increased. Currently, hatchery production contributes a significant component of the salmon prey base returning to watersheds within the range of Southern Resident killer whales (*i.e.*, review PFMC 2011 for Puget Sound; Barnett-Johnson *et al.* 2007 for Central Valley California; and NMFS 2008b for Columbia River Basin). Although hatchery production has contributed some offset of the historical declines in the abundance of wild salmon within the range of Southern Residents, hatcheries also pose risks to wild salmon populations (*i.e.*, Ford 2002; Nickelson *et al.* 1986; Levin and Williams 2002; Naish *et al.* 2007). In recent decades, managers have been moving toward hatchery reform, and are in the process of reducing risks identified in hatchery programs, through region-wide recovery planning efforts and hatchery program reviews. Healthy wild salmon populations are important to the long-term maintenance of prey populations available to Southern Resident killer whales, because it is uncertain whether a hatchery dominated mix of stocks is sustainable indefinitely.

One factor affecting the rangewide status of Chinook salmon, and aquatic habitat at large is climate change. For example, salmon abundance is substantially affected by climate variability in freshwater and marine environments, particularly by conditions during early life-history stages of salmon (NMFS 2008b). Sources of variability include inter-annual climatic variations (*e.g.*, El Niño and LaNiña), longer term cycles in ocean conditions (*e.g.*, Pacific Decadal Oscillation, Mantua *et al.* 1997), and ongoing global climate change. For example, climate variability can affect ocean productivity in the marine environment and water storage (*e.g.* snow pack) and in-stream flow in the freshwater environment. Early life-stage growth and survival of salmon can be negatively affected when climate variability results in conditions that hinder ocean productivity (*e.g.*, Scheuerell and Williams 2005) and/or water storage (*e.g.*, ISAB 2007) in marine and freshwater systems, respectively. Severe flooding in freshwater systems can also constrain salmon populations (NMFS 2008c). The availability of adult salmon may be reduced in years following unfavorable conditions to the early life-stage growth and survival of salmon.

When prey is scarce, whales likely spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition can lead to reduced body size and condition of individuals and lower reproductive and survival rates of a population (*e.g.*, Trites and Donnelly 2003). The Center for Whale Research has observed the very poor body condition in 13 members of the Southern Resident population, and all but two of those whales subsequently died (Durban *et al.* 2009). Both females and males across a range of ages were found in poor body condition (Durban *et al.* 2009).

The Center for Whale Research is the primary source of data for body condition of Southern Resident killer whales and retains photographs of all individual Southern Resident killer whales identified during annual census. They document body condition with boat-based visual observation and photographs. This technique is not able to detect fine scale differences in condition, because from the dorsal vantage a detectable change is only visible when a whale's condition has become very poor (Durban *et al.* 2009). Very poor condition is detectable by a depression behind the blowhole that presents as a "peanut-head" appearance. The Center for Whale Research has observed the "peanut-head" condition in 13 members of the Southern Resident population, and all but two of those whales subsequently died (Table 20). Durban *et al.* (2009) are currently refining methods to detect changes in body condition at a finer scale with aerial photogrammetry.

None of the whales that died were subsequently recovered, and therefore definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition (Table 20). Regardless of the cause(s) of death, it is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females and juveniles, which have been studied extensively (*e.g.*, adult females: Gamel *et al.* 2005; Daan *et al.* 1996; juveniles: Noren *et al.* 2009; Trites and Donnelly 2003). Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey. Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76% of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (*i.e.*, if the most successful foragers did not share with other individuals). Therefore, although cause of death for these specific individuals is unknown, poor nutrition could contribute to additional mortality in this population.

Table 20. Dates of observed "peanut-head" condition of individual Southern Resident killer whales and their fates (Durban *et al.* 2009).

Year	Whale ID	Whale Sex/Age	Description	Fate
1994	L42	M / 21	A slight depression behind the blowhole was first noticed in mid-June; a prominent depression by mid-July; the dorsal fin was drooping by mid-August; the depression had becom large by early September exposing the shape of the back of the cranium and vertebrae; last seen in late September.	Died
	K17	M / 28	A slight depression behind the blowhole was first noticed in mid-July; a prominent depression by mid-August; last seen in mid-September with the fin severly drooping.	Died
1995	J3	M / 43	A slight depression behind the blowhole noticeable by the end of March; moderate depression by mid-May with the fin beginning to droop; last seen late May.	Died
	L63	M / 11	A prominent depression behind the blowhole noticeable by late July; last seen late July.	Died
	L68	M / 10	A moderate depression behind the blowhole was noticeable in mid May; depression prominent by mid-June; last seen in late June.	Died
1996	J12	F / 24	A slight depression behind the blowhole first noticed in mid-February; depression moderate by April with the base of the cranium apparent; prominent depression by early June, with ribs beginning to show on flanks; depression very prominent by early September, revealing the shape of the base of the cranium and vertebrae, and ribs visible on flanks showing; last seen late September.	Died
	L9	F / 65	A slight depression behind the blowhole noticeable in early July; depression prominent by mid-August, exposing the shape of the base of the cranium; last seen mid-August.	Died
1997	J5	F / 59	A slight depression noticeable in early April; last seen early April.	Died
2002	L102	Unk / Calf	Moderate depression behind the blowhole noticeable in early December- only time the calf was seen; last seen early December	Died
2005	K25	M / 14	A moderate depression was noticeable behind the blowhole in late July, with a laceration on the whale's back following a collision with a whale-watch boat in early July; depression slight by early September; whale survived.	Survived
2006	K28	F / 12	A prominent depression behind the blowhole was noticeable in mid-September; whale not seen afterward.	Died
2008	L106	M / 3	A prominent depression behind the blowhole was noticeable in mid-June; depression just slight by mid-July; depression barely noticeable by early August; whale survived the year, and seen in early 2009.	Survived
	L67	F / 23	A slight depression behind the blowhole was first noticeable in late June; depression still slight in early August; depression prominent by mid-September; last seen mid-September.	Died

Ford *et al.* (2005 and 2010b) evaluated 25 years of demographic data from Southern and Northern Resident killer whales and found that changes in survival largely drive their population, and the populations' survival rates are strongly correlated with coast-wide availability of Chinook salmon (from Pacific Salmon Commission (PSC) abundance indices that estimate abundance between Southeast Alaska and Oregon). Ward *et al.* (2009) found that Northern and Southern Resident killer whale fecundity is highly correlated with Chinook abundance indices, and reported the probability of calving increased by 50% between low and high Chinook PSC abundance years. PSC Chinook abundance indices from the West Coast of Vancouver Island (WCVI) were the most important predictor of the relationship. Recently, Ward (2010) considered new information to update the 2009 fecundity model with new birth data and a singular focus on the Southern Resident killer whale population. Ward (2010) also conducted the updated analysis for survival, where the survival of L pod was evaluated separately from the survival of J and K pods because of the apparent lower survival in L pod (Ward *et al.* 2011; Krahn *et al.* 2004). Best-ranked models all included one of the PSC Chinook indices (the Northern British Columbia indices performed best, and WCVI, Southeast Alaska and inland WCVI indices performed equally well at second best). The results are consistent with findings from Ford *et al.* 2010b. More recently, Ward *et al.* (2013) considered new stock-specific Chinook salmon indices and found strong correlations between the indices of Chinook salmon abundance and killer whale demographic rates. However, no single stock or group of stocks was identified as being most correlated with the whales' demographic rates. Further, they stress that the relative importance of specific stocks to the whales likely changes over time (Ward *et al.* 2013).

Quality of Prey. The quality of Chinook salmon, Southern Resident killer whales' primary prey, is likely influenced by a variety of factors, including contaminant load, size of the fish, their fat content, and origin (natural vs. hatchery). Overall, Chinook have the highest lipid content (Stansby 1976; Winship and Trites 2003), largest size, and highest caloric value per kg of any salmonid species (Ford and Ellis 2006; Osborne 1999). Details about contaminant load, size, and origin are provided below.

Levels of persistent organic pollutants (POPs) in killer whales are primarily determined by contaminant levels in their prey and the geographic region, although the age, gender, and birth order of the whale will also influence accumulation. Various studies have documented a range of concentrations of POPs in many populations of adult Pacific salmon (Table 21). Reported POP values for Pacific salmon are limited to adults and sub-adults (*i.e.*, most applicable to the diet of the whales) sampled in terminal areas. Terminal areas include coastal marine waters and river mouths through which salmon migrate *en route* to their natal streams to spawn. POP accumulation in Pacific salmon is primarily determined by geographic proximity to contaminated environments (Mongillo *et al.* in prep.). In general, Chinook salmon and coho salmon populations from the west coast of North America have a more coastal marine distribution along the continental shelf and are more readily exposed to contaminants that are present in coastal waters than other species. In contrast, sockeye, pink, and chum salmon have lower POP concentrations because by the end of their first year, they have migrated through the coastal waters and are found in the open waters of the North Pacific, Gulf of Alaska, and Bering Sea (Quinn 2005). Measured average concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) were highest for Chinook, intermediate for coho, less for sockeye, and lowest for pink and chum salmon (Table 21). Similarly, average DDT values were higher in Chinook and coho salmon compared to sockeye and lowest for pink and chum salmon (Table 21). Intermediate levels of PCB and PBDEs were measured in California and Oregon populations and the lowest average levels were measured in populations off Alaska (Mongillo *et al.* in prep.). The biological traits in Pacific salmon (*e.g.* trophic status, lipid content, age, exposure duration, metabolism, and detoxification) may also affect the degree to which POPs accumulate (Mongillo *et al.* in prep.).

Size of individual salmon is an aspect of prey quality that could affect the foraging efficiency of Southern Resident killer whales. As discussed above, available data suggests that Southern Residents consume larger prey. The degree to which this is a function of the availability of all sizes of fish in the coastal range of the whales, their ability to detect all sizes or a true preference of only large fish is unknown. It is possible although not conclusive that there has been a historical decrease in salmon age, size, or size at a given age (*i.e.*, Bigler *et al.* 1996, but also see PFMC data [PFMC 2011]). Fish size is influenced by factors such as environmental conditions, selectivity in fishing effort through gear type, fishing season or regulations, and hatchery practices. The available information on size is also confounded by factors including inter-population difference, when the size was recorded, and differing data sources and sampling methods (review in Quinn 2005).

Southern Resident killer whales likely consume both natural and hatchery salmon (Hanson *et al.* 2010c). The best available information does not indicate that natural and hatchery salmon generally differ in size, run-timing, or ocean distribution (*e.g.*, Nickum *et al.* 2004; NMFS 2008c; Weitkamp and Neely 2002, regarding differences that could affect Southern Residents); however, there is evidence of size and run-timing differences between hatchery and natural salmon from specific river systems or runs (*i.e.*, size and run timing differences as described for Willamette River Chinook in NMFS 2008d). We analyze potential run-specific differences in the quality of natural and hatchery salmon where data are available.

Table 21. Lipid and persistent organic pollutant concentrations (ng g^{-1} wet weight) of adult and subadult Pacific salmon sampled in terminal areas. Terminal areas include coastal marine water and river mouths through which fish migrate en route to their natal stream. From Mongillo *et al.* (in prep).

Species	Region	Sub-region	Population	n	Tissue Analyzed	Lipids (%)	PCBs	DDTs	PBDEs	Citation
Chinook salmon	Alaska	unknown	Unknown	2	muscle w/o skin	NR	5.6	NR	0.95	4
	Alaska	Aleutian Islands	Unknown	3	muscle w/skin	7.6	5.0	22	0.71	14, 15*
	Alaska	SE Alaska/ Gulf of Alaska/ Berring Sea	Unknown	35	muscle wo/skin	9.7	11	7.1	0.53	21
	Alaska	SE Alaska	Unknown	3	muscle w/skin	NR	8.0	NR	0.50	5*, 6*
	Alaska	South Central	River	10	muscle wo/skin	NR	9.1	9.8	NR	13
		Alaskan Chinook salmon Average				**8.7**	**7.7**	**13.0**	**0.67**	
	British Columbia	BC North Coast	Skeena	30	whole body	NR	7.3	7.3	0.08	11
	British Columbia	Fraser River	Thompson	6	muscle wo/skin	10	9.1	1.5	NR	1
	British Columbia	Fraser River		13	whole body	NR	9.4	6.6	0.80	11
	British Columbia	Fraser River	Thompson	7	muscle wo/skin	12	8.6	7.7	1.54	17**
	British Columbia	Fraser River	Shuswap	2	muscle wo/skin	3.0	9.8	5.5	NR	17**
	British Columbia	Fraser River	Harrison	6	muscle wo/skin	5.4	47	4.3	17.7	1
		Fraser River Chinook salmon Average (excluding Harrison)				**8.3**	**10**	**5.7**	**1.67**	
		British Columbia Chinook salmon Average				**7.6**	**15**	**5.5**	**4.87**	
	Washington	Puget Sound	Nooksack River	28	muscle wo/skin	3.5	37	NR	NR	12
	Washington	Puget Sound	Skagit River	29	muscle wo/skin	4.8	40	NR	NR	12
	Washington	Puget Sound	Duwamish River	65	muscle wo/skin	7.3	56	NR	NR	12
	Washington	Puget Sound	Nisqually River	20	muscle wo/skin	3.8	41	NR	NR	12
	Washington	Puget Sound	Deschutes River	34	muscle wo/skin	1.7	59	NR	NR	12
	Washington	Puget Sound	PS mixed	28	muscle wo/skin	4.8	76	NR	NR	12
	Washington	Puget Sound	Duwamish River	3	whole body	6.4	35	18.3	6.43	1
	Washington	Puget Sound	Deschutes River	4	whole body	4.3	56	NR	NR	1
	Washington	Puget Sound	Deschutes River	10	muscle wo/skin	1.0	49	NR	NR	8
	Washington	Puget Sound	Issaquah Creek	10	muscle wo/skin	0.6	49	NR	NR	8
	Washington	Puget Sound	PS mixed	36	whole body	NR	43	29.1	18.9	11
	Washington	Puget Sound	PS mixed	34	whole body	NR	91	16.4	42.2	11

Species	Region	Sub-region	Population	n	Tissue Analyzed	Lipids (%)	PCBs	DDTs	PBDEs	Citation
	Washington	WA Coast	Makah	10	muscle wo/skin	1.5	19	NR	NR	8
	Washington	WA Coast	Quinault	10	muscle wo/skin	1.8	16	NR	NR	8
		Puget Sound Chinook salmon Average				**3.8**	**53**	**21.3**	**22.5**	
		Washington Coast Chinook salmon Average				**1.7**	**17**	**NR**	**NR**	
		Washington Chinook salmon Average				**3.5**	**48**	**21.3**	**22.5**	
	Oregon	unknown	Unknown	3	muscle w/skin	NR	10	NR	2.10	5*, 6*
	Oregon	Columbia River	unknown Fall	17	whole body	NR	18	19.9	3.69	11
	Oregon	Columbia River	unknown Spring	20	whole body	NR	33	34.8	9.77	11
	Oregon	Columbia River	mixed fall Chinnook	15	muscle w/skin	7.0	37	21.0	NR	18
	Oregon	Columbia River	mixed spring Chinook	24	muscle w/skin	9.0	38	22.0	NR	18
	Oregon	Columbia River	fall Chinnook	4	whole body	9.4	15	NR	2.30	16
	Oregon	Columbia River	Clackamas River	3	muscle w/skin	8.8	13	NR	1.80	16
	Oregon	Columbia River	Clackamas River	3	muscle wo/skin	6.1	10	NR	1.50	16
		Oregon Chinook salmon Average				**8.1**	**22**	**24.4**	**3.53**	
	California	Sacramento /San Joaquin	Unknown	29	whole body	**NR**	**14**	**33.6**	**2.56**	11
	Chinook salmon Average					**5.6**	**29**	**15.7**	**6.22**	
Sockeye salmon	Alaska	unknown	Alaska	2	muscle wo/skin	NR	3.6	NR	0.21	4
	Alaska	Aleutian Islands	Unknown	13	muscle wo/skin	5.8	*130*	6.9	NR	3
	Alaska	Kodiak	Unknown	3	muscle w/skin	NR	5.0	NR	0.10	5*, 6*
	Alaska	Gulf of Alaska/ Berring Sea	Unknown	24	muscle wo/skin	8.2	13	12.0	0.22	21
	Alaska	Gulf of Alaska/ Berring Sea	Copper River	97	muscle wo/skin	5.5	37	12.2	NR	19**
	Alaska	SE Alaska	Unknown	3	muscle w/skin	NR	13.3	NR	0.10	5*, 6*
	Alaskan sockeye salmon Average					**6.5**	**14.4**[#]	**10.4**	**0.16**	
	British Columbia	unknown	Unknown	3	muscle w/skin	NR	8.0	NR	0.10	5*, 6*
	British Columbia	Fraser River	Early Stuart	3	soma	16	*13*	NR	NR	7**
	British Columbia	Fraser River	Early Stuart	5	muscle wo/skin	4.0	3.9	NR	NR	7**
	British Columbia	Fraser River	Early Stuart	6	muscle wo/skin	5.0	6.9	NR	NR	7**
	British Columbia	Fraser River	Adams	5	muscle wo/skin	8.8	7.7	6.6	NR	17**
	British Columbia	Fraser River	Weaver Creek	3	muscle wo/skin	1.4	6.8	NR	NR	7**
	British Columbia	Fraser River	Weaver Creek	2	muscle wo/skin	1.1	3.6	NR	NR	7**

Species	Region	Sub-region	Population	n	Tissue Analyzed	Lipids (%)	PCBs	DDTs	PBDEs	Citation
	British Columbia	Fraser River	Weaver Creek	2	muscle wo/skin	1.5	5.3	NR	NR	7**
	British Columbia	Fraser River	Weaver Creek	1	muscle wo/skin	1.1	4.0	NR	NR	7**
	British Columbia	Fraser River	Weaver	8	muscle wo/skin	3.9	6.8	5.4	NR	17**
	British Columbia	West Coast VI	Great Central Lk.	6	muscle	6.1	1.7	NR	NR	7**
	British Columbia	West Coast VI	Great Central Lk.	3	muscle	6.6	1.6	NR	NR	2**
	British Columbia	West Coast VI	Great Central Lk.	2	muscle	1.0	1.5	NR	NR	2**
	British Columbia	West Coast VI	Great Central Lk.	3	muscle	1.0	2.4	NR	NR	2**
	British Columbian sockeye salmon Average					**4.4**	**5.2**	**6.00**	**0.10**	
	Sockeye salmon Average					**4.8**	**7.6[#]**	**8.6**	**0.15**	
Steelhead	**Oregon**	**Columbia River**		21	muscle w/skin	**6.0**	**34**	**21.0**	**NR**	18
Coho Salmon	Alaska	unknown	Unknown	2	muscle wo/skin	NR	1.6	NR	0.32	4
	Alaska	Kodiak	Unknown	3	muscle w/skin	NR	4.0	NR	0.10	5*, 6*
	Alaska	seak/goa	Unknown	14	muscle wo/skin	2.9	2.0	1.5	0.19	21
	Alaska	SE Alaska	Unknown	3	muscle w/skin	NR	4.0	NR	0.10	5*, 6*
	Alaskan coho salmon Average					**2.9**	**2.9**	**1.5**	**0.18**	
	British Columbia	unknown	Unknown	3	muscle w/skin	**NR**	**6.0**	**NR**	**0.30**	5*, 6*
	Washington	Puget Sound	Unknown	32	muscle wo/skin	3.1	35	NR	NR	10
	Washington	Puget Sound	PS mixed	125	muscle wo/skin	3.1	27	NR	NR	10
	Washington	Puget Sound	PS mixed	266	muscle wo/skin	3.3	NR	11.7	NR	20
	Washington coho salmon Average					**3.2**	**31**	**11.7**	**NR**	
	Oregon	Columbia River	Umatilla River	3	muscle w/skin	**2.5**	**35**	**41.0**	**NR**	18
	Coho salmon Average					**3.0**	**14**	18.1	**0.20**	
Pink salmon	Alaska	Kodiak	Unknown	3	muscle w/skin	NR	3.0	NR	0.10	5*, 6*
	Alaska	northern Alaska	Unknown	7	canned	6.3	2.6	1.8	NR	22
	Alaska	SE Alaska/GOA	Unknown	12	muscle wo/skin	3.5	1.3	0.6	0.22	21
	Alaska	SE Alakka	Unknown	3	muscle w/skin	NR	2.0	NR	0.10	5*, 6*
	Alaskan pink salmon Average					**4.9**	**2.2**	**1.2**	**0.14**	
	British Columbia	unknown	Unknown	3	muscle w/skin	NR	3.0	NR	0.30	5*, 6*
	Pink salmon Average					**4.9**	**2.4**	**1.2**	**0.18**	

Species	Region	Sub-region	Population	n	Tissue Analyzed	Lipids (%)	PCBs	DDTs	PBDEs	Citation
Chum salmon	Alaska	Kodiak	Unknown	3	muscle w/skin	NR	2.0	NR	0.10	5*, 6*
	Alaska	SE Alaska	Unknown	3	muscle w/skin	NR	3.0	NR	0.10	5*, 6*
	Alaska	Berring Sea	Unknown	18	muscle wo/skin	4.8	3.2	1.9	0.16	21
	Alaskan chum salmon Average					**4.8**	**2.7**	**1.9**	**0.12**	
	British Columbia	unknown	Unknown	3	muscle w/skin	NR	2.0	NR	0.20	5*, 6*
	Chum salmon Average					**4.8**	**2.6**	**1.9**	**0.14**	

1) Cullon *et al.* 2009; 2) Debruyn *et al.* 2004; 3) Hardell *et al.* 2010; 4) Hayward *et al.* 2007; 5) Hites *et al.* 2004a; 6) Hites *et al.* 2004b;
7) Kelly *et al.* 2007; 8) Missildine *et al.* 2005; 9) Montory *et al.* 2010; 10) O'Neill *et al.* 1998; 11) O'Neill *et al.* 2006;
12) O'Neill and West 2009; 13) Rice and Moles 2006; 14) Shaw *et al.* 2008; 15) Shaw *et al.* 2006; 16) Stone 2006;
17) Veldhoen *et al.* 2010; 18) EPA 2002; 19) Ewald *et al.* 1998; 20) West *et al.* 2001; 21) ADEC 2011; 22) O'Hara *et al.* 2005

* estimated values from figure

** estimated value from reported lipid weight

#excluded value as an outlier

Extinction Risk

In conjunction with the 2004 status review, NMFS conducted a population viability analysis (PVA) for Southern Resident killer whales (Krahn *et al.* 2004). Demographic information from the 1970s to fairly recently (1974-2003, 1990-2003, and 1994-2003) were considered to estimate extinction and quasi-extinction risk. We defined "quasi-extinction" as the stage at which 10 or fewer males or females remained, a threshold from which the population was not expected to recover.

The model evaluated a range in Southern Resident survival rates, based on variability in mean survival rates documented from past time intervals (highest, intermediate, and lowest survival). The model used a single fecundity rate for all simulations. The study considered seven values of carrying capacity for the population ranging from 100 to 400 whales, three levels of catastrophic event (*e.g.*, oil spills and disease outbreaks) frequency ranging from none to twice per century, and three levels of catastrophic event magnitude in which 0, 10, or 20% of the animals died per event.

The analysis indicated that the Southern Resident killer whales have a range of extinction risk from 0.1 to 18.7% in 100 years and 1.9 to 94.2% in 300 years, and a range of quasi-extinction risk from 1 to 66.5% in 100 years and 3.6 to 98.3% in 300 years (Table 22). The population is generally at greater risk of extinction as survival rate decreases and over a longer time horizon (300 years) than over a shorter time horizon (100 years) (as would be expected with long-lived mammals). There is a greater extinction risk associated with increased probability and magnitude of catastrophic events. The Northwest Fisheries Science Center (NWFSC) continues to evaluate mortality rates and reproduction, and will complete work on a PVA similar to the analysis summarized above. Until these updated analyses are completed, the Krahn *et al.* (2004) analysis represents the best available science on extinction risk of Southern Resident killer whales.

Table 22. Range of extinction and quasi-extinction risk for Southern Resident killer whales in 100 and 300 years, assuming a range in survival rates (depicted by time period), a constant rate of fecundity, between 100 and 400 whales, and a range catastrophic probabilities and magnitudes (Krahn et al. 2004).

Time Period	**Extinction Risk (%)**		**Quasi-Extinction Risk (%)**	
	100 yrs	**300 yrs**	**100 yrs**	**300 yrs**
Highest survival	0.1 – 2.8	1.9 – 42.4	1.0 – 14.6	3.6 – 67.7
Intermediate survival	0.2 – 5.2	14.4 – 65.6	6.1 – 29.8	21.4 – 85.3
Lowest survival	5.6 – 18.7	68.2 – 94.2	39.4 – 66.5	76.1 – 98.3

2.2.3 Status of the Critical Habitats – Fish

This section examines the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated areas. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

Salmon and Steelhead. For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC_5) in terms of the conservation value they provide to each listed species they support.[11] The conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NOAA Fisheries 2005). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (*e.g.*, one of a very few spawning areas), a unique contribution of the population it served (*e.g.*, a population at the extreme end of geographic distribution), or if it serves another important role (*e.g.*, obligate area for migration to upstream spawning areas).

The physical or biological features of freshwater spawning and incubation sites include water flow, quality, and temperature; suitable substrate for spawning and incubation; and migratory access for adults and juveniles (Tables 23-24). These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The physical or biological features of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean.

[11] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

Table 23. Primary constituent elements (PCEs) of critical habitats designated for listed salmon and steelhead species considered in the opinion (except SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, and SONCC coho salmon), and corresponding species life history events.

Primary Constituent Elements		**Species Life History Event**
Site Type	**Site Attribute**	
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing

Table 24. Essential features of critical habitats designated for SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, SONCC coho salmon, and corresponding species life history events.

Essential Features		Species Life History Event
Site	**Site Attribute**	
Spawning and juvenile rearing areas	Access (sockeye) Cover/shelter Food (juvenile rearing) Riparian vegetation Space (Chinook, coho) Spawning gravel Water quality Water temp (sockeye) Water quantity	Adult spawning Embryo incubation Alevin growth and development Fry emergence from gravel Fry/parr/smolt growth and development
Adult and juvenile migration corridors	Cover/shelter Food (juvenile) Riparian vegetation Safe passage Space Substrate Water quality Water quantity Water temperature Water velocity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Areas for growth and development to adulthood	Ocean areas – not identified	Nearshore juvenile rearing Subadult rearing Adult growth and sexual maturation Adult spawning migration

CHART Salmon and Steelhead Critical Habitat Assessments

The CHART for each recovery domain assessed biological information pertaining to areas occupied by listed salmon and steelhead, determine whether those areas contained PCEs essential for the conservation of those species and whether unoccupied areas existed within the historical range of the listed salmon and steelhead that are also essential for conservation. The CHARTs assigned a 0 to 3 point score for the PCEs in each HUC_5 watershed for:

Factor 1. Quantity,
Factor 2. Quality – Current Condition,
Factor 3. Quality – Potential Condition,
Factor 4. Support of Rarity Importance,
Factor 5. Support of Abundant Populations, and
Factor 6. Support of Spawning/Rearing.

Thus, the quality of habitat in a given watershed was characterized by the scores for Factor 2 (quality – current condition), which considers the existing condition of the quality of PCEs in the

HUC_5 watershed; and Factor 3 (quality – potential condition), which considers the likelihood of achieving PCE potential in the HUC_5 watershed, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility.

Southern DPS Green Sturgeon. A team similar to the CHARTs, referred to as a Critical Habitat Review Team (CHRT), identified and analyzed the conservation value of particular areas occupied by southern green sturgeon, and unoccupied areas they felt are necessary to ensure the conservation of the species (USDC 2009). The CHRT did not identify those particular areas using HUC nomenclature, but did provide geographic place names for those areas, including the names of freshwater rivers, the bypasses, the Sacramento-San Joaquin Delta, coastal bays and estuaries, and coastal marine areas (within 110 m depth) extending from the California/Mexico border north to Monterey Bay, California, and from the Alaska/Canada border northwest to the Bering Strait; and certain coastal bays and estuaries in California, Oregon, and Washington.

For freshwater rivers north of and including the Eel River, the areas upstream of the head of the tide were not considered part of the geographical area occupied by the southern DPS. However, the critical habitat designation recognizes not only the importance of natal habitats, but of habitats throughout their range. Critical habitat has been designated in coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) (USDC 2009). The designated areas in Oregon bays include all tidally influenced areas up to the elevation of mean higher high water, including, but not limited to, areas upstream to the head of tide in various streams that drain into the bays, as listed in Table 1 in USDC (2009). In the Columbia River, the designated area includes all tidally influenced areas of the lower Columbia River estuary from the mouth upstream to river kilometer 74, up to the elevation of mean higher high water, including, but not limited to, areas upstream to the head of tide endpoint in various streams that drain into the estuary, as listed in Table 1 of USDC (2009).

Table 25 lists the physical and biological features (PBFs) of critical habitat designated for southern green sturgeon and corresponding species life history events.

Table 25. Physical or biological features of critical habitat designated for southern green sturgeon and corresponding species life history events.

Physical or Biological Features		Species Life History Event
Site Type	**Site Attribute**	
Freshwater riverine system	Food resources Migratory corridor Sediment quality Substrate type or size Water depth Water flow Water quality	Adult spawning Embryo incubation, growth and development Larval emergence, growth and development Juvenile metamorphosis, growth and development
Estuarine areas	Food resources Migratory corridor Sediment quality Water flow Water depth Water quality	Juvenile growth, development, seaward migration Subadult growth, development, seasonal holding, and movement between estuarine and marine areas Adult growth, development, seasonal holding, movements between estuarine and marine areas, upstream spawning movement, and seaward post-spawning movement
Coastal marine areas	Food resources Migratory corridor Water quality	Subadult growth and development, movement between estuarine and marine areas, and migration between marine areas Adult sexual maturation, growth and development, movements between estuarine and marine areas, migration between marine areas, and spawning migration

The CHRT identified several activities that threaten the PBFs in coastal bays and estuaries and necessitate the need for special management considerations or protection. The application of pesticides is likely to adversely affect prey resources and water quality within the bays and estuaries, as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Other activities of concern include those that disturb bottom substrates, adversely affect prey resources, or degrade water quality through re-suspension of contaminated sediments. Of particular concern are activities that affect prey resources. Prey resources are affected by: commercial shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon). In addition, petroleum spills from commercial shipping and proposed hydrokinetic energy projects are likely to affect water quality or hinder the migration of green sturgeon along the coast (USDC 2009).

Southern DPS Eulachon. Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington (USDC 2011). All of these areas are designated as migration and spawning habitat for this species. In Oregon, we designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. The mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles is also designated as critical habitat. Table 26 lists the physical or biological features of critical habitat designated for eulachon and corresponding species life history events.

Table 26. Physical or biological features of critical habitats designated for eulachon and corresponding species life history events.

Physical or biological features		Species Life History Event
Site Type	**Site Attribute**	
Freshwater spawning and incubation	Flow Water quality Water temperature Substrate	Adult spawning Incubation
Freshwater migration	Flow Water quality Water temperature Food	Adult and larval mobility Larval feeding

The range of eulachon in the Pacific Northwest completely overlaps with the range of several listed stocks of salmon and steelhead as well as green sturgeon. Although the habitat requirements of these fishes differ somewhat from eulachon, efforts to protect habitat generally focus on the maintenance of watershed processes that would be expected to benefit eulachon. The BRT identified dams and water diversions as moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath systems, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods (Gustafson *et al.* 2010). Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown (Gustafson *et al.* 2010). The BRT identified dredging as a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.

The lower Columbia River mainstem provides spawning and incubation sites, and a large migratory corridor to spawning areas in the tributaries. Prior to the construction of Bonneville Dam, eulachon ascended the Columbia River as far as Hood River, Oregon. Major tributaries that support spawning runs include the Grays, Skamokawa, Elochoman, Kalama, Lewis and Sandy rivers.

The number of eulachon returning to the Umpqua River seems to have declined in the 1980s, and does not appear to have rebounded to previous levels. Additionally, eulachon are regularly caught in salmonid smolt traps operated in the lower reaches of Tenmile Creek by the Oregon Dpartment of Fish and Wildlife (ODFW).

Willamette-Lower Columbia Recovery Domain. Critical habitat was designated in the WLC recovery domain for UWR Chinook salmon, LCR Chinook salmon, LCR steelhead, UWR steelhead, CR chum salmon, southern green sturgeon, and eulachon, and has been proposed for LCR coho salmon. In addition to the Willamette and Columbia River mainstems, important tributaries on the Oregon side of the WLC include Youngs Bay, Big Creek, Clatskanie River, and Scappoose River in the Oregon Coast subbasin; Hood River in the Gorge; and the Sandy, Clackamas, Molalla, North and South Santiam, Calapooia, McKenzie, and Middle Fork Willamette rivers in the West Cascades subbasin.

The WLC recovery domain CHART determined that most HUC_5 watersheds with PCEs for salmon or steelhead are in fair-to-poor or fair-to-good condition (NOAA Fisheries 2005). However, most of these watersheds have some or a high potential for improvement. Only watersheds in the upper McKenzie River and its tributaries are in good to excellent condition with no potential for improvement (Table 27).

Table 27. **Willamette-Lower Columbia Recovery Domain:** Current and potential quality of HUC_5 watersheds identified as supporting historically independent populations of listed Chinook salmon (CK), chum salmon (CM), and steelhead (ST) (NOAA Fisheries 2005).[12] Watersheds are ranked primarily by "current quality" and secondly by their "potential for restoration."

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name(s) and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Columbia Gorge #1707010xxx			
Wind River (511)	CK/ST	2/2	2/2
East Fork Hood (506), & Upper (404) & Lower Cispus (405) rivers	CK/ST	2/2	2/2
Plympton Creek (306)	CK	2	2
Little White Salmon River (510)	CK	2	0
Grays Creek (512) & Eagle Creek (513)	CK/CM/ST	2/1/2	1/1/2
White Salmon River (509)	CK/CM	2/1	1/2
West Fork Hood River (507)	CK/ST	1/2	2/2
Hood River (508)	CK/ST	1/1	2/2
Unoccupied habitat: Wind River (511)	Chum conservation value "Possibly High"		
Cascade and Coast Range #1708000xxx			
Lower Gorge Tributaries (107)	CK/CM/ST	2/2/2	2/3/2
Lower Lewis (206) & North Fork Toutle (504) rivers	CK/CM/ST	1/3/1	2/1/2
Salmon (101), Zigzag (102), & Upper Sandy (103) rivers	CK/ST	2/2	2/2
Big Creek (602)	CK/CM	2/2	2/2
Coweeman River (508)	CK/CM/ST	2/2/1	2/1/2
Kalama River (301)	CK/CM/ST	1/2/2	2/1/2
Cowlitz Headwaters (401)	CK/ST	2/2	1/1
Skamokawa/Elochoman (305)	CK/CM	2/1	2
Salmon Creek (109)	CK/CM/ST	1/2/1	2/3/2
Green (505) & South Fork Toutle (506) rivers	CK/CM/ST	1/1/2	2/1/2

[12] On January 14, 2013, NMFS published a proposed rule for the designation of critical habitat for LCR coho salmon (USDC 2013c). We also completed a draft biological report on critical habitat (NMFS 2012a). Habitat quality assessments for LCR coho salmon are out for review; therefore, they are not included on this table.

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name(s) and HUC5 Code(s)	Listed Species	Current Quality	Restoration Potential
Jackson Prairie (503) & East Willapa (507)	CK/CM/ST	1/2/1	1/1/2
Grays Bay (603)	CK/CM	1/2	2/3
Upper Middle Fork Willamette River (101)	CK	2	1
Germany/Abernathy creeks (304)	CK/CM	1/2	2
Mid-Sandy (104), Bull Run (105), & Lower Sandy (108) rivers	CK/ST	1/1	2/2
Washougal (106) & East Fork Lewis (205) rivers	CK/CM/ST	1/1/1	2/1/2
Upper Cowlitz (402) & Tilton rivers (501) & Cowlitz Valley Frontal (403)	CK/ST	1/1	2/1
Clatskanie (303) & Young rivers (601)	CK	1	2
Rifle Reservoir (502)	CK/ST	1	1
Beaver Creek (302)	CK	0	1
Unoccupied Habitat: Upper Lewis (201) & Muddy (202) rivers; Swift (203) & Yale (204) reservoirs	CK & ST Conservation Value "Possibly High"		
Willamette River #1709000xxx			
Upper (401) & South Fork (403) McKenzie rivers; Horse Creek (402); & McKenzie River/Quartz Creek (405)	CK	3	3
Lower McKenzie River (407)	CK	2	3
South Santiam River (606)	CK/ST	2/2	1/3
South Santiam River/Foster Reservoir (607)	CK/ST	2/2	1/2
North Fork of Middle Fork Willamette (106) & Blue (404) rivers	CK	2	1
Upper South Yamhill River (801)	ST	2	1
Little North Santiam River (505)	CK/ST	1/2	3/3
Upper Molalla River (905)	CK/ST	1/2	1/1
Abernethy Creek (704)	CK/ST	1/1	1/2
Luckiamute River (306) & Yamhill (807) Lower Molalla (906) rivers; Middle (504) & Lower (506) North Santiam rivers; Hamilton Creek/South Santiam River (601); Wiley Creek (608); Mill Creek/Willamette River (701); & Willamette River/Chehalem Creek (703); Lower South (804) & North (806) Yamhill rivers; & Salt Creek/South Yamhill River (805)	CK/ST	1	1
Hills (102) & Salmon (104) creeks; Salt Creek/Willamette River (103), Hills Creek Reservoir (105), Middle Fork Willamette/Lookout Point (107); Little Fall (108) & Fall (109) creeks; Lower Middle Fork of Willamette (110), Long Tom (301), Marys (305) & Mohawk (406) rivers	CK	1	1
Willamina Creek (802) & Mill Creek/South Yamhill River (803)	ST	1	1
Calapooia River (303); Oak (304) Crabtree (602), Thomas (603) & Rickreall (702) creeks; Abiqua (901), Butte (902) & Rock (903) creeks/Pudding River; & Senecal Creek/Mill Creek (904)	CK/ST	1/1	0/1
Row River (201), Mosby (202) & Muddy (302) creeks, Upper (203) & Lower (205) Coast Fork Willamette River	CK	1	0
Unoccupied habitat in North Santiam (501) & North Fork Breitenbush (502) rivers; Quartzville Creek (604) and Middle Santiam River (605)	CK & ST Conservation Value "Possibly High"		
Unoccupied habitat in Detroit Reservoir/Blowout Divide Creek (503)	Conservation Value: CK "Possibly Medium"; ST Possibly High"		

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name(s) and HUC5 Code(s)	Listed Species	Current Quality	Restoration Potential
Lower Willamette #1709001xxx			
Collawash (101), Upper Clackamas (102), & Oak Grove Fork (103) Clackamas rivers	CK/ST	2/2	3/2
Middle Clackamas River (104)	CK/ST	2/1	3/2
Eagle Creek (105)	CK/ST	2/2	1/2
Gales Creek (002)	ST	2	1
Lower Clackamas River (106) & Scappoose Creek (202)	CK/ST	1	2
Dairy (001) & Scoggins (003) creeks; Rock Creek/Tualatin River (004); & Tualatin River (005)	ST	1	1
Johnson Creek (201)	CK/ST	0/1	2/2
Lower Willamette/Columbia Slough (203)	CK/ST	0	2

Interior Columbia Recovery Domain. Critical habitat has been designated in the IC recovery domain, which includes the Snake River Basin, for SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, UCR spring-run Chinook salmon, SR sockeye salmon, MCR steelhead, UCR steelhead, and SRB steelhead. Major tributaries in the Oregon portion of the IC recovery domain include the Deschutes, John Day, Umatilla, Walla Walla, Grande Ronde, and Imnaha rivers.

Habitat quality in tributary streams in the IC recovery domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994; NMFS 2009a). Critical habitat throughout much of the IC recovery domain has been degraded by intense agriculture, alteration of stream morphology (*i.e.*, channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas.

Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System (FCRPS) in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia river basins. For example, construction of Hells Canyon Dam eliminated access to several likely production areas in Oregon and Idaho, including the Burnt, Powder, Weiser, Payette, Malheur, Owyhee, and Boise river basins (Good *et al.* 2005), and Grand Coulee and Chief Joseph dams completely block anadromous fish passage on the upper mainstem Columbia River.

A series of large regulating dams on the middle and upper Deschutes River affect flow and block access to upstream habitat, and have extirpated one or more populations from the Cascades

Eastern Slope major population. Also, the operation and maintenance of large water reclamation systems such as the Umatilla Basin and Yakima Projects have significantly modified flow regimes and degraded water quality and physical habitat in this domain.

Many stream reaches designated as critical habitat in the IC recovery domain are over-allocated, with more allocated water rights than existing streamflow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence *et al.* 1996). Reduced tributary stream flow has been identified as a major limiting factor for all listed salmon and steelhead species in this recovery domain except SR fall-run Chinook salmon and SR sockeye salmon (NMFS 2011c).

Many stream reaches designated as critical habitat are listed on Oregon's Clean Water Act section 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat.

The CHART determined that few watersheds with PCEs for Chinook salmon or steelhead are in good to excellent condition with no potential for improvement. Overall, most IC recovery domain watersheds are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or high potential for improvement. In Washington, the Upper Methow, Lost, White, and Chiwawa watersheds are in good-to-excellent condition with no potential for improvement. In Oregon, only the Lower Deschutes, Minam, Wenaha, and Upper and Lower Imnaha Rivers HUC_5 watersheds are in good-to-excellent condition with no potential for improvement. In Idaho, a number of watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, Middle Fork Salmon, Little Salmon, Selway, and Lochsa rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River HUC_5watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (Table 28).

Table 28. **Interior Columbia Recovery Domain:** Current and potential quality of HUC_5 watersheds identified as supporting historically independent populations of listed Chinook salmon (CK) and steelhead (ST) (NOAA Fisheries 2005). Watersheds are ranked primarily by "current quality" and secondly by their "potential for restoration."

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Upper Columbia # 1702000xxx			
White (101), Chiwawa (102), Lost (801) & Upper Methow (802) rivers	CK/ST	3	3
Upper Chewuch (803) & Twisp rivers (805)	CK/ST	3	2
Lower Chewuch River (804); Middle (806) & Lower (807) Methow rivers	CK/ST	2	2
Salmon Creek (603) & Okanogan River/Omak Creek (604)	ST	2	2
Upper Columbia/Swamp Creek (505)	CK/ST	2	1
Foster Creek (503) & Jordan/Tumwater (504)	CK/ST	1	1
Upper (601) & Lower (602) Okanogan River; Okanogan River/Bonaparte Creek (605); Lower Similkameen River (704); & Lower Lake Chelan (903)	ST	1	1
Unoccupied habitat in Sinlahekin Creek (703)	ST Conservation Value "Possibly High"		
Upper Columbia #1702001xxx			
Entiat River (001); Nason/Tumwater (103); & Lower Wenatchee River (105)	CK/ST	2	2
Lake Entiat (002)	CK/ST	2	1
Columbia River/Lynch Coulee (003); Sand Hollow (004); Yakima/Hansen Creek (604), Middle Columbia/Priest Rapids (605), & Columbia River/Zintel Canyon (606)	ST	2	1
Icicle/Chumstick (104)	CK/ST	1	2
Lower Crab Creek (509)	ST	1	2
Rattlesnake Creek (204)	ST	0	1
Yakima #1703000xxx			
Upper (101) & Middle (102) Yakima rivers; Teanaway (103) & Little Naches (201) rivers; Naches River/Rattlesnake Creek (202); & Ahtanum (301) & Upper Toppenish (303) & Satus (305) creeks	ST	2	2
Umtanum/Wenas (104); Naches River/Tieton River (203); Upper Lower Yakima River (302); & Lower Toppenish Creek (304)	ST	1	2
Yakima River/Spring Creek (306)	ST	1	1
Lower Snake River #1706010xxx			
Snake River/Granite (101), Getta (102), & Divide (104) creeks; Upper (201) & Lower (205) Imnaha River; Snake River/Rogersburg (301); Minam (505) & Wenaha (603) rivers	ST	3	3
Grande Ronde River/Rondowa (601)	ST	3	2
Big (203) & Little (204) Sheep creeks; Asotin River (302); Catherine Creek (405); Lostine River (502); Bear Creek (504); & Upper (706) & Lower (707) Tucannon River	ST	2	3

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Middle Imnaha River (202); Snake River/Captain John Creek (303); Upper Grande Ronde River (401); Meadow (402); Beaver (403); Indian (409), Lookingglass (410) & Cabin (411) creeks; Lower Wallowa River (506); Mud (602), Chesnimnus (604) & Upper Joseph (605) creeks	ST	2	2
Ladd Creek (406); Phillips/Willow Creek (408); Upper (501) & Middle (503) Wallowa rivers; & Lower Grande Ronde River/Menatche Creek (607)	ST	1	3
Five Points (404); Lower Joseph (606) & Deadman (703) creeks	ST	1	2
Tucannon/Alpowa Creek (701)	ST	1	1
Mill Creek (407)	ST	0	3
Pataha Creek (705)	ST	0	2
Snake River/Steptoe Canyon (702) & Penawawa Creek (708)	ST	0	1
Flat Creek (704) & Lower Palouse River (808)	ST	0	0
Upper Salmon and Pahsimeroi #1706020xxx			
Germania (111) & Warm Springs (114) creeks; Lower Pahsimeroi River (201); Alturas Lake (120), Redfish Lake (121), Upper Valley (123) & West Fork Yankee (126) creeks	ST	3	3
Basin Creek (124)	ST	3	2
Salmon River/Challis (101); East Fork Salmon River/McDonald Creek (105); Herd Creek (108); Upper East Fork Salmon River (110); Salmon River/Big Casino (115), Fisher (117) & Fourth of July (118) creeks; Upper Salmon River (119); Valley Creek/Iron Creek (122); & Morgan Creek (132)	ST	2	3
Salmon River/Bayhorse Creek (104); Salmon River/Slate Creek (113); Upper Yankee Fork (127) & Squaw Creek (128); Pahsimeroi River/Falls Creek (202)	ST	2	2
Yankee Fork/Jordan Creek (125)	ST	1	3
Salmon River/Kinnikinnick Creek (112); Garden Creek (129); Challis Creek/Mill Creek (130); & Patterson Creek (203)	ST	1	2
Road Creek (107)	ST	1	1
Unoccupied habitat in Hawley (410), Eighteenmile (411) & Big Timber (413) creeks	Conservation Value for ST "Possibly High"		
Middle Salmon, Panther and Lemhi #1706020xxx			
Salmon River/Colson (301), Pine (303) & Moose (305) creeks; Indian (304) & Carmen (308) creeks, North Fork Salmon River (306); & Texas Creek (412)	ST	3	3
Deep Creek (318)	ST	3	2
Salmon River/Cow Creek (312) & Hat (313), Iron (314), Upper Panther (315), Moyer (316) & Woodtick (317) creeks; Lemhi River/Whimpey Creek (402); Hayden (414), Big Eight Mile (408), & Canyon (408) creeks	ST	2	3
Salmon River/Tower (307) & Twelvemile (311) creeks; Lemhi River/Kenney Creek (403); Lemhi River/McDevitt (405), Lemhi River/Yearian Creek (406); & Peterson Creek (407)	ST	2	2
Owl (302) & Napias (319) creeks	ST	2	1

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Salmon River/Jesse Creek (309); Panther Creek/Trail Creek (322); & Lemhi River/Bohannon Creek (401)	ST	1	3
Salmon River/Williams Creek (310)	ST	1	2
Agency Creek (404)	ST	1	1
Panther Creek/Spring Creek (320) & Clear Creek (323)	ST	0	3
Big Deer Creek (321)	ST	0	1
Mid-Salmon-Chamberlain, South Fork, Lower, and Middle Fork Salmon #1706020xxx			
Lower (501), Upper (503) & Little (504) Loon creeks; Warm Springs (502); Rapid River (505); Middle Fork Salmon River/Soldier (507) & Lower Marble Creek (513); & Sulphur (509), Pistol (510), Indian (511) & Upper Marble (512) creeks; Lower Middle Fork Salmon River (601); Wilson (602), Upper Camas (604), Rush (610), Monumental (611), Beaver (614), Big Ramey (615) & Lower Big (617) creeks; Middle Fork Salmon River/Brush (603) & Sheep (609) creeks; Big Creek/Little Marble (612); Crooked (616), Sheep (704), Bargamin (709), Sabe (711), Horse (714), Cottonwood (716) & Upper Chamberlain Creek (718); Salmon River/Hot Springs (712); Salmon River/Kitchen Creek (715); Lower Chamberlain/McCalla Creek (717); & Slate Creek (911)	ST	3	3
Marsh (506); Bear Valley (508) Yellow Jacket (604); West Fork Camas (607) & Lower Camas (608) creeks; & Salmon River/Disappointment Creek (713) & White Bird Creek (908)	ST	2	3
Upper Big Creek (613); Salmon River/Fall (701), California (703), Trout (708), Crooked (705) & Warren (719) creeks; Lower South Fork Salmon River (801); South Fork Salmon River/Cabin (809), Blackmare (810) & Fitsum (812) creeks; Lower Johnson Creek (805); & Lower (813), Middle (814) & Upper Secesh (815) rivers; Salmon River/China (901), Cottonwood (904), McKenzie (909), John Day (912) & Lake (913) creeks; Eagle (902), Deer (903), Skookumchuck (910), French (915) & Partridge (916) creeks	ST	2	2
Wind River (702), Salmon River/Rabbit (706) & Rattlesnake (710) creeks; & Big Mallard Creek (707); Burnt Log (806), Upper Johnson (807) & Buckhorn (811) creeks; Salmon River/Deep (905), Hammer (907) & Van (914) creeks	ST	2	1
Silver Creek (605)	ST	1	3
Lower (803) & Upper (804) East Fork South Fork Salmon River; Rock (906) & Rice (917) creeks	ST	1	2
Little Salmon #176021xxx			
Rapid River (005)	ST	3	3
Hazard Creek (003	ST	3	2
Boulder Creek (004)	ST	2	3
Lower Little Salmon River (001) & Little Salmon River/Hard Creek (002)	ST	2	2
Selway, Lochsa and Clearwater #1706030xxx			
Selway River/Pettibone (101) & Gardner (103) creeks; Bear (102), White Cap (104), Indian (105), Burnt Knob (107), Running (108) &	ST	3	3

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name and HUC_5 Code(s)	Listed Species	Current Quality	Restoration Potential
Goat (109) creeks; & Upper Selway River (106); Gedney (202), Upper Three Links (204), Rhoda (205), North Fork Moose (207), Upper East Fork Moose (209) & Martin (210) creeks; Upper (211), Middle (212) & Lower Meadow (213) creeks; Selway River/Three Links Creek (203); & East Fork Moose Creek/Trout Creek (208); Fish (302), Storm (309), Warm Springs (311), Fish Lake (312), Boulder (313) & Old Man (314) creeks; Lochsa River/Stanley (303) & Squaw (304) creeks; Lower Crooked (305), Upper Crooked (306) & Brushy (307) forks; Lower (308), Upper (310) White Sands, Ten Mile (509) & John's (510) creeks			
Selway River/Goddard Creek (201); O'Hara Creek (214) Newsome (505) creeks; American (506), Red (507) & Crooked (508) rivers	ST	2	3
Lower Lochsa River (301); Middle Fork Clearwater River/Maggie Creek (401); South Fork Clearwater River/Meadow (502) & Leggett creeks; Mill (511), Big Bear (604), Upper Big Bear (605), Musselshell (617), Eldorado (619) & Mission (629) creeks, Potlatch River/Pine Creek (606); & Upper Potlatch River (607); Lower (615), Middle (616) & Upper (618) Lolo creeks	ST	2	2
South Fork Clearwater River/Peasley Creek (502)	ST	2	1
Upper Orofino Creek (613)	ST	2	0
Clear Creek (402)	ST	1	3
Three Mile (512), Cottonwood (513), Big Canyon (610), Little Canyon (611) & Jim Ford (614) creeks; Potlatch River/Middle Potlatch Creek (603); Clearwater River/Bedrock (608), Jack's (609) Lower Lawyer (623), Middle Lawyer (624), Cottonwood (627) & Upper Lapwai (628) creeks; & Upper (630) & Lower (631) Sweetwater creeks	ST	1	2
Lower Clearwater River (601) & Clearwater River/Lower Potlatch River (602), Fivemile Creek (620), Sixmile Creek (621) and Tom Taha (622) creeks	ST	1	1
Mid-Columbia #1707010xxx			
Wood Gulch (112); Rock Creek (113); Upper Walla Walla (201), Upper Touchet (203), & Upper Umatilla (301) rivers; Meacham (302) & Birch (306) creeks; Upper (601) & Middle (602) Klickitat River	ST	2	2
Glade (105) & Mill (202) creeks; Lower Klickitat River (604); Mosier Creek (505); White Salmon River (509); Middle Columbia/Grays Creek (512)	ST	2	1
Little White Salmon River (510)	ST	2	0
Middle Touchet River (204); McKay Creek (305); Little Klickitat River (603); Fifteenmile (502) & Fivemile (503) creeks	ST	1	2
Alder (110) & Pine (111) creeks; Lower Touchet River (207), Cottonwood (208), Pine (209) & Dry (210) creeks; Lower Walla Walla River (211); Umatilla River/Mission Creek (303) Wildhorse Creek (304); Umatilla River/Alkali Canyon (307); Lower Butter Creek (310); Upper Middle Columbia/Hood (501); Middle Columbia/Mill Creek (504)	ST	1	1
Stage Gulch (308) & Lower Umatilla River (313)	ST	0	1
John Day #170702xxx			

Current PCE Condition	Potential PCE Condition
3 = good to excellent	3 = highly functioning, at historical potential
2 = fair to good	2 = high potential for improvement
1 = fair to poor	1 = some potential for improvement
0 = poor	0 = little or no potential for improvement

Watershed Name and HUC$_5$ Code(s)	Listed Species	Current Quality	Restoration Potential
Middle (103) & Lower (105) South Fork John Day rivers; Murderers (104) & Canyon (107) creeks; Upper John Day (106) & Upper North Fork John Day (201) rivers; & Desolation Creek (204)	ST	2	2
North Fork John Day/Big Creek (203); Cottonwood Creek (209) & Lower NF John Day River (210)	ST	2	1
Strawberry (108), Beech (109), Laycock (110), Fields (111), Mountain (113) & Rock (114) creeks; Upper Middle John Day River (112); Granite (202) & Wall (208) creeks; Upper (205) & Lower (206) Camas creeks; North Fork John Day/Potamus Creek (207); Upper Middle Fork John Day River (301) & Camp (302), Big (303) & Long (304) creeks; Bridge (403) & Upper Rock (411) creeks; & Pine Hollow (407)	ST	1	2
John Day/Johnson Creek (115); Lower Middle Fork John Day River (305); Lower John Day River/Kahler Creek (401), Service (402) & Muddy (404) creeks; Lower John Day River/Clarno (405); Butte (406), Thirtymile (408) & Lower Rock (412) creeks; Lower John Day River/Ferry (409) & Scott (410) canyons; & Lower John Day River/McDonald Ferry (414)	ST	1	1
Deschutes #1707030xxx			
Lower Deschutes River (612)	ST	3	3
Middle Deschutes River (607)	ST	3	2
Upper Deschutes River (603)	ST	2	1
Mill Creek (605) & Warm Springs River (606)	ST	2	1
Bakeoven (608) & Buck Hollow (611) creeks; Upper (701) & Lower (705) Trout Creek	ST	1	2
Beaver (605) & Antelope (702) creeks	ST	1	1
White River (610) & Mud Springs Creek (704)	ST	1	0
Unoccupied habitat in Deschutes River/McKenzie Canyon (107) & Haystack (311); Squaw Creek (108); Lower Metolius River (110), Headwaters Deschutes River (601)	ST Conservation Value "Possibly High"		

Oregon Coast Recovery Domain. In this recovery domain, critical habitat has been designated for OC coho salmon, southern green sturgeon, and eulachon. Many large and small rivers supporting significant populations of coho salmon flow through this domain, including the Nehalem, Nestucca, Siletz, Yaquina, Alsea, Siuslaw, Umpqua, Coos, and Coquille.

The historical disturbance regime in the central Oregon Coast Range was dominated by a mixture of high and low-severity fires, with a natural rotation of approximately 271 years. Old-growth forest coverage in the Oregon Coast Range varied from 25 to 75% during the past 3,000 years, with a mean of 47%, and never fell below 5% (Wimberly *et al.* 2000). Currently, the Coast Range has approximately 5% old-growth, almost all of it on Federal lands. The dominant disturbance now is logging on a cycle of approximately 30 to 100 years, with fires suppressed.

Oregon's assessment of OC coho salmon (Nicholas *et al.* 2005) mapped how streams with high intrinsic potential for rearing are distributed by land ownership categories. Agricultural lands and private industrial forests have by far the highest percentage of land ownership in high intrinsic potential areas and along all coho salmon stream miles. Federal lands have only about 20% of coho salmon stream miles and 10% of high intrinsic potential stream reaches. Because of this distribution, activities in lowland agricultural areas are particularly important to the conservation of OC coho salmon.

The OC coho salmon assessment concluded that at the scale of the entire domain, pools are generally abundant, although slow-water and off-channel habitat (which are important refugia for coho salmon during high winter flows) are limited in the majority of streams when compared to reference streams in minimally-disturbed areas. The amount of large wood in streams is low in all four ODFW monitoring areas and land-use types relative to reference conditions. Amounts of fine sediment are high in three of the four monitoring areas, and were comparable to reference conditions only on public lands. Approximately 62 to 91% of tidal wetland acres (depending on estimation procedures) have been lost for functionally and potentially independent populations of coho salmon.

As part of the coastal coho salmon assessment, the Oregon Department of Environmental Quality analyzed the status and trends of water quality in the range of OC coho salmon using the Oregon water quality index, which is based on a combination of temperature, dissolved oxygen, biological oxygen demand, pH, total solids, nitrogen, total phosphates, and bacteria. Using the index at the species scale, 42% of monitored sites had excellent to good water quality, and 29% show poor to very poor water quality (DEQ 2005). Within the four monitoring areas, the North Coast had the best overall conditions (six sites in excellent or good condition out of nine sites), and the Mid-South coast had the poorest conditions (no excellent condition sites, and only two out of eight sites in good condition). For the 10-year period monitored between 1992 and 2002, no sites showed a declining trend in water quality. The area with the most improving trends was the North Coast, where 66% of the sites (six out of nine) had a significant improvement in index scores. The Umpqua River basin, with one out of nine sites (11%) showing an improving trend, had the lowest number of improving sites.

Southern Oregon/Northern California Coast Recovery Domain. In this recovery domain critical habitat has been designated for SONCC coho salmon and southern green sturgeon. Many large and small rivers supporting significant populations of coho salmon flow through this area, including the Elk, Rogue, Chetco, Smith and Klamath.

The Elk River flows through Curry County, and drains approximately 92 square miles (or 58,678 acres) (Maguire 2001). Historical logging, mining, and road building have degraded stream and riparian habitats in the Elk River basin. Limiting factors identified for salmon and steelhead production in this basin include sparse riparian cover, especially in the lower reaches, excessive fine sediment, high water temperatures, and noxious weed invasions (Maguire 2001).

The Rogue River drains approximately 5,160 square miles within Curry, Jackson and Josephine counties in southwest Oregon. The mainstem is about 200 miles long and traverses the coastal mountain range into the Cascades. The Rogue River estuary has been modified from its historical condition. Jetties were built by the U.S Army Corps of Engineers (USACE) in 1960, which stabilized and deepened the mouth of the river. A dike that extends from the south shore near Highway 101 to the south jetty was completed in 1973. This dike created a backwater for the large shallow area that existed here, which has been developed into a boat basin and marina, eliminating most of the tidal marsh.

The quantity of estuary habitat is naturally limited in the Rogue River. The Rogue River has a large drainage area, but its 1,880 acres estuary is one of the smallest among Oregon's coastal rivers. Between 1960 and 1972, approximately 13 acres of intertidal and 14 acres of subtidal land were filled in to build the boat basin dike, the marina, north shore riprap and the other north shore developments (Hicks 2005). Jetties constructed in 1960 to stabilize the mouth of the river and prevent shoaling have altered the Rogue River, which historically formed a sill during summer months (Hicks 2005).

The Lower Rogue Watershed Council's watershed analysis (Hicks 2005) lists factors limiting fish production in tributaries to the Lower Rogue River watershed. The list includes water temperatures, low stream flows, riparian forest conditions, fish passage and over-wintering habitat. Limiting factors identified for the Upper Rogue River basin include fish passage barriers, high water temperatures, insufficient water quantity, lack of large wood, low habitat complexity, and excessive fine sediment (Rogue Basin Coordinating Council 2006).

The Chetco River estuary has been significantly modified from its historical condition. Jetties were erected by the USACE in 1957, which stabilized and deepened the mouth of the river. These jetties have greatly altered the mouth of the Chetco River and how the estuary functions as habitat for salmon migrating to the ocean. A boat basin and marina were built in the late 1950s and eliminated most of the functional tidal marsh. The structures eliminated shallow water habitats and vegetation in favor of banks stabilized with riprap. Since then, nearly all remaining bank habitat in the estuary has been stabilized with riprap. The factors limiting fish production in the Chetco River appear to be high water temperature caused by lack of shade, especially in tributaries, high rates of sedimentation due to roads, poor over-wintering habitat due to a lack of large wood in tributaries and the mainstem, and poor quality estuary habitat (Maguire 2001).

2.3 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

2.3.1 Water Quality Environmental Baseline

The extent of waterbodies listed as "water quality limited" under section 303(d) of the CWA in Oregon river basins (dissolved oxygen, temperature and pH only) that are inhabited by the listed species included in this opinion is shown in Figures 6 through 13.

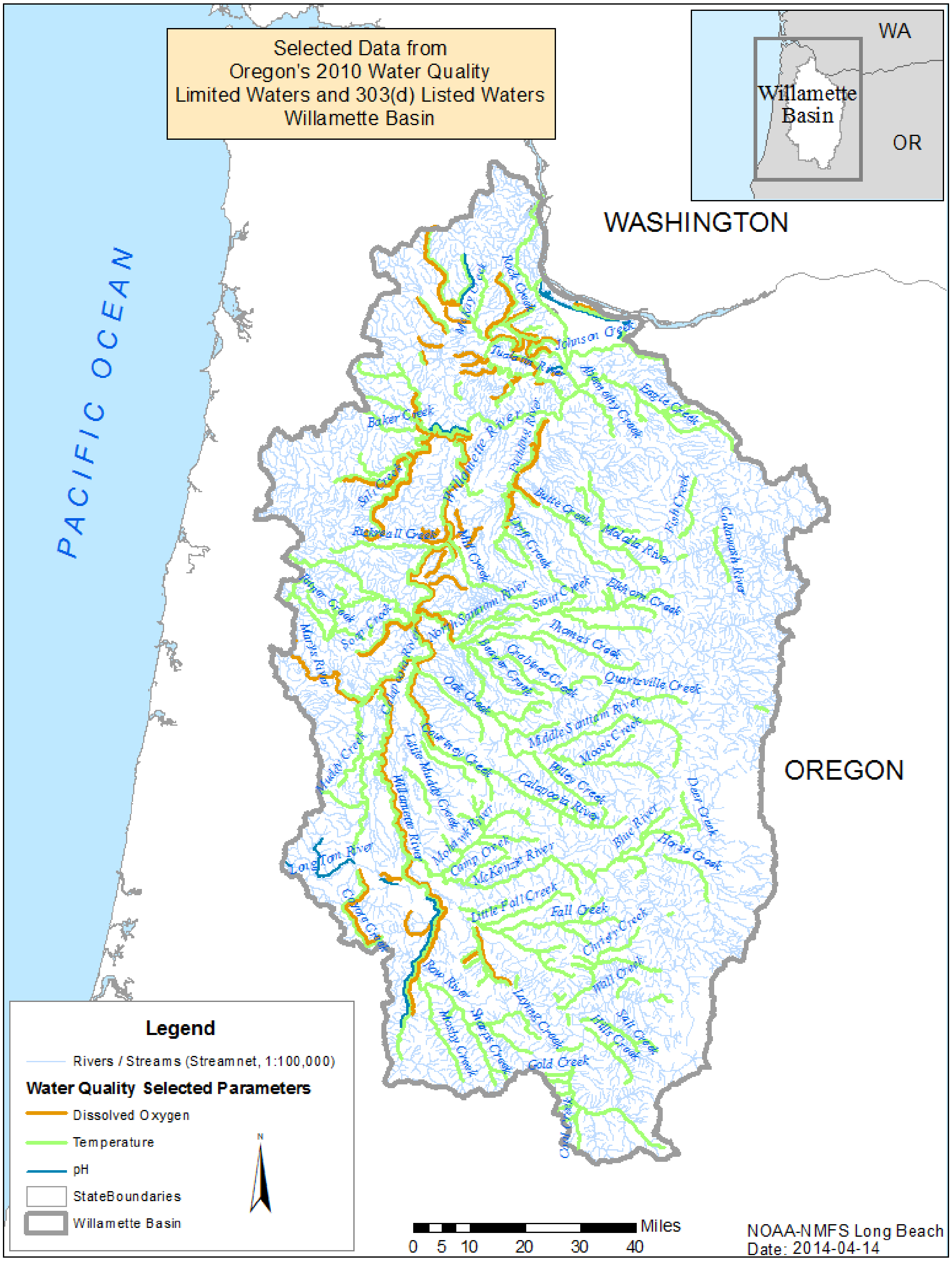

Figure 6. Water quality limited waters in Willamette Basin.

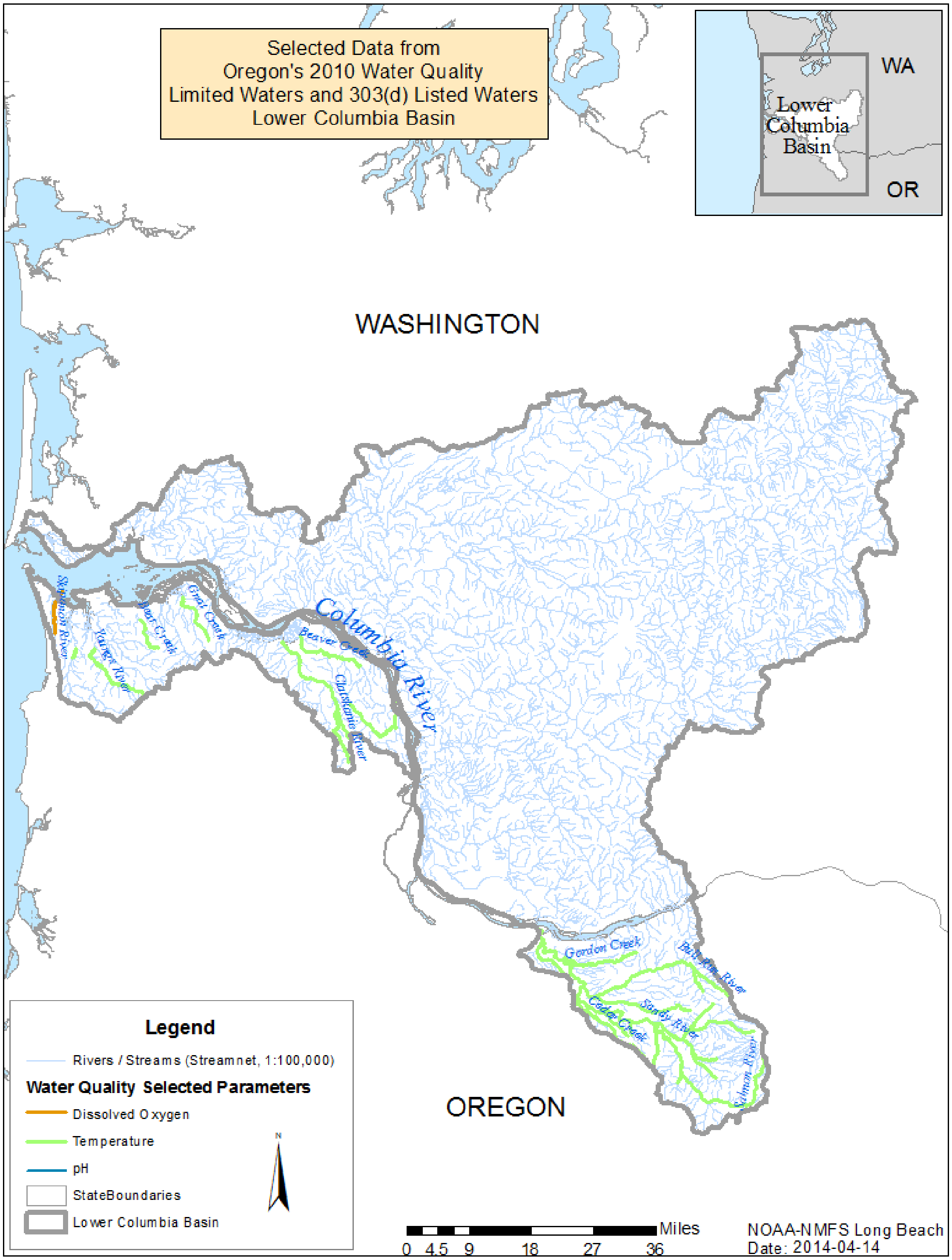

Figure 7. Water quality limited waters in Lower Columbia Basin.

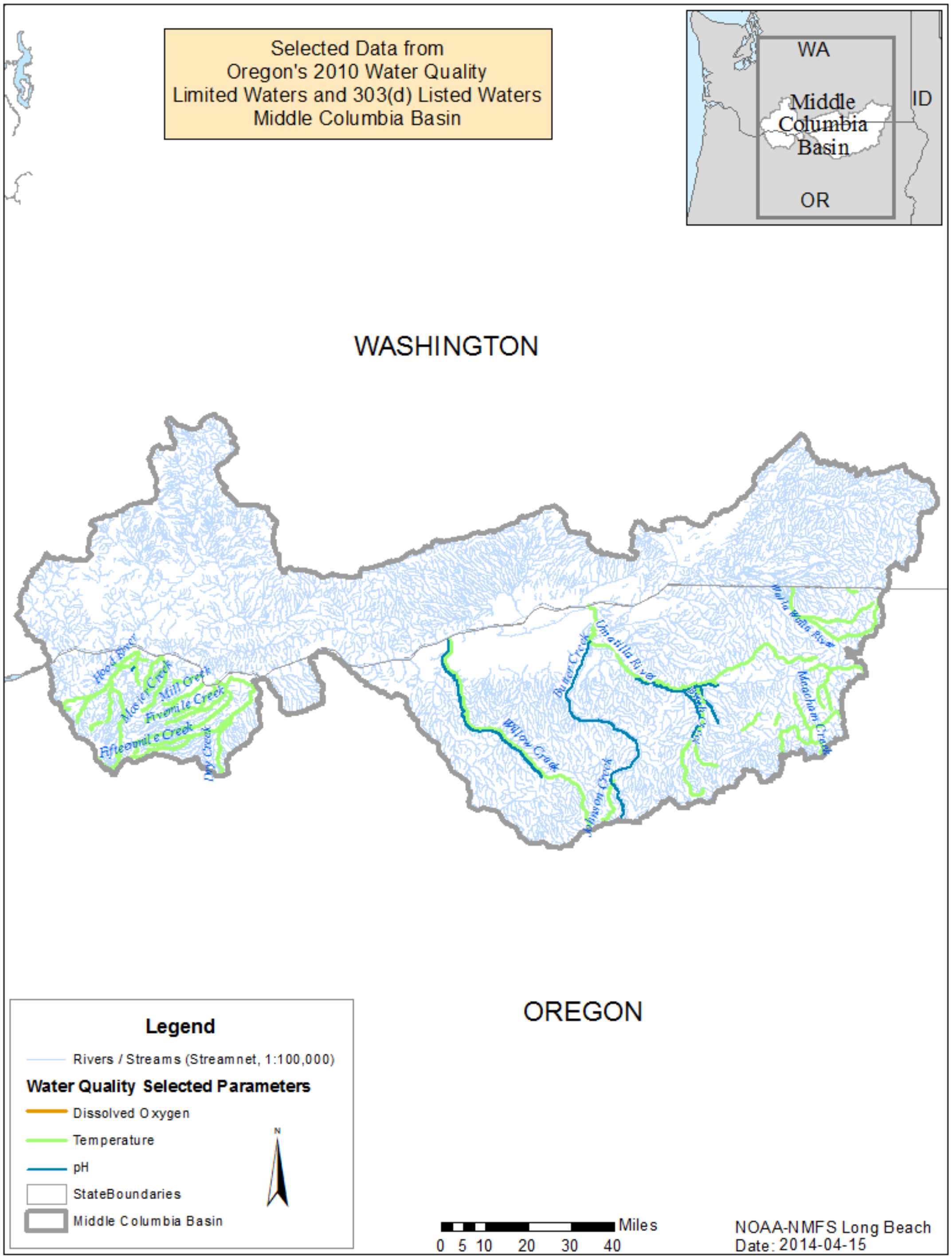

Figure 8. Water quality limited waters in Middle Columbia Basin.

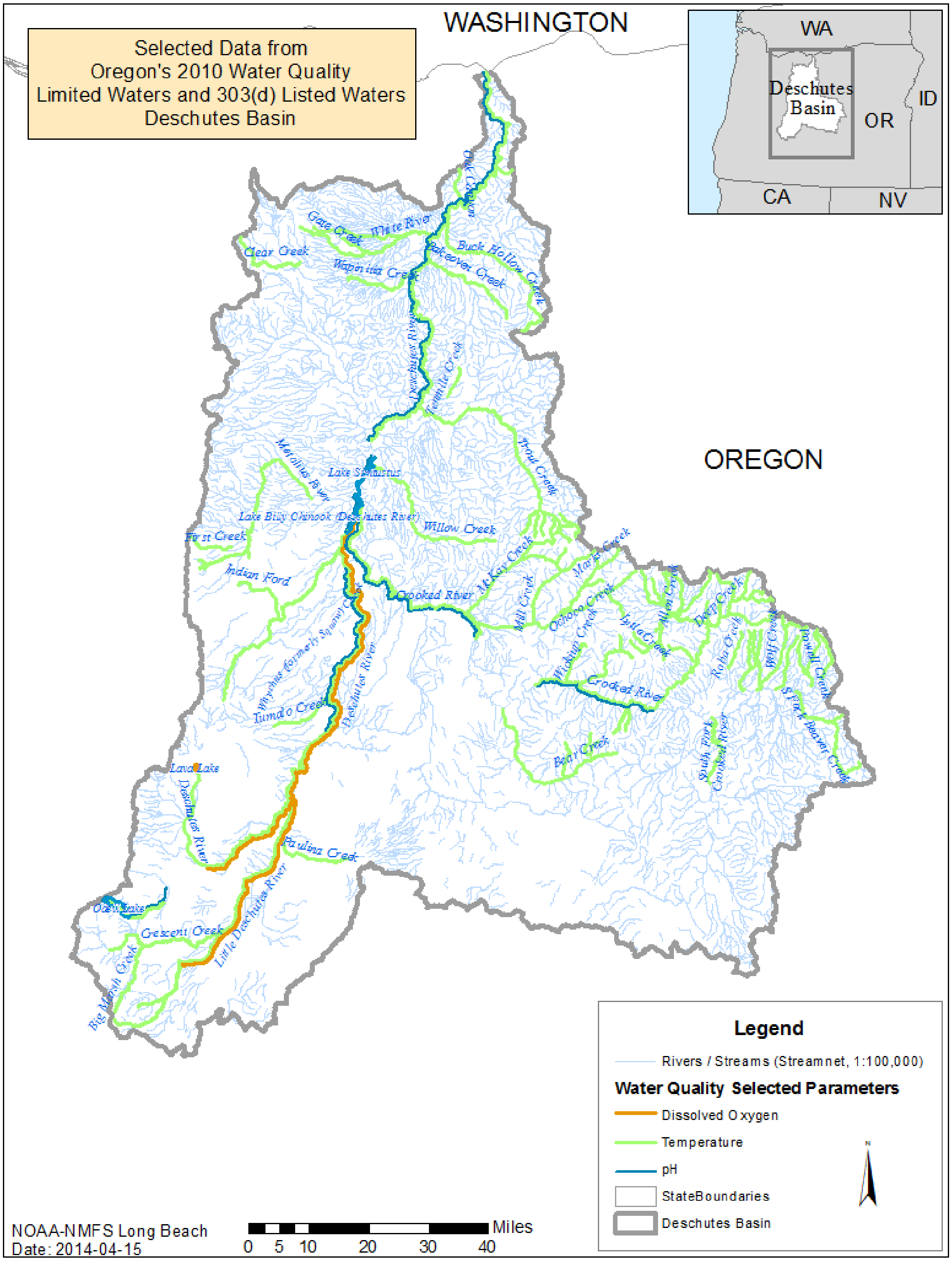

Figure 9. Water quality limited waters in Deschutes Basin.

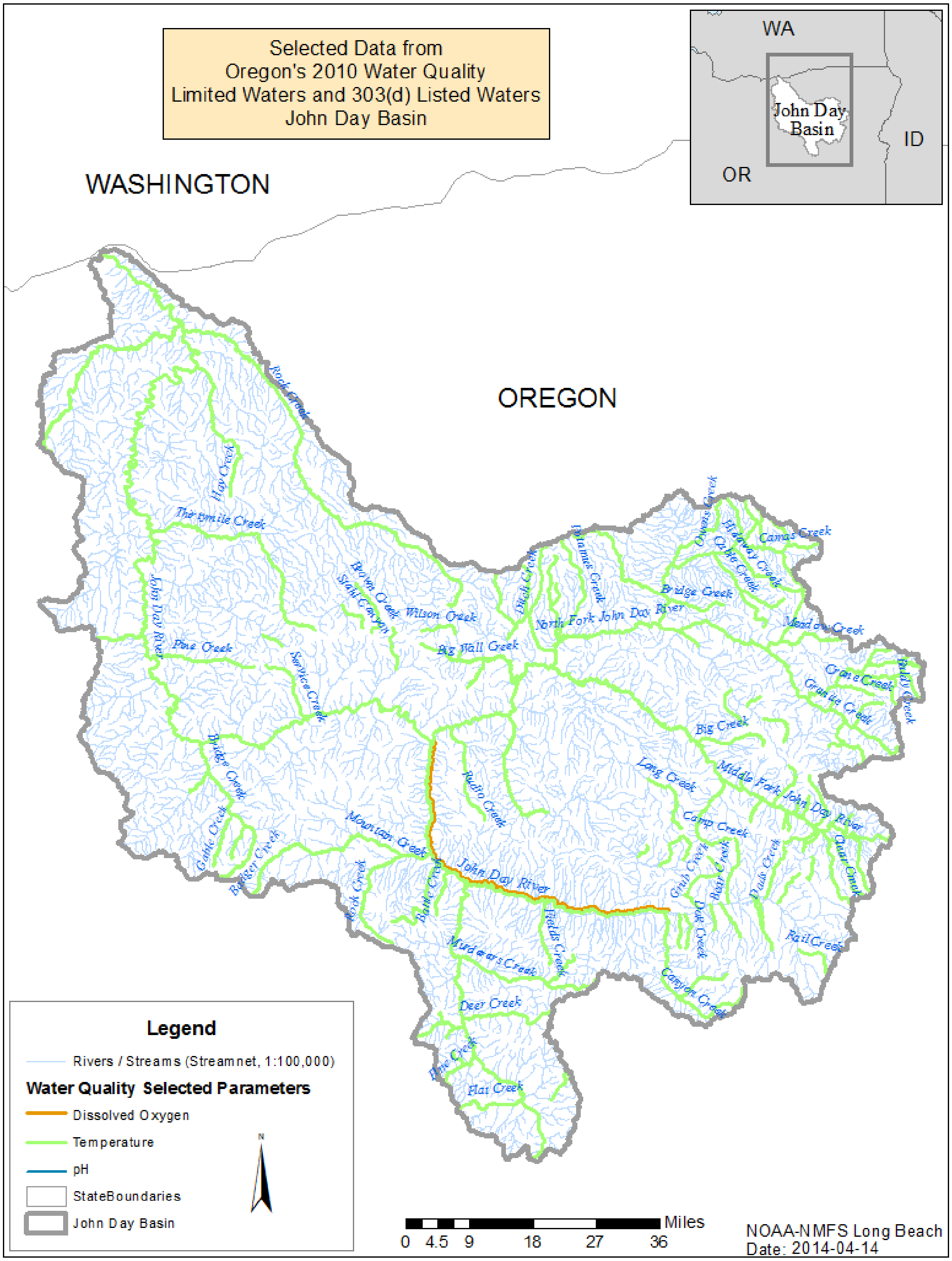

Figure 10. Water quality limited waters in John Day Basin.

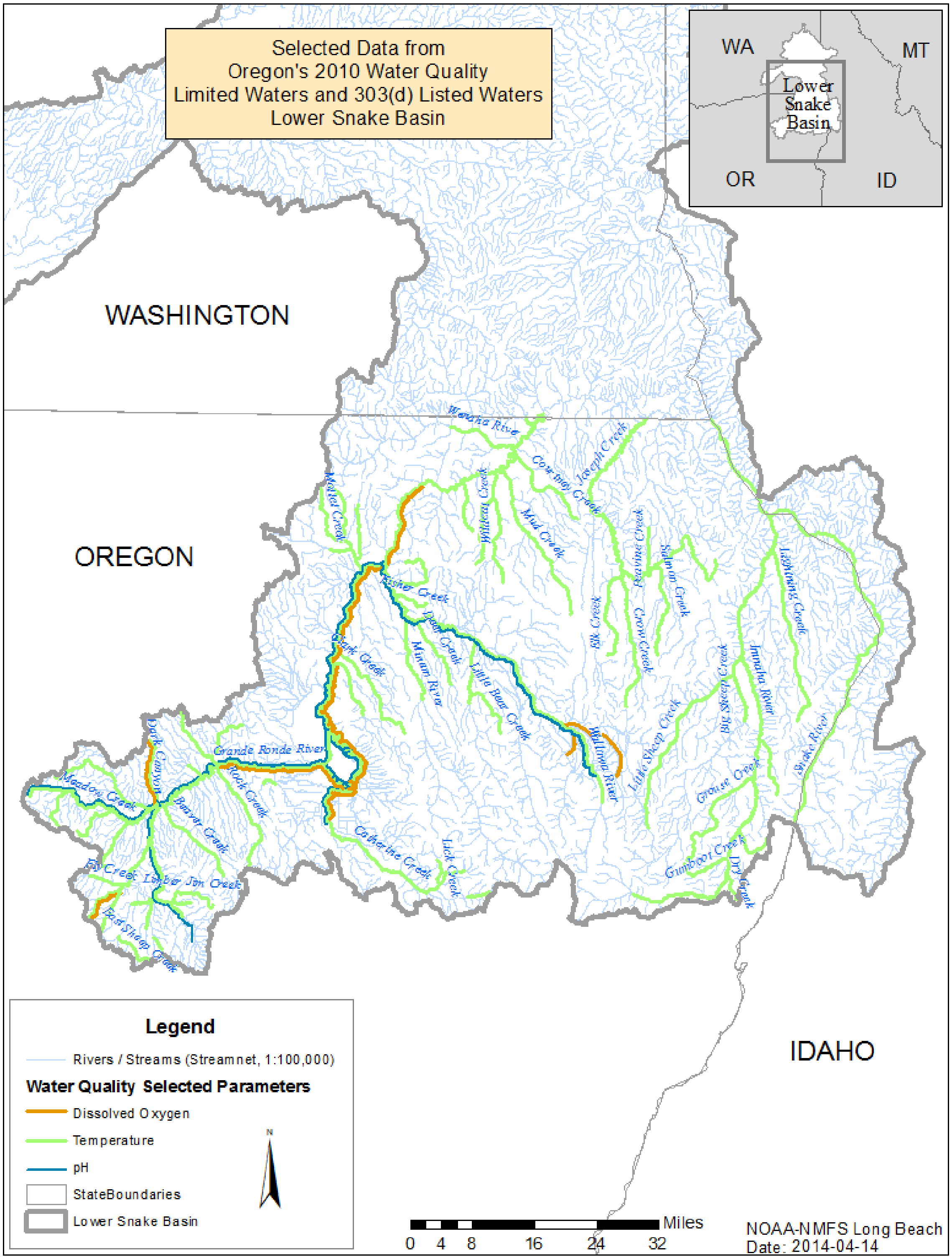

Figure 11. Water quality limited waters in Lower Snake Basin.

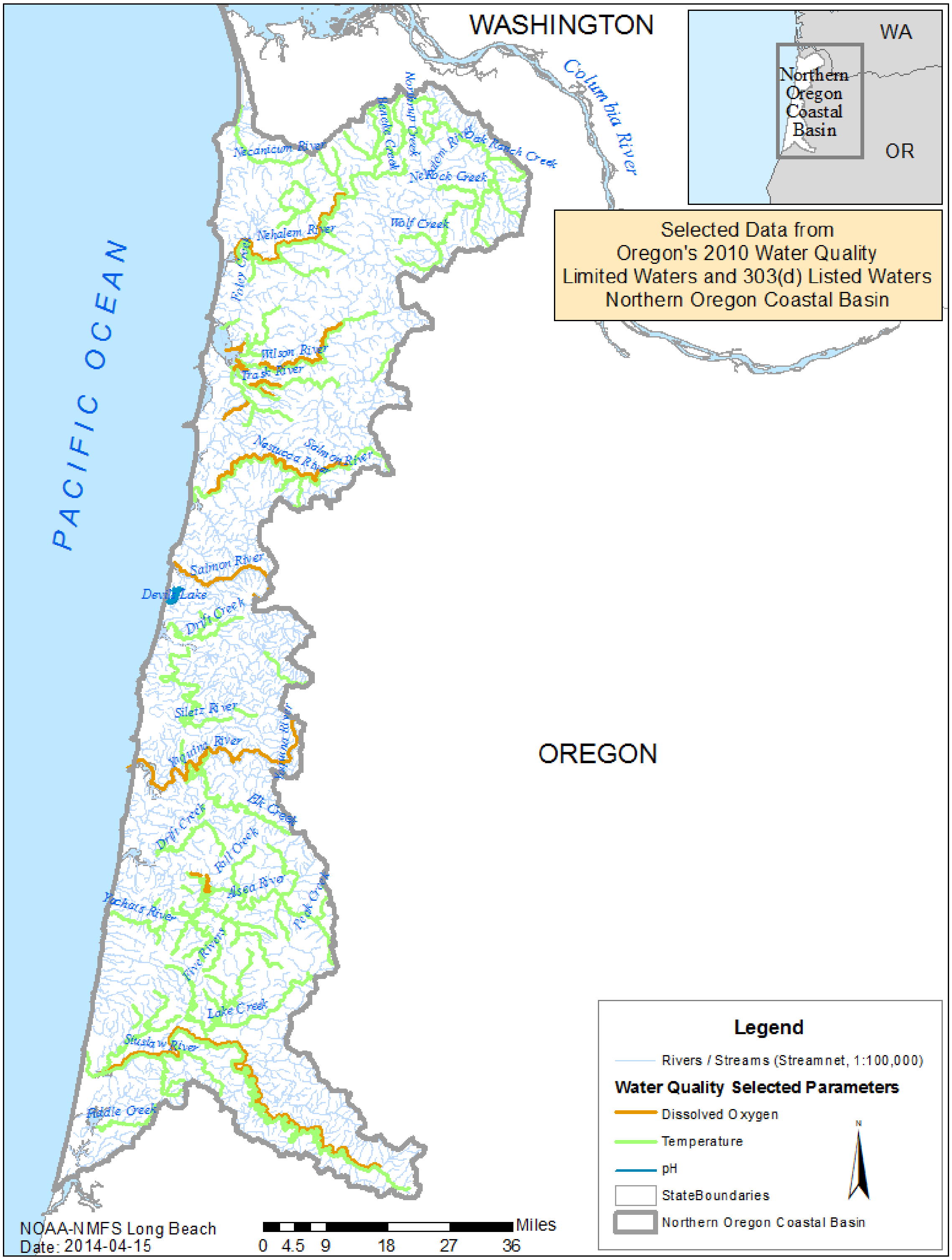

Figure 12. Water quality limited waters in Northern Oregon Coastal Basin.

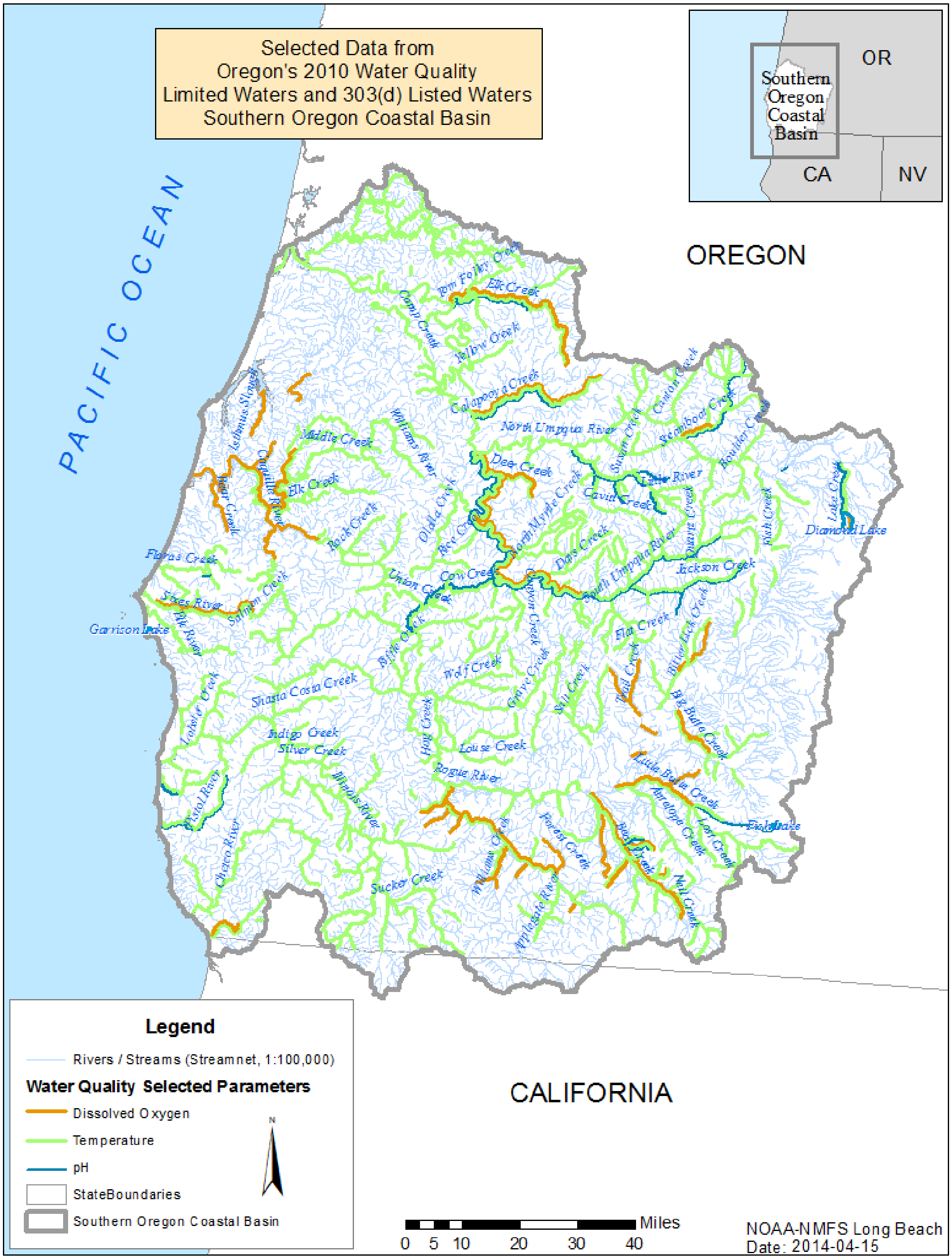

Figure 13. Water quality limited waters in Southern Oregon Coastal Basin.

Of note regarding the water quality environmental baseline, we consulted on the Environmental Protection Agency's proposed approval of certain Oregon administrative rules related to revised water quality criteria for toxic pollutants (NMFS 2012b). We concluded that the revised water quality criteria were likely to jeopardize LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, SONCC coho salmon, OC coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, green sturgeon, and eulachon.

2.3.2 General Environmental Baseline

Because the proposed action includes all fresh waters in Oregon with listed species, the action areas for all previously consulted-upon actions in these fresh waters overlap with the current action area. Impacts to the environmental baseline from these previous actions vary from adverse to beneficial.

Willamette-Lower Columbia Recovery Domain.

Land management activities have severely degraded stream habitat conditions in the Willamette River mainstem above Willamette Falls and in associated subbasins. The construction of 37 dams in the basin blocked access to more than 435 miles of stream and river spawning habitat. The dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally-spawned eggs and fry. The complexity of the mainstem river and extent of riparian forest have both been reduced by 80% (PNERC 2002). About 75% of what was formerly prairie and 60% of what was wetland have been converted to agricultural purposes. These actions, combined with urban development, bank stabilization, and in-river and nearshore gravel mining, have resulted in a loss of floodplain connectivity and off-channel habitat (PNERC 2002). Habitat loss has fragmented habitat and human density increase has created additional loads of pollutants and contaminants within the Columbia River estuary (Anderson *et al.* 2007).

The mainstem Willamette River has been channelized and stripped of large wood. Development began to encroach on the riparian forest beginning in the 1870s (Sedell and Froggatt 1984). The total area of river channels and islands in the Willamette River decreased from 41,000 to 23,000 acres, and the total length of all channels decreased from 355 miles to 264 miles, between 1895 and 1995 (Gregory *et al.* 2002a).

The banks of the Willamette River have more than 96 miles of revetments; approximately half were constructed by the USACE. Generally, the revetments were placed in the vicinity of roads or on the outside bank of river bends, so that while only 26% of the total length is revetted, 65% of the meander bends are revetted (Gregory *et al.* 2002b). The majority of dynamic sections have been armored, reducing adjustments in channel bed and sediment storage by the river, and thereby diminishing both the complexity and productivity of aquatic habitats (Gregory *et al.* 2002b).

Riparian forests have diminished considerably in the lower reaches of the Willamette River (Gregory *et al.* 2002c). Sedell and Froggatt (1984) noted that agriculture and cutting of streamside trees were major agents of change for riparian vegetation, along with snagging of large wood in the channel. The reduced shoreline, fewer and smaller snags, and reduced riparian forest comprise large functional losses to the river, reducing structural features, inputs of wood and litter, shade, entrained allochthonous materials, and flood flow filtering capacity. Extensive changes began before the major dams were built, with navigational and agricultural demands dominating the early use of the river. The once expansive forests of the Willamette River floodplain provided valuable nutrients and organic matter during flood pulses, food sources for macroinvertebrates, and slow-water refugia for fish during flood events. These forests also cooled river temperatures as the river flowed through its many channels.

Hyporheic flow in the Willamette River has been examined through discharge measurements and is significant in some areas, particularly those with gravel deposits (Wentz *et al.* 1998; Fernald *et al.* 2001). The loss of channel complexity and meandering that fosters creations of gravel deposits decreases the potential for hyporheic flows, as does gravel mining. Hyporheic flow processes water and affects its quality on reemerging into the main channel, stabilizing variations in physical and chemical water characteristics. Hyporheic flow is important for ecological functions, some aspects of water quality (such as temperature and dissolved oxygen), and some benthic invertebrate life stages. Alcove habitat, which has been limited by channelization, combines low hydraulic stress and high food availability with the potential for hyporheic flows across the steep hydraulic gradients in the gravel separating them from the main channel (Fernald *et al.* 2001).

On the mainstem of the Columbia River, hydropower projects, including the FCRPS, have significantly degraded salmon and steelhead habitats (Bottom *et al.* 2005; Fresh *et al.* 2005; NMFS 2011e; NMFS 2013a). The series of dams and reservoirs that make up the FCRPS block an estimated 12 million cubic yards of debris and sediment that would otherwise naturally flow down the Columbia River and replenish shorelines along the Washington and Oregon coasts.

Industrial harbor and port development are also significant influences on the Lower Willamette and Lower Columbia rivers (Bottom *et al.* 2005; Fresh *et al.* 2005; NMFS 2011e; NMFS 2013a). Since 1878, 100 miles of river channel within the mainstem Columbia River, its estuary, and Oregon’s Willamette River have been dredged as a navigation channel by the USACE. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the Lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The Lower Columbia River supports five ports on the Washington State side: Kalama, Longview, Skamania County, Woodland, and Vancouver. In addition to loss of riparian habitat, and disruption of benthic habitat due to dredging, high levels of several sediment chemicals, such as arsenic and polycyclic aromatic hydrocarbons (PAHs), have been identified in Lower Columbia River watersheds in the vicinity of the ports and associated industrial facilities.

The most extensive urban development in the Lower Columbia River subbasin has occurred in the Portland/Vancouver area. Outside of this major urban area, the majority of residences and businesses rely on septic systems. Common water quality issues with urban development and residential septic systems include higher water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff.

The Columbia River estuary has lost a significant amount of the tidal marsh and tidal swamp habitats that are critical to juvenile salmon and steelhead, particularly small or ocean-type species (Bottom *et al.* 2005; Fresh *et al.* 2005; NMFS 2011e; NMFS 2013a). Edges of marsh areas provide sheltered habitats for juvenile salmon and steelhead where food, in the form of amphipods or other small invertebrates which feed on marsh detritus, is plentiful, and larger predatory fish can be avoided. Historically, floodwaters of the Columbia River inundated the margins and floodplains along the estuary, allowing juvenile salmon and steelhead access to a wide expanse of low-velocity marshland and tidal channel habitats. In general, the riverbanks were gently sloping, with riparian and wetland vegetation at the higher elevations of the river floodplain becoming habitat for salmon and steelhead during flooding river discharges or flood tides. Sherwood *et al.* (1990) estimated that the Columbia River estuary lost 20,000 acres of tidal swamps, 10,000 acres of tidal marshes, and 3,000 acres of tidal flats between 1870 and 1970. This study further estimated an 80% reduction in emergent vegetation production and a 15% decline in benthic algal production.

Habitat and food-web changes within the estuary, and other factors affecting salmon population structure and life histories, have altered the estuary's capacity to support juvenile salmon (Bottom *et al.* 2005; Fresh *et al.* 2005; NMFS 2011e; NMFS 2013a). Diking and filling have reduced the tidal prism and eliminate emergent and forested wetlands and floodplain habitats. These changes have likely reduced the estuary's salmon-rearing capacity. Moreover, water and sediment in the Lower Columbia River and its tributaries have toxic contaminants that are harmful to aquatic resources (Lower Columbia River Estuary Partnership 2007). Contaminants of concern include dioxins and furans, heavy metals, polychlorinated biphenyls (PCBs) and organochlorine pesticides such as DDT. Simplification of the population structure and life-history diversity of salmon possibly is yet another important factor affecting juvenile salmon viability. Restoration of estuarine habitats, particularly diked emergent and forested wetlands, reduction of avian predation by terns, and flow manipulations to restore historical flow patterns have likely begun to enhance the estuary's productive capacity for salmon, although historical changes in population structure and salmon life histories may prevent salmon from making full use of the productive capacity of estuarine habitats.

Interior Columbia Recovery Domain.

Agriculture and Ranching. Roughly 6% of the annual flow from the Columbia River is diverted for the irrigation of 7.3 million acres of croplands within the basin. The vast majority of these agricultural lands are located along the lower Columbia River, the Willamette, Hood, and Snake rivers, and the Columbia Plateau (Hinck *et al.* 2004).

The USGS has a number of fixed water quality sampling sites throughout various tributaries of the Columbia River, many of which have been in place for decades. Water volumes, crop rotation patterns, crop type, and basin location are some of the variables that influence the distribution and frequency of pesticides within a tributary. Detection frequencies for a particular pesticide can vary widely. One study conducted between May 1999 and January 2000 detected

25 pesticide compounds (Ebbert and Embrey 2001). Another study detected at least two pesticides or their breakdown products in 91% of the samples collected, with the median number of chemicals being eight, and a maximum of 26. The herbicide 2,4-D occurred most often in the mixtures, along with azinphos-methyl, the most heavily applied pesticide, and atrazine, one of the most mobile aquatic pesticides (Fuhrer *et al.* 2004). In addition to current-use chemicals, these legacy chemicals continue to pose a serious problem to water quality and fish communities despite their ban in the 1970s and 1980s (Hinck *et al.* 2004).

Fish and macroinvertebrate communities exhibit an almost linear decline in condition as the level of agriculture intensity increases within a basin (Cuffney *et al.* 1997, Fuhrer *et al.* 2004). A study conducted in the late 1990s examined 11 species of fish, including anadromous and resident fish collected throughout the Columbia River basin for a suite of 132 contaminants. The study revealed PCBs, metals, chlorinated dioxins and furans (products of wood pulp bleaching operations) and other contaminants within fish tissues; white sturgeon tissues contained the greatest concentrations of chlorinated dioxins and furans (Hinck *et al.* 2004).

Habitat Modification

More than 400 dams exist in the basin, ranging from mega dams that store large amounts of water to small diversion dams for irrigation. Every major tributary of the Columbia River except the Salmon River is totally or partially regulated by dams and diversions. More than 55% of the Columbia River Basin that was accessible to salmon and steelhead before 1939 has been blocked by large dams (NWPPC 1986). More than 150 dams are major hydroelectric projects, with 18 dams located on mainstem Columbia River and its major tributary, the Snake River.

The development of hydropower and water storage projects within the Columbia River basin has resulted in the inundation of many mainstem spawning and shallow-water rearing areas, resulting in the loss of spawning gravels and reduced access to spawning and rearing areas. It has also changed the volume and timing of peak and low flows; increased mortality of migrating juvenile fish due to increased travel time, physical injury, increased predation and other factors; altered water temperature patterns); and altered food webs, including the type and availability of prey species (Ferguson *et al.* 2005; Williams *et al.* 2005).

Mining. Most of the mining in the basin is focused on minerals such as phosphate, limestone, dolomite, perlite, or metals such as gold, silver, copper, iron, and zinc. Many of the streams and river reaches in the basin are impaired from mining, and several abandoned, and former mining sites are designated as Superfund cleanup areas (Stanford *et al.* 2005). According to the United States Bureau of Mines, there are about 14,000 inactive or abandoned mines within the Columbia River Basin of which nearly 200 pose a potential hazard to the environment (Quigley *et al.* 1997). Contaminants detected in the water include lead and other trace metals. Mining of copper, cadmium, lead, manganese, and zinc in the upper Clark Fork River have contributed wastes to this basin since 1880 (Woodward *et al.* 1994). Benthic macroinvertebrates and fish within the basin have bioaccumulated metals, which are suspected of reducing their survival and growth (Farag *et al.* 1994, Woodward *et al.* 1994).

Habitat quality in tributary streams in the interior Columbia River subbasins varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994, Carmichael 2006).

Oregon Coast Recovery Domain.

Because the environmental baseline for this consultation includes all waters in the state with listed species, the information is the same as given for the designation-wide status of critical habitat in this domain in Section 2.2.3 (Status of the Critical Habitats – Fish).

Southern Oregon/Northern California Coast Recovery Domain.

Because the environmental baseline for this consultation includes all waters in the state with listed species, the information is the same as given for the designation-wide status of critical habitat in this domain in Section 2.2.3 (Status of the Critical Habitats – Fish).

Impacts from Prior ESA Section 7 Consultations.

The environmental baseline includes the anticipated impacts of all Federal actions in the action area that have already undergone formal consultation. Given that the action area for this consultation includes all waters in Oregon with listed species or critical habitat, consultations for which we have completed formal consultation (discussed below) are likely to have had effects within the action area for EPA's current proposed action. Impacts to the environmental baseline from these previous actions include a wide range of short and long-term effects that range from adverse to beneficial.

From 2001 through 2011, the U.S. Army Corps of Engineers (hereafter, "Corps") authorized approximately 428 transportation projects and 132 restoration actions in Oregon under programmatic consultations. The U.S. Bureau of Indian Affairs, U.S. Bureau of Land Management, and the U.S. Forest Service have consulted on Federal land management actions throughout Oregon, including restoration actions, forest management, livestock grazing, and special use permits. The Bonneville Power Administration (hereafter, "BPA"), NOAA Restoration Center, and USFWS have also consulted on large restoration programs that consist of actions designed to address species limiting factors or make contributions that would aid in species recovery. The Corps, BPA, and Bureau of Reclamation (hereafter, "BOR") have consulted on large water management actions, such as operation of the Federal Columbia River Power System, the Willamette River Basin Flood Control Project, the Umatilla Basin Project, and the Deschutes Project. Consultations completed from 1995 through 2012 that overlap with the action area for EPA's current proposed action for which we concluded that the proposed action would jeopardize the ESA-listed species and/or destroy or adversely modify designated critical habitat are listed in Table 29). All of these consultations included reasonable and prudent alternatives that could be taken to avoid jeopardy to the listed species and/or adverse modification of critical habitat.

Table 29. Jeopardy and/or adverse modification consultations completed in Oregon from 1995 through 2012. Source: NMFS Public Consultation Tracking System.

Action Title	Consultation Number	Issuance Date	Conclusion
Reinitiation of consultation on 1994-1998 Operation of the Federal Columbia River Power System (FCRPS) and Juvenile Transportation Program in 1995 and Future Years (BOR)	NWR-1994-93	1995-03-02	Jeopardy & Adverse Modification
Reinitiation of consultation on 1994-1998 Operation of the Federal Columbia River Power System (FCRPS) and Juvenile Transportation Program in 1995 and Future Years (Corps)	NWR-1994-92	1995-03-02	Jeopardy & Adverse Modification
Reinitiation of consultation on 1994-1998 Operation of the Federal Columbia River Power System (FCRPS) and Juvenile Transportation Program in 1995 and Future Years (BPA)	NWR-1994-91	1995-03-02	Jeopardy & Adverse Modification
Inland Land Inc. Pumping Facility on the Columbia River	NWR-1996-130	1997-05-16	Jeopardy & Adverse Modification
Proposed Milltown Hill Dam, Umpqua River	NWR-1996-131	1997-12-18	Jeopardy & Adverse Modification
Stewart Mining Operation affecting Umpqua River cutthroat trout, City Creek Drainage, Steamboat Creek Watershed, Umpqua National Forest	NWR-1997-1308	1998-08-19	Jeopardy & Adverse Modification
Coos Bay North Bend Water Board Water Supply Expansion Project, Upper Pony Creek Dam and Joe Ney Reservoir	NWR-1999-33	1999-12-14	Jeopardy & Adverse Modification
Operation of the Federal Columbia River Power System (FCRPS) Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, For the Same Projects (Corps)	NWR-1999-884	2000-02-04	Jeopardy & Adverse Modification
Operation of the Federal Columbia River Power System (FCRPS) Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, For the Same Projects (BOR)	NWR-1999-1911	2000-02-04	Jeopardy & Adverse Modification
Operation of the Federal Columbia River Power System (FCRPS) Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, For the Same Projects (BPA)	NWR-1999-1910	2000-02-04	Jeopardy & Adverse Modification
Treaty Indian and Non-Indian Year 2000 Winter, Spring, and Summer Season Fisheries	NWR-2000-356	2000-02-29	Jeopardy, No Adverse Modification
Impacts of Treaty Indian and Non-Indian Fisheries in the Snake River Basin in 2000	NWR-2000-911	2000-06-30	Jeopardy, No Adverse Modification
Reinitiation of Operation of the Federal Columbia River Power System (FCRPS), Including the Juvenile Fish Transportation System, and 19 Bureau of Reclamation Projects in the Columbia Basin (BPA)	NWR-1999-1909	2000-12-21	Jeopardy & Adverse Modification

Action Title	Consultation Number	Issuance Date	Conclusion
Reinitiation of Operation of the Federal Columbia River Power System (FCRPS), Including the Juvenile Fish Transportation System, and 19 Bureau of Reclamation Projects in the Columbia Basin (BOR)	NWR-1999-1902	2000-12-21	Jeopardy & Adverse Modification
Reinitiation of Operation of the Federal Columbia River Power System (FCRPS), Including the Juvenile Fish Transportation System, and 19 Bureau of Reclamation Projects in the Columbia Basin (Corps)	NWR-1999-1901	2000-12-21	Jeopardy & Adverse Modification
Impacts of Treaty Indian and Non-Indian Fisheries in the Snake River Basin in Year 2001 on Listed Salmon	NWR-2001-830	2001-07-03	Jeopardy, No Adverse Modification
LTM, Inc. Instream Sand and Gravel Mining Project, Umpqua River, Douglas County	NWR-2003-1665	2004-08-06	Jeopardy & Adverse Modification
K-D Sand and Gravel, Gravel Removal Project, Willamette River, Polk County	NWR-2001-932	2005-08-23	Jeopardy & Adverse Modification
Remand of 2004 Biological Opinion on the Federal Columbia River Power System (FCRPS) including 19 Bureau of Reclamation Projects in the Columbia Basin (Revised pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)	NWR-2005-5883	2008-05-05	Jeopardy & Adverse Modification
Continued Operation of 13 Dams & Maintenance of 43 Miles of Revetments in the Willamette Basin, OR	NWR-2000-2117	2008-07-11	Jeopardy & Adverse Modification
Pesticide Use of Chlorpyrifos	FPR-2003-428	2008-11-18	Jeopardy & Adverse Modification
Pesticide Use of Malathion	FPR-2002-2724	2008-11-18	Jeopardy & Adverse Modification
Pesticide Use of Diazinon	FPR-2002-1905	2008-11-18	Jeopardy & Adverse Modification
Pesticide use of carbofuran	FPR-2004-2637	2009-04-20	Jeopardy & Adverse Modification
Pesticide Use of Methomyl	FPR-2003-430	2009-04-20	Jeopardy & Adverse Modification
Pesticide use of carbaryl	FPR-2003-2430	2009-04-20	Jeopardy & Adverse Modification
Pesticide use of Phorate	FPR-2004-2643	2010-08-31	Jeopardy & Adverse Modification

Action Title	Consultation Number	Issuance Date	Conclusion
Pesticide Use of Methidathion	FPR-2004-2641	2010-08-31	Jeopardy & Adverse Modification
Pesticide Use of Dimethoate	FPR-2004-2639	2010-08-31	Jeopardy & Adverse Modification
Pesticide use of Phosmet	FPR-2003-2436	2010-08-31	Jeopardy & Adverse Modification
Pesticide Use of Naled	FPR-2003-2435	2010-08-31	Jeopardy & Adverse Modification
Pesticide Use of Fenamiphos	FPR-2003-2434	2010-08-31	Jeopardy & Adverse Modification
Pesticide Use of Ethoprop	FPR-2003-2433	2010-08-31	Jeopardy & Adverse Modification
Pesticide Use of Disulfoton	FPR-2003-2432	2010-08-31	Jeopardy & Adverse Modification
Environmental Protection Agency's Registration of Oryzalin	FPR-2003-427	2012-05-31	Jeopardy & Adverse Modification
Biological Opinion for the Environmental Protection Agency's Proposed Approval of Certain Oregon Administrative Rules Related to Revised Water Quality for Toxic Pollutants	NWR-2008-148	2012-08-14	Jeopardy & Adverse Modification

2.3.3 Marine Mammal Environmental Baseline

Prey Availability. Based on persuasive scientific information that the diet of Southern Residents is predominantly composed of Chinook salmon in inland waters (see further discussion above), their diet may equally be predominantly composed of Chinook salmon when available in the action area. As mentioned above, when prey is scarce the whales likely spend more time foraging than when it is plentiful. Ford *et al.* reported correlated declines in both the Southern Resident killer whales and Chinook salmon and suggested the potential for nutritional stress in the whales (Ford *et al.* 2005, Ford *et al.* 2010b). Food scarcity could also cause whales to draw on fat stores, mobilizing contaminants stored in their fat and potentially have the ability to alter thyroid homeostasis, reduce immune function, cause neurotoxicity, reproductive failure, and restrict the development and growth of the individual (see Table 9 in NMFS 2008a for a review of physiological effects resulting from exposure to toxic chemicals in marine mammals). Thus, nutritional stress may act synergistically with high contaminant burdens in the whales and result in contaminant-induced adverse health effects, higher mortality rates, or lower birth rates.

The availability of Chinook salmon to Southern Residents is affected by a number of natural and human actions. Climate effects from Pacific decadal oscillation and the El Nino/Southern oscillation conditions and events cause changes in ocean productivity which can affect natural mortality of salmon. Predation in the ocean also contributes to natural mortality of salmon. Salmonid fishes are prey for pelagic fishes, birds, and marine mammals (including Southern Residents). Human activities with impacts to salmon include logging, agriculture, ranching, hydroelectric power generation, mining, fishing, recreational activities, and urban uses. Many of these activities have a Federal nexus and have undergone section 7 consultation. Those actions have all met the standard of not jeopardizing the continued existence of the listed salmonid fishes or adversely modifying their critical habitat, or if they did not meet that standard, we identified reasonable and prudent alternatives. Since the Southern Residents were listed, Federal agencies have also consulted on impacts to the whales, including impacts to available prey. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of Chinook ESUs contemplated in this consultation. Here we provide a review of Southern Resident killer whale determinations in previous ESA Section 7(a)(2) consultations where effects occurred in the action area, and where effects resulted in a significant reduction in available prey (*i.e.*, where prey reduction was likely to adversely affect or jeopardize the continued existence of the whales).

We consulted on the Environmental Protection Agency's proposed approval of certain Oregon administrative rules related to revised water quality criteria for toxic pollutants (NMFS 2012b). We concluded that the revised water quality criteria were likely to jeopardize LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, SONCC coho salmon, OC coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, green sturgeon, and eulachon. NMFS characterized the short-term and long-term effects on Southern Residents from prey reduction caused by the revised water quality criteria, as well as the reduced prey quality and potential toxic chemical accumulation in the whales. We concluded that the revised water quality criteria were likely to jeopardize the Southern Resident killer whales.

We also consulted on the effects of fishery harvest actions on Southern Residents, including 10-year terms of the Pacific Salmon Treaty (term of biological opinion from 2009-2018, NMFS 2008e) and the *United States v. Oregon* 2008 Management Agreement (term of biological opinion from 2008-2017; NMFS 2008f), and the Pacific Coast Salmon Plan fisheries (NMFS 2009b). In these past harvest opinions, we characterized the short-term and long-term effects on Southern Residents from prey reduction caused by harvest. We considered the short-term effects on whales resulting from reductions in Chinook salmon abundance that occur during a specified year, and the long-term effects on whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn. These past analyses suggested that in the short term prey reductions were small relative to remaining prey available to the whales. In the long term, harvest actions have met the conservation objectives of harvested stocks, were not likely to appreciably reduce the survival or recovery of listed Chinook salmon, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon. The harvest biological opinions referenced above concluded that the harvest actions cause prey reductions in a given year, but were not likely to jeopardize the continued existence of listed Chinook salmon or Southern Residents. Following a more recent harvest biological opinion (NMFS 2011f), we implemented conservation measures that included convening an independent panel to critically evaluate the available scientific information about Southern Residents, their feeding habits, and the potential effects of salmon fisheries on the abundance of Chinook salmon available to Southern Residents. Overall, the panel concluded that the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to Southern Residents is not clear, and cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn *et al.* 2012). We are considering the independent science panel's review (Hilborn *et al.* 2012) and a related comprehensive analysis by Ward *et al.* (2013) to develop a risk assessment framework to support future consultations that evaluate the effects of changes in Chinook salmon abundance on Southern Resident killer whales, including future harvest consultations.

We also consulted on the effects of the long-term operations of the Central Valley Project (CVP) and State Water Project (SWP) (2008/09022). We concluded that the proposed long-term operations of the CVP and SWP were likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, green sturgeon, and Southern Resident killer whales. We found that the increased risk of extinction of the winter- and spring-run Chinook salmon as a long-term consequence of the proposed action diminished the potential for Southern Residents to survive and recover.

We conducted additional consultations on the effects of hydro-power dams and flood control programs on Southern Residents (NMFS 2008g, NMFS 2008h). As part of the proposed action for the FCRPS and the Willamette Flood Control Program, the action agencies proposed funding hatchery programs in addition to their proposals for dam operations and maintenance. For both programs, the proposed actions did not result in a net decrease in Chinook salmon prey for Southern Residents in the short term. To mitigate for the harmful effects of hatchery production on long-term Chinook salmon viability (and thus killer whale prey availability) the action agencies committed to a schedule of future hatchery reforms. Thus, the reasonable and prudent alternative (RPAs) and proposed actions combined were determined not likely to adversely affect the killer whales.

Quality of Prey. As introduced in the above sections, contaminants enter marine waters from numerous sources throughout the action area, but are typically concentrated near populated areas of high human activity and industrialization. The majority of growth in salmon occurs while feeding in saltwater (Quinn 2005). Therefore, the majority (> 96%) of persistent pollutants in adult salmon are accumulated while feeding in the marine environment (Cullon *et al.* 2009, O'Neill and West 2009). Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by the whales in marine waters. Only limited information is available for contaminant levels of Chinook salmon in Oregon rivers; however, in general Chinook salmon contain higher levels of some contaminants than other salmon species (see Table 21). As discussed in the Status of the Species, the marine distribution is an important factor affecting pollutant accumulation as is evident across the different salmon populations. For example, Chinook populations feeding in close proximity to land-based sources of contaminants have higher concentrations (O'Neill *et al.* 2006).

Vessel Activity and Sound. Commercial, military, recreational and fishing vessels traverse the coastal range of Southern Residents. Vessels may affect foraging efficiency, communication, and/or energy expenditure by their physical presence and by creating underwater sound (Williams *et al.* 2006b, Holt 2008, Holt *et al.* 2011). Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality. Large ships that traverse coastal waters of the whales' range move at relatively slow speeds and likely are detected and avoided by Southern Residents.

Vessel sounds in coastal waters are most likely from large ships, tankers and tugs. Sound generated by large vessels is a source of low frequency (5 to 500 Hz) human-generated sound in the world's oceans (NRC 2003). While larger ships generate some broadband noise in the hearing range of whales, the majority of energy is below their peak hearing sensitivity. At close range large vessels can still be a significant source of background noise at frequencies important to the whales (Holt 2008). Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (NRC 2003). Frequencies fall between 1 and 500 kHz, which is within the hearing range of some marine mammals, including killer whales, and may have masking effects.

Non-Vessel Sound. Anthropogenic (human-generated) sound in the range of Southern Residents is generated by other sources besides vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (*e.g.*, hearing, echolocation, communication).
In-water construction activities are permitted by the Corps under section 404 of the CWA and section 10 of the Rivers and Harbors Act of 1899. Consultations on these permits have been conducted and conservation measures have been included to minimize or eliminate potential effects of in-water activities, such as pile driving, on marine mammals. Military sonar also has the potential to disturb killer whales.

Oil Spills. Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, at refineries and associated production facilities, and pipelines. The magnitude of risk posed by oil discharges in the action area is difficult to precisely quantify, but improvements in oil spill prevention procedures since the 1980s likely provide some reduced risk of spill. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, neurological damage (Geraci and St. Aubin 1990), potentially death, and long-term effects on population viability (Matkin *et al.* 2008). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Scientific Research. Although research activities are typically conducted between May and October in inland waters, some permits include authorization to conduct research in coastal waters. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. In 2006, NMFS issued scientific research permits to seven investigators who studied Southern Residents (NMFS 2006). Additionally in 2008, NMFS issued another scientific permit to one investigator intending to study Southern Residents (NMFS 2008i). In the biological opinions NMFS prepared to assess the impact of issuing the permits, we determined that the effects of these disturbances on Southern Residents were likely to adversely affect, but not likely to jeopardize the continued existence of, the Southern Residents (NMFS 2006, 2008i). A small portion of the authorized take would occur in the coastal range of Southern Residents. In 2012, NMFS issued several permits to characterize the population size, structure, ecology, behavior, movement patterns and habitat use of the Southern Residents (NMFS 2012c, 2013).

Summary of Environmental Baseline for Southern Residents. Southern Residents are exposed to a wide variety of past and present state, Federal or private actions and other human activities in the coastal waters that comprise the action area, as well as Federal projects in this area that have already undergone formal section 7 consultation, and state or private actions that are contemporaneous with this consultation. All of the activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in the action area.

No single threat has been directly linked to or identified as the cause of the recent decline of the Southern Residents, although the three primary threats are identified as prey availability, environmental contaminants, and vessel effects and sound (Krahn *et al.* 2002). Researchers are unsure about which threats are most significant. There is limited information on how these factors or additional unknown factors may be affecting Southern Residents when in coastal waters. For reasons discussed earlier, it is possible that two or more of these factors may act together to harm the whales. The small size of the population increases the level of concern about all of these risks (NMFS 2008a).

2.4 Effects of the Action on Species and Designated Critical Habitat

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur.

Relevance of WQS to Water Quality - General

As stated earlier, the EPA proposes to approve a combination of definitions, numeric criteria, narrative criteria, and beneficial use designations that are part of Oregon's WQS. According to EPA's Water Quality Standards Handbook (hereafter, "Handbook"), once states and authorized tribes have established appropriate WQS, they implement source control actions to manage pollutant loadings.[13] Such actions can be implemented for impaired waters before or after development of a TMDL. Generally, states, tribes, and the EPA regulate point sources through the NPDES permitting program. Federal, state and local government agencies, private land managers, and landowners manage nonpoint sources through state and tribal laws and local ordinances. States and tribes may also use the CWA section 401 certification process to ensure that Federal permits and licenses are adequate to maintain state and tribal WQS.

According to the Handbook, in accordance with 40 CFR 122.1(b), the NPDES program generally requires permits for the discharge of pollutants from any point source into waters of the United States. An NPDES permit is a license for a facility to discharge a specified amount of a pollutant into a receiving waterbody under certain conditions. An NPDES permit provides the following two types of control:

- Technology-based effluent limits based on the pollutant reductions in effluents that can be achieved through application of specified levels of technology controls, taking into account the technological and economic ability of dischargers to control the discharge of pollutants in wastewater.
- Water-quality based effluent limits (WQBELs) established to meet the WQS that protect the quality of the specific waterbody receiving the discharge.

By analyzing the effect of a discharge on the receiving waterbody, a permit writer could find that technology-based effluent limits alone will not achieve the applicable WQS. In such cases, Section 301(b)(1)(C) of the CWA and 40 CFR 122.44(d) require development of WQBELs. WQBELs must derive from and comply with all applicable WQS and be consistent with the assumptions and requirements of any available wasteload allocation (*e.g.*, a TMDL wasteload allocation).

WQBELs establish the level of effluent quality necessary to protect water quality in the receiving waterbody in order to ensure attainment of WQS. Allowable loadings are often developed as allowable wasteload allocations (WLA) for specific point sources of pollutants, and WQBELs then are derived from these wasteload allocations and incorporated into NPDES permits. WQBELs may be determined from a TMDL's wasteload allocation or calculated for an individual point source directly from the applicable WQS. Wasteload allocations and WQBELs are both designed to prevent exceedances of WQS. Therefore, WQS are an important means to maintain water quality through the NPDES program.

<u>Relevance of WQS - Post-TMDL</u>

According to EPA's Handbook, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive while still meeting its applicable WQS. Pollutant loadings above this amount generally will result in the waterbody not attaining WQS. In many cases, the TMDL analysis is the trigger for determining the source(s) of pollutants. TMDLs quantify pollutant sources and allocate allowable pollutant loads to contributing point sources through wasteload allocations and nonpoint sources through load allocations, which may include both anthropogenic and natural background sources of a pollutant. The DEQ has completed

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[13] Available at http://water.epa.gov/scitech/swguidance/standards/handbook/ (accessed April 23, 2015).

temperature TMDLs for many river basins that are important to listed species (*e.g.*, Lower Columbia River, Snake River – Hells Canyon, Willamette River, John Day River, Upper and Lower Grande Ronde Rivers, Umpqua River).

One could ask if the components of WQS such as numeric and narrative criteria are still important once a TMDL has been completed. According to DEQ,[14] when an NPDES permit is issued, the permit writer must calculate reasonable potential and effluent limits based on the TMDL WLA *and* the effective standard at the time of permit renewal. The permit must be written based on whichever of those is more stringent. If the WQS is revised, effluent limits may or may not become more stringent depending on the WLA, the revisions to the standards, and quality of the effluent. According to EPA, this approach is consistent with the CWA at 40 CFR 122.44(d)(1)(vii).[15]

If a WQS changes after a TMDL is completed, nonpoint sources must continue to implement their load allocations under an existing TMDL until such time as the TMDL is revised and new load allocations are assigned. A new, more stringent standard would create some direct new NPS obligations for certain Federal agencies, and some indirect new obligations for Oregon Department of Forestry and Oregon Department of Agriculture, since their programs reference compliance with WQSs.[16]

A revision to a WQS also could affect the list of impaired water bodies maintained by DEQ under section 303(d) of the CWA. Again according to DEQ, for temperature, water bodies are assessed based on the biologically-based numeric criteria in the temperature standard. If the WQS was to change enough that DEQ no longer expected the TMDL load and wasteload allocations and water quality management plans to result in attainment of the new standard, the water body would be re-listed as category 5 (*i.e.*, impaired and in need of a TMDL). However, if the allocations and water quality management plans were resulting in progress toward attaining the new standard, the water body could be left in category 4a (*i.e.*, impaired with a TMDL approved by EPA in place), and any adjustments needed would be made when the TMDL is updated. Also, although a change in the WQS in a given river basin would not require an existing TMDL be redone sooner, DEQ may identify it as a higher priority.[17] Some of the factors related to redoing a temperature TMDL when a new standard is in place are the content of the new

[14] April 23, 2015 email from Debra Sturdevant, DEQ, to Jeff Lockwood, NMFS, regarding "new questions for water quality consultation."

[15] April 24, 2015 email from Rochelle Labiosa, EPA, to Jeff Lockwood, NMFS regarding "permit reg − re: new questions for water quality consultation."

[16] April 23, 2015 email from Debra Sturdevant, DEQ, to Jeff Lockwood, NMFS, regarding "new questions for water quality consultation."

[17] Category 5 means that "Available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed." Category 4a means that "A state developed TMDL has been approved by EPA or a TMDL has been established by EPA for any segment-pollutant combination." Source: http://water.epa.gov/scitech/swguidance/standards/handbook/ (accessed April 23, 2015).

standard, the workload associated with redoing the TMDLs, technical ability and data associated with redoing the TMDL, potential environmental benefit, and consideration of other workload.[18]

2.4.1 Effects of the Action on ESA-listed Fish

Definitions, OAR 340-041-0002

The EPA proposes to approve the following indented and numbered definitions shown below, which are a subset of the definitions found in the temperature standard:

> (2) "Ambient Stream Temperature" means the stream temperature measured at a specific time and place. The selected location for measuring stream temperature must be representative of the stream in the vicinity of the point being measured.
>
> (4) "Applicable Criteria" means the biologically-based temperature criteria set out in OAR 340-041-0028(4), the superseding cold water protection criteria as described in OAR 340-041-0028(12), or the superseding natural condition criteria as described in OAR 340-041-0028(8). In addition, the applicable criteria may also be site-specific criteria approved by USEPA. A subbasin may have a combination of applicable temperature criteria derived from some or all of these numeric and narrative criteria.
>
> (7) "Basin" means a third field hydrologic unit as identified by the U.S. Geological Survey.
>
> (9) "Cold-Water Aquatic Life" means aquatic organisms that are physiologically restricted to cold water, including but not limited to native salmon, steelhead, mountain whitefish, char (including bull trout), and trout.
>
> (10) "Cold Water Refugia" means those portions of a water body where, or times during the diel temperature cycle when, the water temperature is at least 2°C colder than the daily maximum temperature of the adjacent well mixed flow of the water body.
>
> (12) "Cool-Water Aquatic Life" means aquatic organisms that are physiologically restricted to cool waters, including but not limited to native sturgeon, pacific lamprey, suckers, chub, sculpins and certain species of cyprinids (minnows).
>
> (13) "Core Cold Water Habitat Use" means waters that are expected to maintain temperatures within the range generally considered optimal for salmon and steelhead rearing, or that are suitable for bull trout migration, foraging and sub-adult rearing that occurs during the summer. These uses are designated on the following subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A.

[18] April 23, 2015 email from Jennifer Wu, EPA, to Jeff Lockwood, NMFS, regarding "new questions for water quality consultation."

(14) “Critical Habitat” means those areas that support rare, threatened or endangered species, or serve as sensitive spawning and rearing areas for aquatic life as designated by the U.S. Fish and Wildlife Service or NOAA Fisheries pursuant to the Endangered Species Act (16 USC 1531).

(31) “Migration Corridors” mean those waters that are predominantly used for salmon and steelhead migration during the summer, and where there is little or no anadromous salmonid rearing occurring in the months of July and August. These uses are designated on the following subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Tables 101B, and 121B, and Figures 151A, 170A, and 340A.

(34) “Natural Conditions” means conditions or circumstances affecting the physical, chemical, or biological integrity of a water of the State that are not influenced by past or present anthropogenic activities. Disturbances from wildfire, floods, earthquakes, volcanic or geothermal activity, wind, insect infestation, diseased vegetation are considered natural conditions.

(35) “Natural Thermal Potential” means the determination of the thermal profile of a water body using best available methods of analysis and the best available information on the site potential riparian vegetation, stream geomorphology, stream flows and other measures to reflect natural conditions.

(36) “Nonpoint Sources” means any source of water pollution other than a point source. Generally, a nonpoint source is a diffuse or unconfined source of pollution where wastes can either enter into, or be conveyed by the movement of water, to waters of the State.

(40) “Point Source” means a discernable, confined and discrete conveyance, including but not limited to a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft, or leachate collection system, from which pollutants are or may be discharged. Point source does not include agricultural storm water discharges and return flows from irrigated agriculture.

(46) “Salmon and Steelhead Spawning Use” means waters that are or could be used for salmon and steelhead spawning, egg incubation and fry emergence. These uses are designated on the following subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Tables 101B, and 121B, and Figures 130B, 151B, 160B, 170B, 220B, 230B, 271B, 286B, 300B, 310B, 320B, and 340B.

(47) “Salmon and Trout Rearing and Migration Use” means thermally suitable rearing habitat for salmon and steelhead, rainbow and cutthroat trout as designated on subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A.

(48) “Salmonid or Salmonids” means native salmon, trout, mountain whitefish and char (including bull trout). For purposes of Oregon water quality standards, salmonid does not include brook or brown trout since they are introduced species.

(50) “Seven-Day Average Maximum Temperature" means a calculation of the average of the daily maximum temperatures from seven consecutive days, made on a rolling basis.

(56) “Subbasin” means a fourth field hydrologic unit as identified by the U.S. Geological Survey.

(57) “Summer” means June 1 through September 30 of each calendar year.

(58) “Threatened or Endangered Species” means aquatic species listed as either threatened or endangered under the federal Endangered Species Act (16 USC 1531 et seq. and Title 50 of the Code of Federal Regulations).

The EPA determined that approval of these definitions in isolation will have no effect on listed species or critical habitat. The EPA analyzed the effects of the definitions as part of the effects of the rule provisions to which they apply. We will do the same below.

IGDO subsection OAR 340-041-0016(1)(c) of dissolved oxygen, OAR 340-041-0016

The EPA proposes to approve subsection OAR 340-041-0016(1)(c), which consists of the following criterion:

(1) For water bodies identified as active spawning areas in the places and times indicated on the following Tables and Figures set out in OAR 340-041-0101 to 340-041-0340: Tables 101B, 121B, and 190B, and Figures 130B, 151B, 160B, 170B, 180A, 201A, 220B, 230B, 260A, 271B, 286B, 300B, 310B, 320B, and 340B,19 (as well as any active spawning area used by resident trout species), the following criteria apply during the applicable spawning through fry emergence periods set forth in the tables and figures and, where resident trout spawning occurs, during the time trout spawning through fry emergence occurs:

The spatial median intergravel dissolved oxygen concentration must not fall below 8.0 mg/L.

Analysis of IGDO Subsection

The early life stages of fish require relatively high concentrations of dissolved oxygen (DO). DO measured within gravel beds is called intergravel DO (IGDO). The purpose of the IGDO criterion is to protect salmonid embryos and alevins in redds within spawning gravel from low IGDO.

[19] These tables and figures are available at http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t2 (accessed July 23, 2014) and are incorporated herein by reference.

The DO demand of embryos increases as temperature increases and as developmental stages progress, with the greatest demand just before hatching (Rombough 1986). At 15°C, the critical level of IGDO (where ambient levels meet metabolic needs) for steelhead increases from 1.0 mg L^{-1} shortly after fertilization to >9.7 mg L^{-1} before hatching.

Alevin size at emergence is correlated with IGDO concentration in some species of salmonid fishes such as rainbow trout (*Salmo gairdneri*) (Turnpenny and Williams 1980). Steelhead are the anadromous form of rainbow trout. Growth in length of brown trout (*S. trutta*, a non-anadromous species of salmonid fish with generally similar biological requirements as the freshwater life stages of salmon and steelhead) alevins was less at IGDO concentrations of 6 to 7 mg L^{-1} than at IGDO concentrations of 9 to 10 mg L^{-1} (Maret *et al.* 1993). Sockeye salmon alevins raised at low DO concentrations were smaller; however, the fish eventually reached nearly the same weight as fish incubated at higher DO concentrations (Brannon 1965).

Water temperature appears to affect how well the early life stages of fall Chinook salmon tolerate low IGDO. Geist *et al.* (2006) studied in a laboratory how water temperatures from 13.8 to 17.8°C and water column DO concentrations from 4 to more than 8 mg O_2 L^{-1} during the first 40 days of incubation followed by declining temperature and rising DO affected survival, development, and growth of Snake River fall Chinook salmon embryos, alevins, and fry. Although the authors did not measure IGDO directly, it could not have been higher than the water column DO, and may have been lower based on the common loss of up to 3 mg O_2 L^{-1} from the water column to the gravel when fine sediment in the gravel is high in abundance (DEQ 1995). During the first 40 days of incubation, temperatures were adjusted downward approximately 0.28°C day^{-1} and oxygen was increased in increments of 2 mg O_2 L^{-1} to mimic the thermal and oxygen regime of the Snake River. At 40 days post-fertilization, embryos were moved to a common exposure regime that followed the thermal and DO profile of the Snake River through emergence. Initial DO as low as 4 mg O_2 L^{-1} over a range of initial temperatures from 15.8° C to 16.5° C did not affect embryo survival to emergence, although the rate of abnormalities in the fish increased (with nearly twice as many abnormalities at the lowest DO). These abnormal fish likely would not have survived in the wild. Geist *et al.* (2006) concluded that the declining temperatures over time in their study protected the fish from increased rates of death due to low DO, although they also state that survival may have been boosted relative to the wild by holding pre-spawn adults at a constant water temperature of 12° C, which is colder than the river during spawning. There were no significant differences in alevin and fry size at hatch and emergence across the range of initial temperature exposures. However, the number of days from fertilization to eyed egg, hatch, and emergence was highly related to temperature and DO; fish required from 6 to 10 days longer to hatch at 4 mg O_2 L^{-1} than at DO saturation[20]. Based on studies with coho salmon, late-emerging alevins and small-sized fry are poor competitors and face almost certain death from predation, disease, starvation, or a combination of these (Mason 1969, Chapman and McLeod 1987).

Intergravel water velocity in redd and IGDO concentrations appear to be closely related (Coble 1961), making it difficult to separate the influence of these two variables on observed survival (DEQ 1995). The effect of water velocity on developing embryos can be attributed to its role in

[20] Saturation is the maximum amount of dissolved oxygen that water can hold at a given water temperature; it decreases as water temperature increases.

transferring sufficient amounts of DO to the surface of the egg membrane and removing waste products (Brannon 1965). A field study of rainbow trout embryos indicated 50% embryo survival at an IGDO concentration of 8 mg L^{-1} and intergravel seepage velocities exceeding 100 cm hr^{-1} (Sowden and Power 1985). Survival was negligible at intergravel water velocities below 20 cm hr^{-1}.

A study in spawning habitat of brown trout in Idaho found a significant relationship between IGDO and survival (Maret *et al.* 1993). Survival was below 10% when mean IGDO fell below 8.0 mg L^{-1}. Maret *et al.* (1993) suggest that growth and survival were positively correlated to IGDO concentrations above 8 mg L^{-1} when seepage velocities exceeded 100 cm/hr. Survival was inversely related to the amount of fine substrate sediment. The IGDO in natural redds with wild brook trout was usually above 6.0 mg L^{-1}, and survival of embryos was positively correlated with mean IGDO up to 8 to 9 mg O_2 L^{-1} (Hollender 1981, as cited in DEQ 1995). Artificial redds used in this study produced much lower survival, with negligible survival below about 8 mg L^{-1}. Few or no steelhead sac fry were recovered from containers placed in streambed gravels with mean IGDO below 8 mg L^{-1} (Phillips and Campbell 1962). About 35% of juvenile trout survived at IGDO concentration of 6 mg L^{-1} and approximately 95% survived when the IGDO concentration was 8 mg L^{-1} (Turnpenny and Williams 1980). Results from Sowden and Power (1985), Phillips and Campbell (1962), and Turnpenny and Williams (1980) suggest that IGDO concentrations of <5 mg L^{-1} are lethal. These three studies had limited data concerning survival rates at IGDO concentrations above 8 mg L^{-1} that could be compared to the findings of Hollender (1981) and Maret *et al.* (1993). Although Geist *et al.* (2006) did not measure IGDO directly, the water column DO values suggest that IGDO in the range of approximately 1.0 to 4.0 mg L^{-1} did not increase mortality of incubating salmon when water temperatures were declining, but did increase the number of abnormalities and reduced size of the fry at emergence, both of which can be lethal eventually.

Regarding the question of possible thresholds for IGDO-related effects on salmonid embryos and alevins, the studies cited above did not use standardized methodologies and their results must be considered in light of certain methodological problems. Spatial variability of IGDO in redds is high, due to variable biological oxygen demand, dilution with ground water, periphytic organisms on and near the gravel surface, and gravel permeability (Vaux 1962). Higher stream flows increase IGDO (Silver *et al.* 1963), and higher water temperatures reduce the amount of oxygen that can dissolve in water (Davis 1975; Table 30).

Table 30. Solubility of oxygen in fresh water at different temperatures when water is exposed to an atmosphere containing 20.9% oxygen at a pressure of 760 mm HG (including water vapor pressure). Parts per million is equivalent to mg L^{-1}. Table from Davis (1975).

Temp (*C*)	Parts per million	Cm^3 per liter (*at 0 C and 760 mm*)	Temp (*C*)	Parts per million	Cm^3 per liter (*at 0 C and 760 mm*)
0	14.62	10.23	16	9.95	6.96
1	14.23	9.96	17	9.74	6.82
2	13.84	9.68	18	9.54	6.68
3	13.48	9.43	19	9.35	6.54
4	13.13	9.19	20	9.17	6.42
5	12.80	8.96	21	8.99	6.29
6	12.48	8.73	22	8.83	6.18
7	12.17	8.52	23	8.68	6.07
8	11.87	8.31	24	8.53	5.97
9	11.59	8.11	25	8.38	5.86
10	11.33	7.93	26	8.22	5.75
11	11.08	7.75	27	8.07	5.65
12	10.83	7.58	28	7.92	5.54
13	10.60	7.42	29	7.77	5.44
14	10.37	7.26	30	7.63	5.34
15	10.15	7.10			

The concentration of IGDO is inversely related to the percentage of inorganic fine material in sediment (Skaugset 1980), contributing to variability. In clean spawning gravel, IGDO concentration can be 3 mg L^{-1} less than the water column DO concentration, but it may be as much as 6 mg L^{-1} less in gravel with a large amount of fine sediment (DEQ 1995). Also, productive streams exhibit diurnal cycles in DO concentrations due to photosynthesis and respiration. Average measures of DO concentration do not reflect the damage to aquatic life that can occur during diurnal minima. Many of the studies described in this section, such as Phillips and Campbell and Maret *et al.*, did not account for such confounding variables. For example, standpipes used in artificial redds (*e.g.*, in Phillips and Campbell 1962) create different conditions than occur in natural redds and do not take into account spatial variability. Samples were taken using a modified Winkler titration method at intervals throughout 10 days and 5 days, but the exact interval was not specified, so it is impossible to determine at which points in the diurnal cycle of IGDO variation the samples were taken. Samples taken during mid-day could be biased towards higher IGDO values that would not be representative of the average conditions experienced by embryos and alevins in the gravel (in this scenario, actual effects thresholds would be lower than those reported). On the other hand, if the samples were taken early in the morning, the reported IGDO values would be lower than the average conditions, and actual effects thresholds would be higher than those reported.

Maret *et al.* (1993) sampled using a hand pump on a biweekly basis. Using this sampling regime, it is impossible to properly account for temporal variability in IGDO. High variability in salmonid embryo survival at the control station (18 to 83% mortality) implies that there were other unmeasured factors (such as predation by macro invertebrates, disease, and handling damage) that contributed to the mortality of the developing embryos. Finally, many of the above studies involved resident, not anadromous, salmonid species.

Low concentrations of IGDO increase the acute toxicity of various toxicants such as metals (*e.g.*, zinc) and ammonia (DEQ 1995). Low IGDO concentrations may increase uptake of waterborne toxics because of increased ventilation rates across the gills. Chemicals that damage the gill epithelium may decrease the efficiency of oxygen uptake, causing increased sensitivity to low IGDO. Exposure to some chemicals, such as pentachlorophenol, a common wood preservative, can increase metabolic oxygen demand by interfering with cellular oxidative phosphorylation. Rainbow trout eggs excrete most of their nitrogenous wastes as ammonia (Carson 1985). Eggs in redds exposed to ammonia under conditions of low IGDO concentrations and low water velocity may experience ammonia toxicity due to insufficient oxygen to nitrify ammonia. In addition, under these conditions, ammonia nitrification can further reduce already low IGDO.

Based on the above information, IGDO thresholds cannot conclusively be established for Pacific salmon and steelhead in general, or at a species-specific level. However, positive relationships between IGDO and both survival and growth of salmonid fishes are evident. Most of the studies used controlled conditions that allow only minor variation in IGDO concentration. These conditions facilitate the interpretation of the study results; however, they do not mimic the natural environment, where IGDO varies within and between redds (DEQ 1995). Also lacking are baseline data on ambient IGDO within natural and impaired spawning sites. Additional research is needed on Pacific salmonid species over a wider geographic area to validate specific protocols for IGDO (Maret *et al.* 1993). On balance, the scientific literature reviewed above suggests that adverse effects on eggs and alevins increase markedly at IGDO concentrations below 8 mg L^{-1}.

Adverse effects related to the IGDO criterion that are intense enough to kill or injure listed species are possible for species that incubate during the late summer, when stream flows generally are lowest and water temperatures are almost always highest, resulting in low dissolved oxygen in the water column and gravel. Below we examine patterns of water temperature and flow that create a risk of low IGDO in one stream in each of the Interior Columbia and Willamette/Lower Columbia recovery domains.

Data was available in the Interior Columbia domain for water temperature and discharge in the Minam River, which is spawning habitat for SRB steelhead and SR spring/summer Chinook salmon. In general, high water temperature from late July to early September and low flows from the second half of August through the first half of September create a risk of low dissolved oxygen during the period of the second half of August through early September (Figures 14 and 15). This pattern likely generally pertains to other rivers without dams in this domain, except where there are other effects caused by dams or water withdrawals. Data from USGS on dissolved oxygen was not available in the Interior Columbia recovery domain.

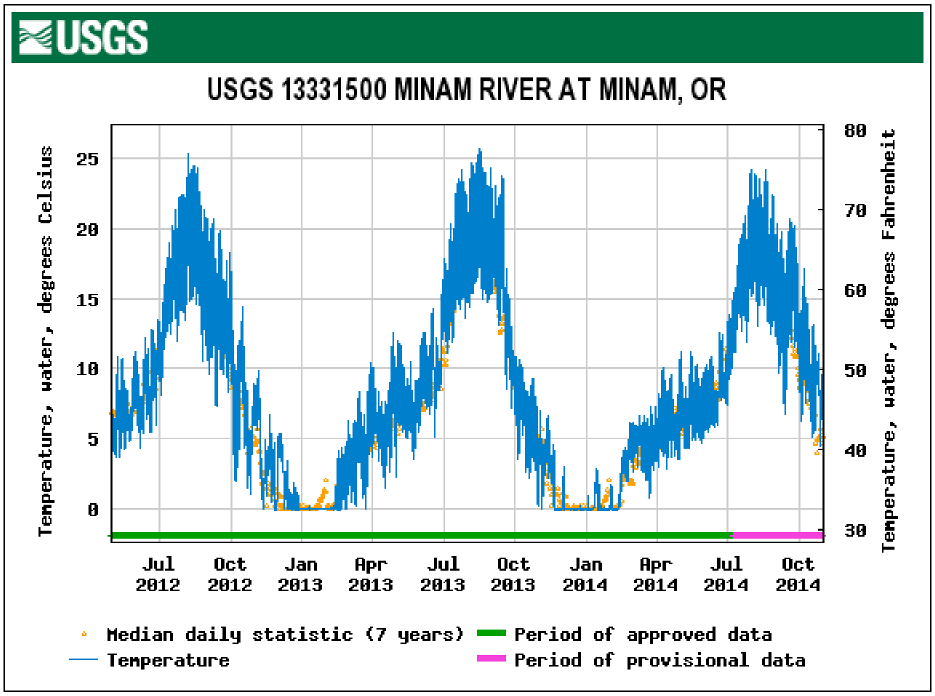

Figure 14. Water temperature as a daily mean for the Minam River (Lower Snake basin, Wallowa subbasin) at Minam, which is spawning habitat for SRB steelhead and SR spring/summer Chinook salmon, from May 2012 through October 2014. Location: 2.3 mi downstream from Squaw Creek, 0.3 mi west of Minam and at mile 0.3. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=13331500&agency_cd=USGS&referred_module=qw (accessed November 21, 2014).

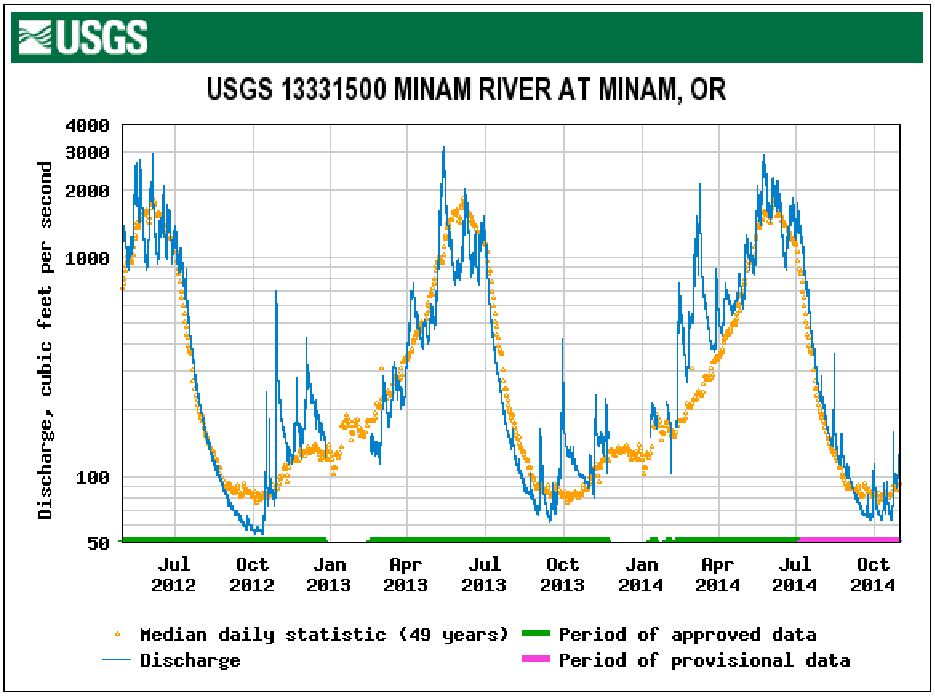

Figure 15. Discharge (flow) for the Minam River (Lower Snake basin, Wallowa subbasin) at Minam, which is spawning habitat for SRB steelhead and SRB spring/summer Chinook salmon, from May 2012 through October 2014. Location: 2.3 mi downstream from Squaw Creek, 0.3 mi west of Minam and at mile 0.3. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=13331500&agency_cd=USGS&referred_module=qw (accessed November 21, 2014).

The Clackamas River is an example of a river with data from USGS on water temperature, discharge, and dissolved oxygen in the Willamette/Lower Columbia recovery domain. In general, water temperature in this river is highest from early July to early September, and flows are low from mid-July through early October (Figures 16 and 18). This results in the lowest dissolved oxygen in this river from the second half of August through the middle of September (Figure 18). This seasonal pattern likely generally pertains to other rivers in this domain, except where there are other effects caused by dams or water withdrawals.

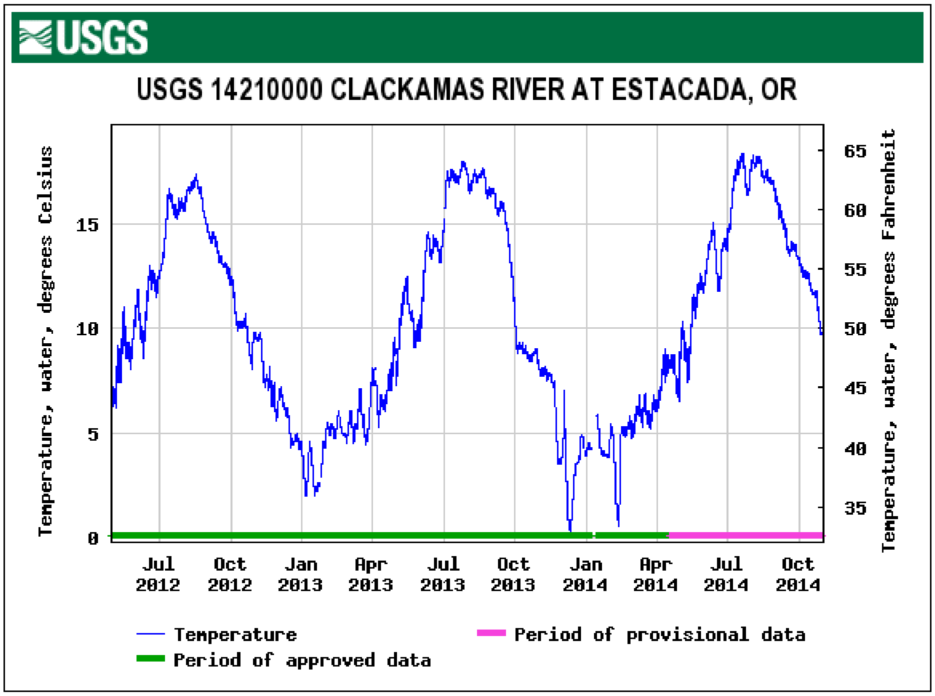

Figure 16. Water temperature as a daily mean for the Clackamas River (Willamette Basin, Clackamas subbasin) at Estacada, which is spawning habitat for UWR Chinook salmon, from May 2012 through October 2014. Location: 0.2 miles downstream from River Mill Dam, 1.5 miles northwest of Estacada and at mile 23.1. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=14210000&PARAmeter_cd=63680,00400,00095,00010,00300 (accessed November 21, 2014).

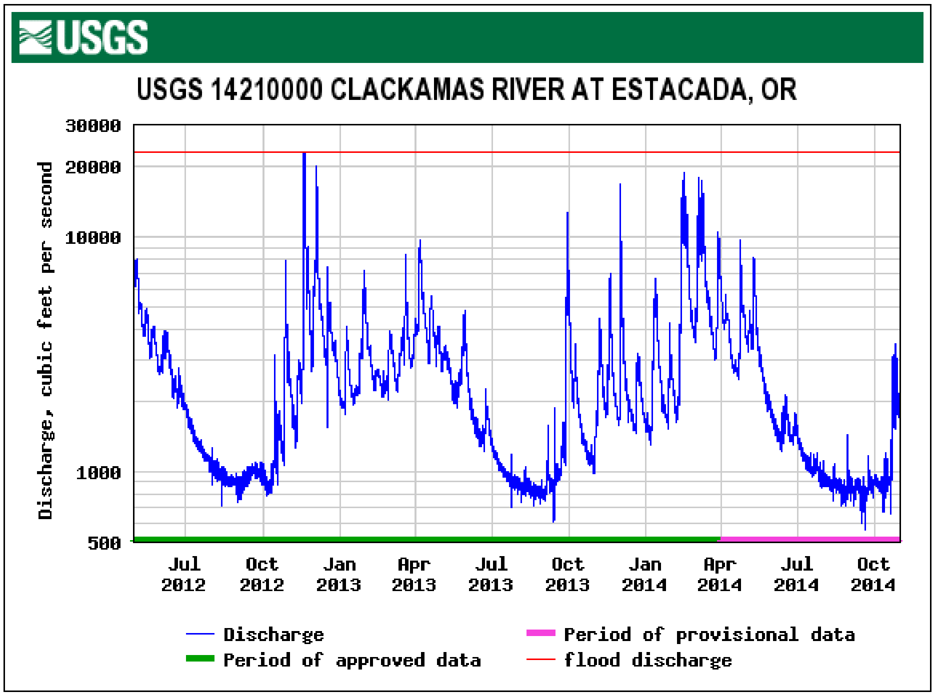

Figure 17. Discharge (flow) for the Clackamas River at Estacada, which is spawning habitat for UWR Chinook salmon, from May 2012 through October 2014. Location: 0.2 miles downstream from River Mill Dam, 1.5 miles northwest of Estacada and at mile 23.1. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=14210000&PARAmeter_cd=63680,00400,00095,00010,00300 (accessed November 21, 2014).

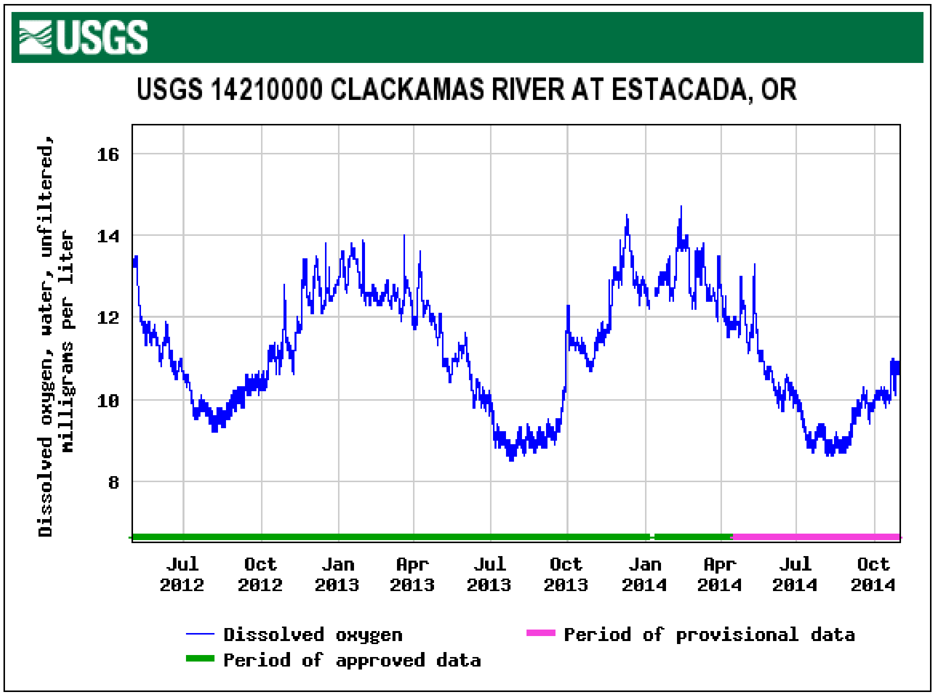

Figure 18. Dissolved oxygen in the water column for the Clackamas River at Estacada, which is spawning habitat for UWR Chinook salmon, from May 2012 through October 2014. Location: 0.2 miles downstream from River Mill Dam, 1.5 miles northwest of Estacada and at mile 23.1. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=14210000&PARAmeter_cd=63680,00400,00095,00010,00300 (accessed November 21, 2014).

The EPA proposes to approve an IGDO criterion that is applicable from spawning until fry emergence from the gravel, with a spatial median IGDO concentration that must not fall below 8.0 mg L^{-1} By definition (340-041-002, No. 53), this means that half of the measurements of IGDO within a sampled area could have values <8.0 mg L^{-1}, and half could have values >8.0 mg L^{-1}. Where spatial variability between IGDO is fairly high, some embryos and alevins would be exposed to IGDO below 8.0 mg L^{-1} in waters where this criterion is attained, and likely would suffer all or some of the following adverse effects:

- Increased developmental abnormalities
- Delayed development to fry stage
- Reduced size at emergence
- Reduced percentage survival to emergence
- Increased rate of injury for fish exposed to toxic chemicals

The following groups of listed species have life history patterns that include incubation of eggs and alevins in the late summer when low IGDO is most likely to occur, and occur in DEQ basins with documented dissolved oxygen problems.[21] They are therefore likely to experience some or all of the adverse effects listed above. Because of this, a small number of individual eggs and alevins are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in each of the following populations:

- UWR Chinook salmon:
    - Clackamas River population
    - Molalla River population
    - North Santiam River population
    - South Santiam River population
    - Calapooia River population
    - McKenzie River population
    - Middle Fork Willamette River population
- SR S/S-run Chinook salmon, Grande Ronde and Imnaha River MPGs:
    - Wenaha River population
    - Lostine/Wallowa River population
    - Minam River population
    - Catherine Creek population
    - Upper Grande Ronde R. population
    - Imnaha River population
    - Big Sheep Creek population
    - Lookingglass Creek population
- SRB steelhead, Imnaha MPG:
    - Imnaha River population[22]

[21] There are no listed species that incubate eggs or alevins in the one stream on the DEQ 303(d) list for dissolved oxygen in DEQ's Lower Columbia River basin.
[22] Period of lesser use only.

There is not a lot of data documenting IGDO where listed fish occur, nor is low IGDO listed as a limiting factor in any recovery plan. On balance, the number of eggs and alevins likely to be killed or injured is likely to be small, for several reasons. Because the criterion is a spatial median, if some sites are below the criterion and at risk of adverse effects, other sites would need to be above the criterion in order to meet the criterion. Also, the Chinook salmon populations listed above begin spawning in summer and continue into the early fall. Only a portion of fish are likely to spawn during the period of the summer when water temperatures are highest and IGDO is lowest, so many of the eggs and alevins will not be exposed to low IGDO. Also, there is some evidence that declining temperatures during incubation may protect from some adverse effects of low IGDO (Geist et al. 2006). Peak incubation of SRB steelhead is from mid-April to mid-July, so most eggs and alevins from the Imnaha population of that DPS will not be exposed to the period with the highest water temperature and lowest IGDO.

Other groups of species also have life history patterns that include incubation of eggs and alevins in the June 15 to September 15 period when water temperatures are relatively warm and IGDO problems are most likely to occur, although the basins in which they occur do not have widespread CWA section 303(d) listings for water column DO. As stated above, some of these streams may have seasonally low dissolved oxygen in the water column that has not been documented. Also, even in streams that are not on the CWA section 303(d) list for dissolved oxygen, fish may be exposed to the IGDO criterion of 8 mg L^{-1} as a spatial median if there is sufficient fine sediment in the substrate — and elevated fine sediment is a common problem in salmon and steelhead spawning areas in Oregon. Figure 19 shows streams in Oregon that DEQ has added to the CWA section 303(d) list of water bodies that are impaired for sedimentation. Based on sediment being a limiting factor for many listed species of salmon and steelhead, and the many streams with insufficient data for DEQ to make CWA section 303(d) determinations (Figure 20), there are likely numerous other streams with this problem. These species are likely to be exposed to the IGDO criterion value in streams with undocumented low dissolved oxygen in summer and/or significant amounts of fine substrate sediment. In such situations, a small number of individual eggs and alevins are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in each of the following populations:

- MCR Steelhead, Walla Walla and Umatilla MPG:
    - Walla Walla River population
- LCR Chinook salmon, Cascade Spring stratum:
    - Sandy River population
- LCR steelhead, Gorge Summer stratum:
    - Hood River population

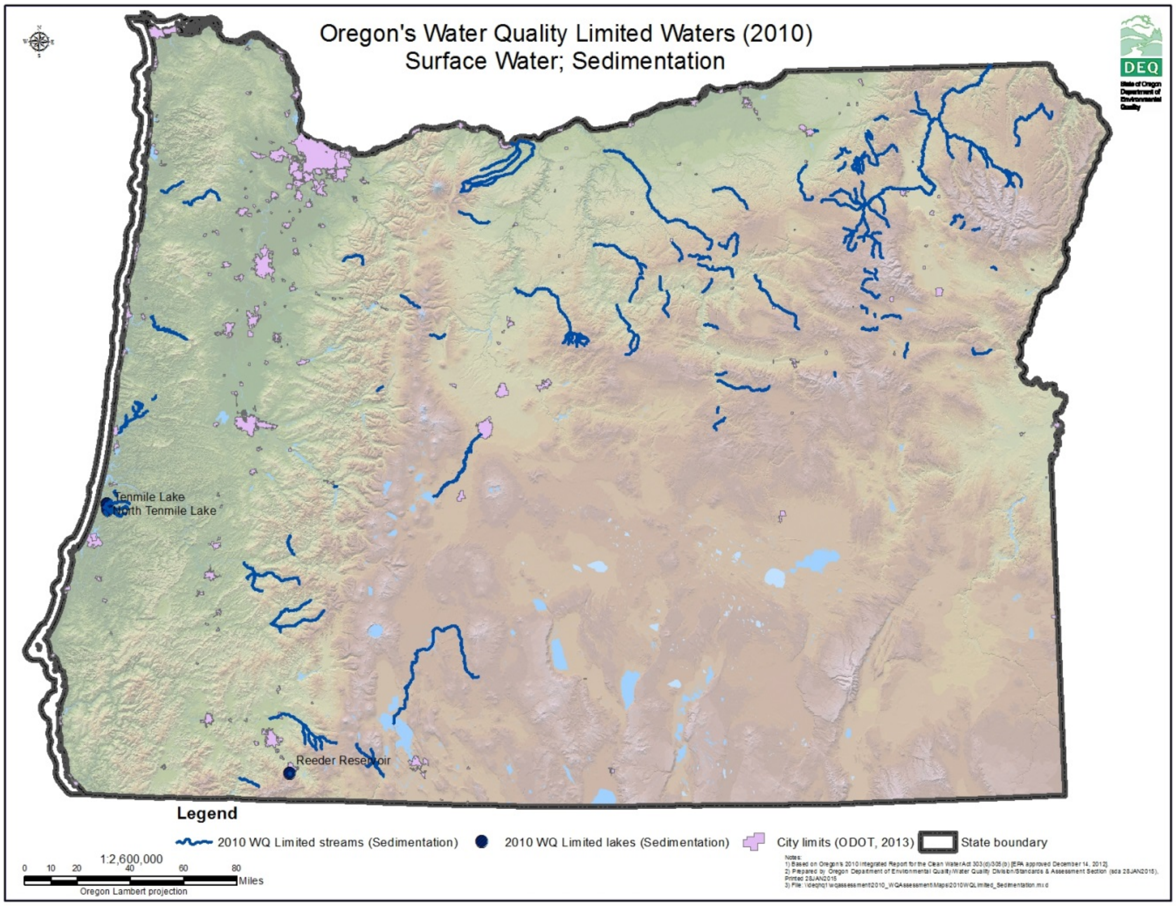

Figure 19. Oregon streams listed as water quality limited for sedimentation based on Oregon's 2010 integrated report to EPA to meet section 303(d) and 305(b) of the Clean Water Act (approved by EPA December 14, 2014; available at http://www.deq.state.or.us/wq/assessment/2010Report.htm)

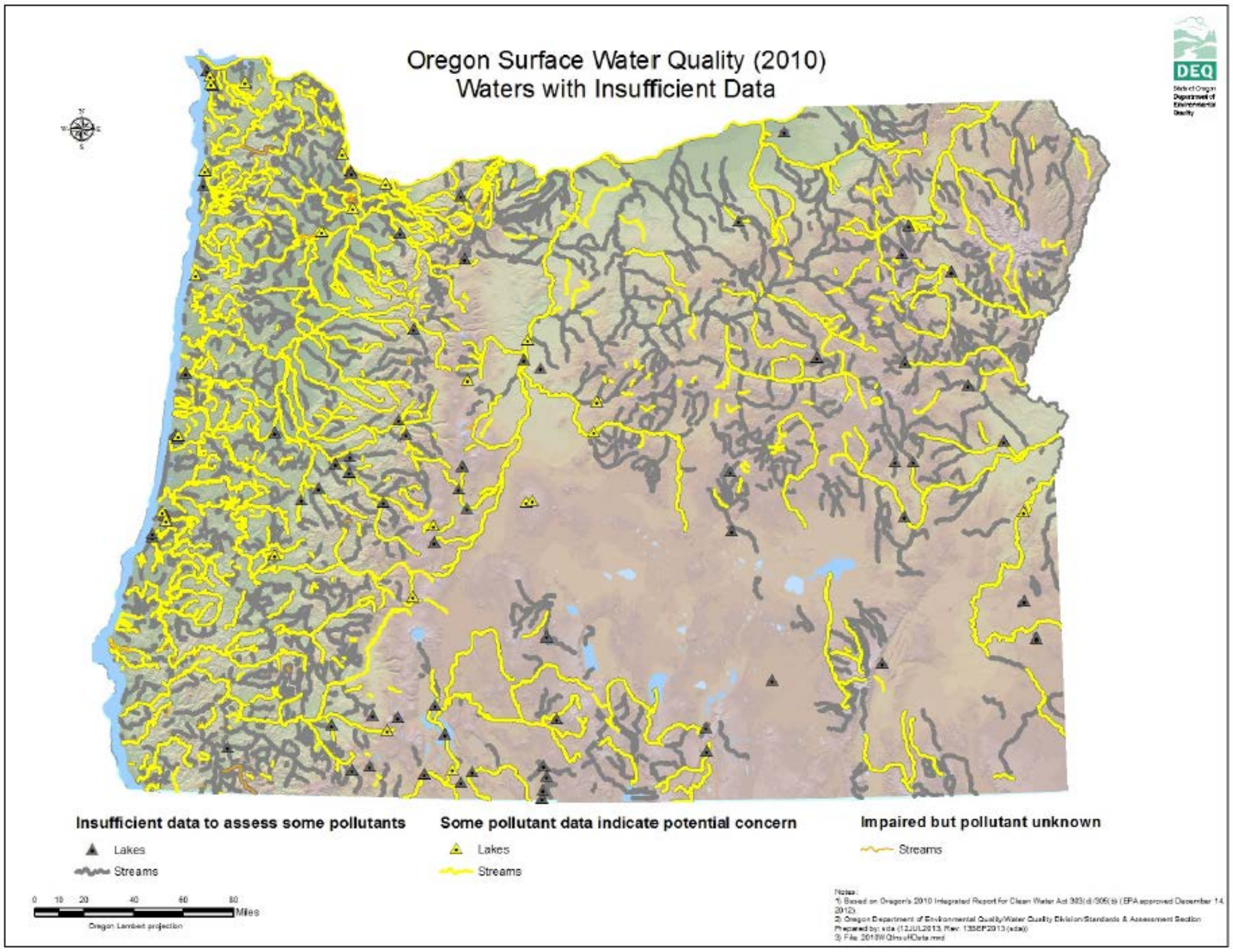

Figure 20. Oregon streams with insufficient data to determine suitability for inclusion on the CWA section 303(d) list of water quality limited water bodies in Oregon based on Oregon's 2010 integrated report to EPA to meet section 303(d) and 305(b) of the Clean Water Act (approved by EPA December 14, 2014; available at http://www.deq.state.or.us/wq/assessment/2010Report.htm)

For this second group of populations, the number of eggs and alevins likely to be killed or injured is likely to be small as well, due to the same reasons as the prior group of populations (e.g., minimal exposure and the nature of the metric for the criterion). Also, as stated in the prior paragraph, the basins in which these populations occur do not have widespread CWA section 303(d) listings for water column DO, so they are less likely to have widespread problems with low IGDO.

All other populations and species not listed in the above bullet list either do not incubate in spawning gravels in Oregon (*e.g.*, , SR sockeye salmon, UCR spring-run Chinook salmon, UCR steelhead, eulachon, green sturgeon, Southern Resident killer whale), or incubate generally outside of the June 15 to September 15 window (*e.g.*, other populations of LCR steelhead, UWR steelhead, SR fall-run Chinook salmon, CR chum salmon, and coho salmon), when lower water temperatures and higher stream flows are likely to maintain IGDO above the criterion value. The number of deaths and injuries due to approval of the IGDO criterion depends on what scale applies to the spatial median embedded in the criterion. If the samples are taken too close to each other (*e.g.*, within the same pool tailout or riffle), fine substrate sediment and stream velocity are likely to be similar, which means that none of the sample values in a site meeting the criterion of 8 mg L^{-1} are likely to be significantly lower. This means that incubating fish would be exposed to IGDO that is not much lower or not much higher than the criterion value, and adverse effects would be minimal. However, if the samples are relatively far apart (*e.g.*, within multiple pool tailouts or riffles), the variability in fine substrate sediment and stream velocity may be high enough that some samples are significantly lower than the criterion and some are significantly higher, yet the criterion is still attained. Adverse effects could be relatively severe at the sample sites that are significantly lower in IGDO.

The DEQ has a guidance document (DEQ 1996) with a protocol for collection of IGDO samples. The protocol states that "Sampling locations should be chosen to represent those areas most sensitive to potentially reduced IGDO concentrations; where flows are relatively low, sediment loads are deposited, and where fish spawn." It also states that measurements should be taken during the critical period between egg deposition and emergence of fry from the gravel. The protocol calls for sampling multiple redds per spawning area, with an "optimal target" of five redds per spawning area. It also cautions field staff to avoid sampling within the egg pockets of redds. According to DEQ, the scale for calculation of the spatial median is individual spawning areas.[23] Overall, the sampling protocol of DEQ provides us with confidence that samples will be taken close enough together that IGDO can be estimated at appropriate scales (within individual spawning areas) to minimize variability contributing to the spatial median compliance point.

Regarding the potential issue of diurnal cycles in DO concentrations due to photosynthesis and respiration, the protocol states that "Samples must be collected at the appropriate locations and times to accurately access [*sic*] the problem of concern." [24] This is somewhat vague direction that leaves open the following possibilities. Samples taken during the afternoon could indicate IGDO values that would be higher than the average IGDO experienced by embryos and alevins in the redds. On the other hand, if the samples were taken early in the morning, the IGDO values measured could be lower than the average IGDO in the redds. This issue is likely to be more of an issue in larger rivers that have higher rates of photosynthesis due to less shade from vegetation. The fish likely to be spawning in these larger rivers include fall Chinook salmon and chum salmon. In smaller, well-shaded rivers commonly used for spawning by spring or summer Chinook salmon, steelhead, and coho salmon, diurnal swings in dissolved oxygen are likely to be relatively small. To date, DEQ has used the protocol only in coastal watersheds where OC coho salmon are the only listed species.[25] Also, since DEQ is likely to sample IGDO over the course of the daylight hours, any skewing of results due to diurnal cycles is likely to be partially or

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[23] December 9, 2014 email from Aron Borok, DEQ, to Jeffrey Lockwood, NMFS, regarding status of the temperature consultation.

[24] We assume the authors intended to use the word "assess" rather than "access" in this sentence.

[25] December 9, 2014 email from Aron Borok, DEQ, to Jeffrey Lockwood, NMFS, regarding status of the temperature consultation.

completely cancelled out because some samples will be overestimates and some samples will be underestimates.

Overall, we do not expect the adverse effects of approving the IGDO criterion to be severe enough to affect any of the VSP variables at the population scale, for any of the listed species, for the following reasons:

- Since the criterion is a spatial median, half of the samples must be above the criterion values. This will limit the extent of IGDO values below the adverse effects threshold of 8 mg L^{-1} to half of the sites within a spawning area, which is the scale at which DEQ calculates the spatial median for compliance. Since a single spawning area is unlikely to have high variability in IGDO, it is unlikely that any sites will have IGDO far below the 8 mg L^{-1} threshold.
- During the most critical time of year for IGDO (June 15 to September 15), the affected species are either in the last month of an incubation period that started in the winter (steelhead), or are in the first 2 to 8 weeks of an incubation period that will extend through the winter (Chinook salmon). During the majority of their incubation period, the eggs and alevins will be exposed to colder water holding more oxygen that is circulated more rapidly through their redds by higher stream flows.
- Areas where steelhead spawn relatively late with eggs and alevins that incubate into July, or where spring or spring/summer Chinook salmon spawn relatively early with eggs that begin incubating before September 15, tend to be higher elevation, cooler streams that are less likely to have low water-column DO and subsequent low IGDO.

Temperature, OAR 340-041-0028

The EPA proposes to approve the portions of OAR 340-041-0028 shown in the numbered, indented paragraphs below:

> (2) Policy - It is the policy of the Commission to protect aquatic ecosystems from adverse warming and cooling caused by anthropogenic activities. The Commission intends to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming, to encourage the restoration and protection of critical aquatic habitat, and to control extremes in temperature fluctuations due to anthropogenic activities. The Commission recognizes that some of the State's waters will, in their natural condition, not provide optimal thermal conditions at all places and at all times that salmonid use occurs. Therefore, it is especially important to minimize additional warming due to anthropogenic sources. In addition, the Commission acknowledges that control technologies, best management practices and other measures to reduce anthropogenic warming are evolving and that the implementation to meet these criteria will be an iterative process. Finally, the Commission notes that it will reconsider beneficial use designations in the event that man-made obstructions or barriers to anadromous fish passage are removed and may justify a change to the beneficial use for that water body.

(3) Purpose - The purpose of the temperature criteria in this rule is to protect designated temperature-sensitive, beneficial uses, including specific salmonid life cycle stages in waters of the State.

Analysis of Policy and Purpose

We do not anticipate effects on listed species from EPA's approval of the policy of Oregon's Environmental Policy Commission or the purpose of the temperature criteria. This is because any effects from the policy and purpose statements will be expressed through the numeric and narrative water temperature criteria.

The EPA proposes to approve the numeric criteria from OAR 340-041-0028 shown in the numbered, indented paragraphs below:

(4) Biologically Based Numeric Criteria - Unless superseded by the natural conditions criteria described in Section (8) of Oregon's rule[26], or by subsequently adopted site-specific criteria approved by USEPA, the temperature criteria for State waters supporting salmonid fishes are as follows:

(a) The seven-day-average maximum temperature of a stream identified as having salmon and steelhead spawning use on subbasin maps and tables set out in OAR 340-041-0101 to OAR 340-041-0340: Tables 101B, and 121B, and Figures 130B, 151B, 160B, 170B, 220B, 230B, 271B, 286B, 300B, 310B, 320B, and 340B,[27] may not exceed 13.0°C (55.4°F) at the times indicated on these maps and tables;
(b) The seven-day-average maximum temperature of a stream identified as having core cold water habitat use on subbasin maps set out in OAR 340-041-101 to OAR 340-041-340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A,[28] may not exceed 16.0°C (60.8°F);
(c) The seven-day-average maximum temperature of a stream identified as having salmon and trout rearing and migration use on subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A,[29] may not exceed 18.0°C (64.4°F);
(d) The seven-day-average maximum temperature of a stream identified as having a migration corridor use on subbasin maps and tables OAR 340-041-0101 to OAR 340-041-0340: Tables 101B and 121B, and Figures 151A, 170A, and 340A,[30] may not exceed 20.0°C (68.0°F). In addition, these water bodies must have cold water refugia

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[26] EPA disapproved the natural conditions criteria (*i.e.*, section 8 of Oregon's rule) on August 8, 2013, and thus it is not in effect under the CWA. Therefore, it is not part of EPA's proposed action, and we do not analyze section 8 in this opinion.

[27] These tables and figures are available at http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t2 (accessed July 23, 2014) and are incorporated herein by reference.

[28] These figures are available at http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t2 (accessed July 23, 2014) and are incorporated herein by reference.

[29] These figures are available at http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t2 (accessed July 23, 2014) and are incorporated herein by reference.

[30] These tables and figures are available at http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm#t2 (accessed July 23, 2014) and are incorporated herein by reference.

that is [*sic*] sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. Finally, the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern;

Analysis of Biologically-Based Numeric Criteria and Beneficial Uses

Oregon's revised numeric criteria for temperature are consistent with those in the Temperature Guidance. Therefore, this analysis of effects is based, in part on the scientific information and rationale developed for the Temperature Guidance, including the six technical issue papers (Dunham *et al.* 2001; Materna 2001; McCullough *et al.* 2001; Poole *et al.* 2001a, b; Sauter *et al.* 2001; Water Temperature Criteria Technical Workgroup 2001). The temperature ranges and associated effects from these issue papers are discussed in the following sections and are summarized in Table 31. We also reviewed and considered other scientific studies and literature reviews published since the Temperature Guidance, as cited below.

McCullough (2010), in a review of how well water temperature standards across the U.S. are protecting fish populations, said that the Temperature Guidance Project "serves as an excellent model for the 50 states of the U.S. in development of protective temperature standards." He noted 23 "excellent ecologically-based provisions and statements of ecological concepts" in the guidance, such as:

- EPA Region 10 guidance offers protection of existing cold waters as being essential to the process of protecting and restoring threatened fish populations.
- It recommends protection of an entire thermal guild of fish by evaluating the full life cycle needs of all species in the guild.
- It focuses on avoidance of sublethal or chronic thermal effects rather than acute effects as the primary means of controlling thermal impact.
- It supports restoration of CWR in large rivers where they have been lost due to channel modification or hydroelectric impacts.
- It acknowledges that by controlling the 7DADM during summer, the prospect of meeting temperature criteria in other seasons is increased.
- It recommends a summer temperature at the warm end of the optimal range so that temperatures near the middle of the range would be the maximum achieved during most of the spring to autumn period. The upper end of optimum as a 7DADM was never considered as representing MWAT[31].

[31] Maximum weekly average temperature.

Table 31. Summary of temperature considerations for salmon and steelhead life stages.

Life Stage	Temperature Consideration	Temperature & Unit	Reference
Spawning and Incubation	Temperature range at which spawning is most frequently observed in the field	4–14°C (daily avg.)	Issue Paper 1,[1] p. 17–18
	Incubation of eggs and alevins • Meet biological requirements • Optimal range	 6–12.8°C (constant) 6–10°C (constant)	 Issue Paper 5,[2] p. 82 Issue Paper 5, p. 16
	Reduced viability of gametes in holding adults	>12.8°C (constant)	Issue Paper 5, p. 16
Juvenile Rearing	Lethal temperature (1-week exposure)	23–26°C (constant)	Issue Paper 5, p. 12, 14 (Table 4), 17, 83, 84
	Optimal growth • Unlimited food • Limited food	 13–20°C (constant) 10–16°C (constant)	 Issue Paper 5, p. 36 and 38–56
	Rearing preference temperature in lab and field studies	10–17°C (constant)	Issue Paper 1, p. 4–9
	Impairment to smoltification	12–15°C (constant)	Issue Paper 5, p. 7 and 57–65
	Impairment to steelhead smoltification	>12°C (constant)	Issue Paper 5, p. 7 and 57–65
	Disease risk (lab studies) • High • Elevated • Minimized	>18–20°C (constant) 14–17°C (constant) 12–13°C (constant)	Issue Paper 4,[3] p. 12–23
Adult Migration	Lethal temperature (1-week exposure)	21–22°C (constant)	Issue Paper 5, p. 17, 83–88
	Migration blockage and migration delay	21–22°C (average)	Issue Paper 5, p. 9, 10, 72–75; Issue Paper 1, p. 15–16
	Disease risk (lab studies) • High • Elevated • Minimized	 >18–20°C (constant) 14–17°C (constant) 12–13°C (constant)	Issue Paper 4, p. 12–23
	Adult swimming performance • Reduced • Optimal	 >20°C (constant) 15–19°C (constant)	 Issue Paper 5, p. 8, 9, 13, 65–72
	Overall reduction in migration fitness due to cumulative stresses	>17–18°C (prolonged exposure)	Issue Paper 5, p. 74

[1] Sauter, S.T., J. McMillan, and J. Dunham. 2001. Issue paper 1: Salmonid behavior and water temperature. EPA-910-01-001. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. 36 p.

[2] McCullough, D.A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue paper 5: Summary of technical literature examining the physiological effects of temperature on salmonids. EPA-910-D-01-005. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. 114 p.

[3] Materna, E. 2001. Issue paper 4: Temperature interaction. EPA-910–D-01-004. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. 33 p.

For each criterion, we have grouped for analysis species that have similar thermal requirements. For criteria that had sufficient information, we analyzed temperature requirements together for each of the following guilds[32]:

- Chinook salmon — LCR, UWR, UCR spring-run, SR spring/summer-run, and SR fall-run: Chinook salmon have a variety of life history strategies that include upstream migration in between late spring and early fall, spawning in the fall, and downstream migration as either sub-yearlings (commonly referred to as "ocean type"), or yearlings (commonly referred to "stream type"). Nevertheless, the responses of these different life history strategies to various water temperatures generally are similar, and they commonly are discussed together in relevant scientific literature evaluating potential water temperature standards (*e.g.*, McCullough *et al.* 2001, Richter and Kolmes 2005).
- Coho salmon — LCR, OC and SONCC: Coho salmon all migrate upstream in late summer through fall, spawn in fall and winter, and migrate as yearlings from late winter through spring or early summer. Because all coho salmon have a similar life history, their thermal requirements are similar and it is logical to analyze them together. Coho salmon commonly are analyzed as a single group in relevant scientific literature evaluating potential water temperature standards (*e.g.*, McCullough *et al.* 2001, Sauter *et al.* 2001, Richter and Kolmes 2005).
- Steelhead — LCR, UWR, MCR, UCR, and SRB: Steelhead also have a variety of life history strategies that include both winter steelhead (ocean-maturing fish that enter fresh water with well-developed gonads and spawn shortly thereafter), and summer steelhead (stream-maturing fish that enter fresh water in a sexually immature condition and require several months in fresh water to mature and spawn) (Busby *et al.* 1996). Nevertheless, the responses of these different life history strategies to various water temperatures generally are similar, and they commonly are discussed together in relevant scientific literature evaluating potential water temperature standards (*e.g.*, McCullough *et al.* 2001, Richter and Kolmes 2005).

We analyzed CR chum salmon, SR sockeye salmon, eulachon, green sturgeon and SRKW separately due to their unique life histories and thermal requirements. We will examine how the status of the species, environmental baseline, and cumulative effects combine with effects of approving the criteria for each species in the Integration and Synthesis section. For SRKW, we analyze all of the effects together following the analysis of effects section for all of the listed fish species.

For each species in this section, we analyze effects of the numeric criteria in conjunction with how it is applied by the beneficial use designation. We analyze how the beneficial use designations were made following this section analyzing the criteria.

[32] For some criteria, we analyze certain of these species separately as not all criteria apply to all species. For example, UCR spring-run Chinook salmon, UCR steelhead, SR sockeye salmon and green sturgeon do not spawn in Oregon, so the effects of the spawning criterion on these species differ from the other species that spawn in Oregon.

<u>Water Temperature Metric</u>

Oregon's metric for its numeric temperature criteria, the maximum 7-day average of the daily maximum (7DADM) is the same as the metric EPA recommended in the Temperature Guidance (EPA 2003). This metric is oriented to daily maximum temperatures, so it can be used to protect against acute effects, such as lethality and migration blockage. The 7DADM metric reflects the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a week-long period.

<u>Salmon and Steelhead Spawning Use − 13.0°C</u>

Under this criterion, the 7DADM temperature of a stream identified as having salmon and steelhead spawning use on the subbasin maps and tables set out in OAR 340-041-0101 to OAR 340-041-0340 may not exceed 13.0°C at the times indicated on these maps and tables. This intent of this criterion is to protect spawning, egg incubation, and fry emergence for salmon and steelhead. The criterion is identical to the criterion EPA recommended in the Temperature Guidance (Table 25 in EPA [2003]). This recommendation was based largely on information developed for the Temperature Guidance project in the physiology issue paper by McCullough *et al.* (2001), which noted the following (p. 16 to 17):

- In laboratory studies, constant temperatures of 6 to 10°C or lower during incubation consistently result in maximum survival and size at emergence for Pacific salmon, For fall-spawning fish, spawning that is initiated as daily maximum temperatures fall below 12 to 14°C results in greater incubation success, with 12.8°C being adequate for most salmon species.
- Constant incubation temperatures as low as 4°C and as high as 12°C can result in good to very good survival to hatching and emergence, with approximately 8°C being optimal for most salmon species.

Laboratory studies such as the ones considered in McCullough *et al.* (2001) commonly use a constant temperature, while field studies usually focus on mean and maximum temperatures. As discussed in the Temperature Guidance (2003, p. 19-20), the "mid-point" temperature between the mean and the maximum is the "equivalent" constant temperature for comparisons to juvenile growth studies done at constant temperatures. Thus, a river with a 7DADM value of 18°C and a 15°C weekly mean temperature is roughly equivalent to a constant laboratory study temperature of 16.5°C (*i.e.*, the mid-point between 15°C and 18°C).

McCullough *et al.* (2001, p. 84) reached the overall conclusion that "a spawning temperature range of 42-55°F (5.6-12.8°C) (maximum) appears to be a reasonable recommendation for Pacific salmon, unless colder thermal regimes are natural in any tributary." The upper limit of this range is close to the limit of 13.0°C imposed by the subject spawning criterion.

Richter and Kolmes (2005, p. 37) reviewed the same information available to the participants in EPA's Temperature Guidance project (as well as information generated in the project) and recommended a 13.0°C criterion for spawning and incubation. However, they also recommended an additional criterion of 10°C measured as a weekly mean to “provide an additional layer of insurance against global and regional environmental challenges including altered flow regimes and water temperatures associated with human activities and projected regional population growth” (Richter and Kolmes 2005, p. 37). However, the authors did not describe how they arrived at the value of 10°C as a weekly mean, or how this criterion specifically would reduce adverse temperature effects in salmon and steelhead relative to the existing 13.0°C criterion as a 7DADM. Richter and Kolmes (2005) also did not attempt to analyze what challenges having two different criteria for spawning and incubation would pose to implementation of the water temperature standard.

Streams with elevated temperatures due to climate change or increased human activity related to population growth are less likely to meet the existing criterion as well as the new criterion proposed by Richter and Kolmes (2005), yet the salmon and steelhead in these waterways still would require biologically appropriate spawning and incubation temperatures. Although we too are concerned about the effects of climate change and human population growth on water temperatures, we do not agree that sufficient information is available to support an additional spawning criterion based on weekly mean temperatures

Below, we analyze the likely effects of approving this criterion on individuals and on the VSP variables for populations of the listed species considered in this opinion. We have organized this section by guilds, which in this case are groups of species with similar thermal requirements. This is the approach taken in the Temperature Guidance and recognized as a strong point by McCullough (2010). We will examine how differences in the environmental baseline, status of species and critical habitat, and cumulative effects affect the individual listed species in the Integration and Synthesis Section later in this opinion.

UCR Spring-Run Chinook Salmon, UCR Steelhead, SR sockeye salmon, and Green Sturgeon:

These species do not spawn in waters of Oregon, so they are not subject to, or affected by, this criterion.

Chinook salmon — LCR, UWR, SR spring/summer-run, and SR fall-run:

Richter and Kolmes (2005, p. 38) confirmed the conclusion of EPA (2003) that a 13.0°C criterion as a 7DADM is adequate to protect spawning and incubation in Chinook salmon, noting that it is “consistent with the upper temperature range for optimum survival of chinook [*sic*] salmon embryos and alevins and [is] within reported temperature ranges for successful spawning.” The study by Geist *et al.* (2006) described in the IGDO discussion above included information on the effects of water temperature on fall Chinook salmon in the laboratory (Geist *et al.* 2006). Fall Chinook salmon embryo survival from fertilization to hatch and from fertilization to emergence was lower at 13.0° with DO at saturation than it was for some of the temperature/dissolved oxygen combinations with higher temperatures and moderate to high (but below saturation) DO concentrations. We view these temperature results with caution, because the authors held the pre-spawn adult salmon at a constant water temperature of 12° C, which is

colder than the river during spawning. This may have protected gametes in the holding fish from injury and improved the later survival to emergence in some of the warmer treatments.
Based on the recommendation of the Temperature Guidance, numerous studies we reviewed during development of the Temperature Guidance, and the confirmation by Richter and Kolmes (2005), the subject criterion fully supports successful spawning and incubation in the subject listed species of Chinook salmon. Therefore, we do not expect approval of this criterion by EPA to increase deaths or injuries among individuals of these species or have any effects on the VSP variables at the population scale.

CR Chum Salmon:

As stated earlier, Richter and Kolmes (2005, p. 34) stated that constant incubation temperatures from 4 to 12°C commonly produce excellent incubation results, while noting that some researchers found less than optimal survival occurring at the edges of this range. After reviewing a number of what appear to be laboratory studies that we presume were at constant temperatures, McCullough *et al.* (2001) stated that initial incubation temperatures of 8 to 10°C would be "the most consistently optimal" for chum salmon.

Although historically CR chum salmon probably spawned in tributaries throughout the lower Columbia River downstream of Celilo Falls (RM 199), these fish presently spawn only in tributaries and mainstem areas below Bonneville Dam (RM 146) (McElhany *et al.* 2007, Poirier *et al.* 2012). Most spawning occurs in three areas: Grays River (RM 21), a lower Columbia River tributary in Washington; the Woods Landing (RM 114) area of the mainstem Columbia River; and the area immediately downstream of Bonneville Dam (Poirier *et al.* 2012). Some spawning also occurs on the Oregon side of the river such as near Multnomah Falls (RM 137); in some years (*e.g.*, 2011), relatively large numbers of fish spawn at this site.[33] In most years, chum salmon are observed in the ladders at Bonneville Dam, but we do not know if these fish successfully spawn above the dam (McElhany *et al.* 2007). Adult chum salmon from wild Grays Creek parents were reintroduced in Clatskanie Creek (RM 50) in 2013 and 2014 with the intent of re-establishing runs in this creek,[34] but it is too early to tell if adults will spawn again in this waterway.

In seven seasons of spawning season monitoring in the mainstem Columbia River and its tributaries just downstream of Bonneville Dam (2000 through 2006), the first day (Julian) that Poirier *et al.* (2012) observed adult chum salmon ranged from day 307 (November 3 in non-leap years, November 2 in leap years) to 330 (November 26 in non-leap years, November 25 in leap years). Data available at the Fish Passage Center for the spawning area near Ives Island (just downstream of Bonneville Dam) for 1998 through 2009 indicate that chum salmon adults first arrived between late October and mid-November. [35] The length of the spawning season ranged

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[33]Data from Fish Passage Center available at http://www.fpc.org/spawning/spawning_surveys.html (accessed May 5, 2015).
[34] May 5, 2015 email from Kristen Homel, ODFW, to Jeff Lockwood, NMFS, regarding chum reintroduction.
[35] Data from Fish Passage Center available at http://www.fpc.org/spawning/spawning_surveys/AdultChumTiming_ForWeb.htm (accessed May 5, 2015).

from 23 to 62 days. Incubation extends through February according to the run timing database maintained by ODFW.[36]

The 10-year mean 7DADM water temperature from 1994 through 2013 at Bonneville Dam (Figure 21), which is in the vicinity of one of the principal spawning areas for CR chum salmon immediately downstream, generally was warmer than the spawning and incubation criterion at the start of chum salmon spawning in late October, with a maximum of 15° to 16°C during this period (Figure 22). The 7DADM water temperature dropped below the spawning and incubation criterion by mid-November and to below 10°C (the upper threshold for optimal rearing) by late November, and remained below 10°C throughout the remainder of the incubation period (Figure 22). This occurred in a river that is not meeting DEQ’s migration corridor criterion for the summer maximum period, so it is likely that the river would cool to an optimal temperature for chum salmon incubation earlier in a scenario where the river was meeting all water temperature criteria.

[36] Available at https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timingtables (accessed August 6, 2014).

Figure 21. Dams in the action area.

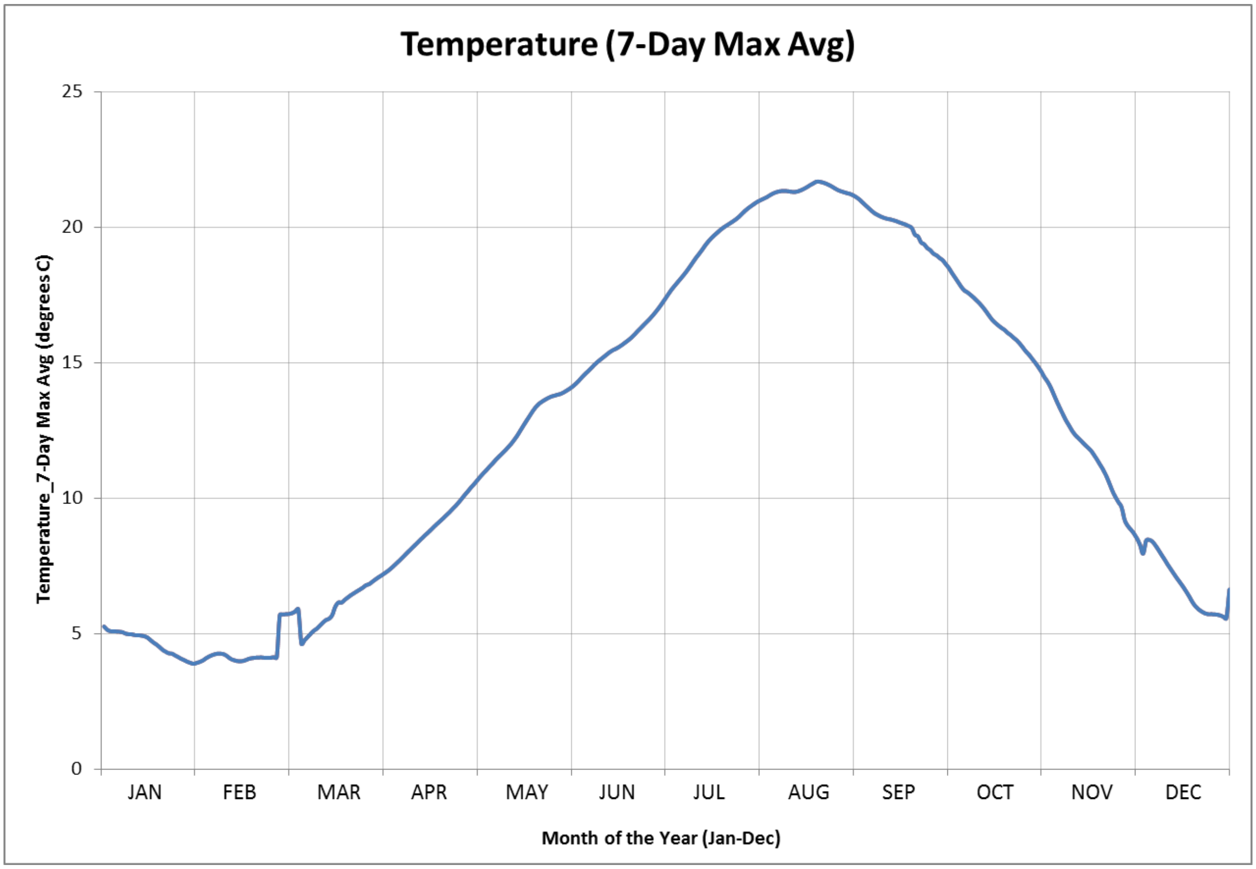

Figure 22. Ten-year average of 7DADM water temperature at Bonneville Dam forebay, 1994 to 2013. Data from Columbia River Columbia River Data Access in Real Time (DART) program. Available at http://www.cbr.washington.edu/dart/query/river_graph_text (accessed August 14, 2014).

The impoundment of water in large storage reservoirs in the interior Columbia Basin and operations of the hydropower projects in the lower Columbia River has contributed to increased water temperatures during the late summer and fall in the Columbia River mainstem and estuary (Ford 2011, NMFS 2013a). Water temperature is listed in the recovery plan for the Lower Columbia River (NMFS 2013a) as one of the factors limiting the recovery of CR chum salmon populations, although the plan does not have specific information about how water temperature is affecting LCR chum salmon.

Based on the Columbia River temperature data discussed above, temperatures in the water column during incubation of CR chum salmon are warmer than optimal during the period of lesser use for incubation and likely are within the "most consistently optimal" range during peak incubation, even in a river that does not meet the water temperature standard. If the river met the spawning criterion during October and November, some developing embryos and fry likely still would be incubating in waters warmer than optimal conditions during the period of lesser use for incubation. Therefore, some deaths and injuries are likely to occur due to approval of this criterion, but the number of fish affected is likely to be small (*i.e.*, <0.25% of the incubating fish) for several reasons:

- The period of "lesser use" when 10% of the fish incubate includes both a period at the start of incubation and a period at the end of incubation. If we assume an equal number of fish incubate during each of the lesser use periods, then only 5% of incubating fish would be exposed to less than optimal conditions due to EPA's proposed approval of the spawning and incubation criterion. Of these 5%, only a small percentage (*i.e.*, 5% or less) are likely to die for reasons described below. Five percent of 5% is 0.25%
- The highest 7DADM temperature allowed under the spawning and incubation criterion likely would occur during one of the earliest weeks in the October to November non-peak spawning season, because water temperatures are cooling rapidly during this period. For most of the non-peak spawning period, spawning and incubating chum salmon would be exposed to waters colder than 13°C. Even during the warmest week of the spawning period (which would be used to determine whether temperatures exceed the warmest 7DADM temperature allowed under the criterion), the temperature during much of each day would be cooler than the daily maximum due to daily temperature fluctuations between nighttime and daytime. Therefore, the fish are likely to be exposed to temperatures approaching 13°C for only a few hours a day during the warmest week of the entire incubation period.
- Chum salmon in the Columbia River select substrate areas for spawning and incubation where groundwater upwelling creates temperatures that are multiple degrees warmer than the river (Geist *et al.* 2002, 2008; Arntzen 2009). For example, during chum salmon spawning in 2007, mean temperature of the substrate at three spawning sites in the Columbia River was 14.5°C, and mean temperature of the river at those sites was 9.4°C (Arntzen 2009). During incubation, mean temperature was 10.5°C in the substrate and 7.2°C in the river (Arntzen 2009). This indicates that the fish are not seeking the coldest possible areas for spawning habitat, and that substrate temperatures may be as relevant as the temperature of the water column for the incubation in this species. The fish may be selecting these warmer areas to protect the eggs from freezing and to help ensure earlier emergence from the substrate, giving the species a competitive advantage over other species in accessing food resources (Geist *et al.* 2002).

Based on the above information, the 13°C criterion supports successful spawning and incubation in the CR chum salmon. This species is likely to suffer only a minor rate of death and injury (on the order of 0.25%) of incubating fish due to approval of this criterion by EPA, which is not enough to affect any of the VSP variables at the population scale.

Coho salmon — LCR, OC and SONCC:

McCullough *et al.* (2001, p. 33) concluded that "to fully support the pre-emergent stages of coho salmon development, the 7-day average of daily maximum temperatures should not exceed 48.2-53.6°F (9-12°C)." McCullough *et al.* (2001, p. 84), also stated that "a spawning temperature range of 42-55°F (5.6-12.8°C) (maximum) appears to be a reasonable recommendation for Pacific salmon, unless colder thermal regimes are natural in any tributary." Richter and Kolmes

(2005, p. 39), reviewing the same studies available to McCullough *et al.* (2001) for coho salmon, concluded that 13°C (7DADM) was "within the generally acceptable range of coho spawning temperatures" and "beyond their optimal temperature but within the upper end of their acceptable incubation temperature range."

There is considerable variability in river entry and time of spawning among different populations of coho salmon. Most coho salmon spawn from November to early January, although the range in Oregon is from September to March (Weitkamp *et al.* 1995). For most populations of coho salmon, at the time of spawning, water temperatures are either dropping rapidly or already near winter lows. See Figure 23 for an example of seasonal water temperature patterns using 7DADM temperatures from the Rogue River basin in southern Oregon, which is occupied by SONCC coho salmon.

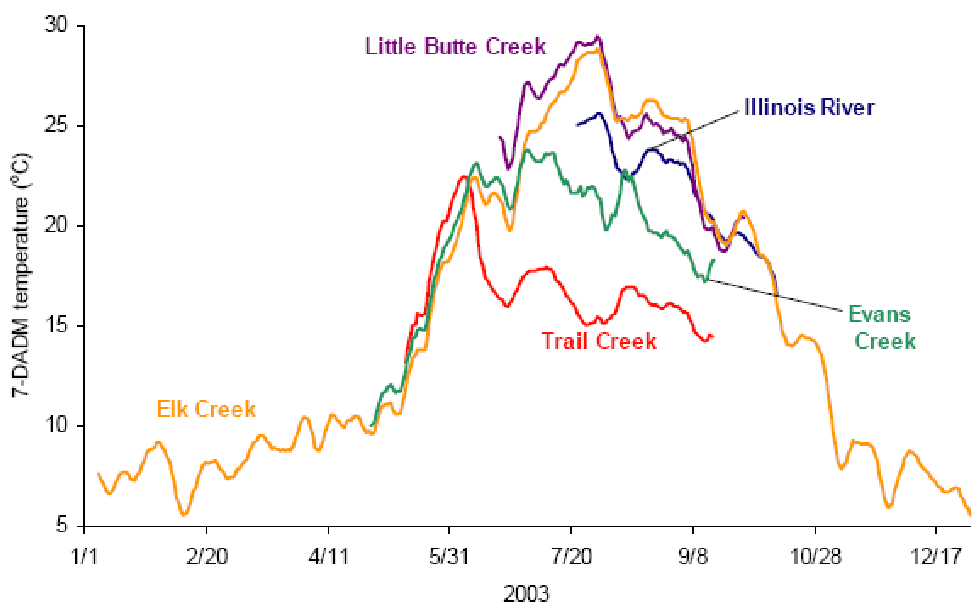

Figure 23. Water temperature as a 7DADM in the Rogue River basin during 2003 (Figure from DEQ 2008).

Water temperature data as a 7DADM during the spawning period of coho salmon in Oregon are not widely available, but there are some USGS monitoring stations that have generated data as daily mean values. Figure 24 shows temperatures for the Little Sandy River, which is spawning habitat for LCR coho salmon and is a free-flowing river, from July 2011 through November 2013. Figure 25 shows temperatures for the Wilson River at mile point 9.3, which is used by OC coho salmon for rearing and migration but is downstream from spawning habitat, from July 2011 through November 2013. Figure 26 shows temperatures for the Clackamas River near Estacada, which also is spawning habitat for LCR coho salmon and is downstream from River Mill Dam, from July 2011 through November 2013. All three figures demonstrate that water temperatures fall rapidly during the peak coho salmon spawning season.

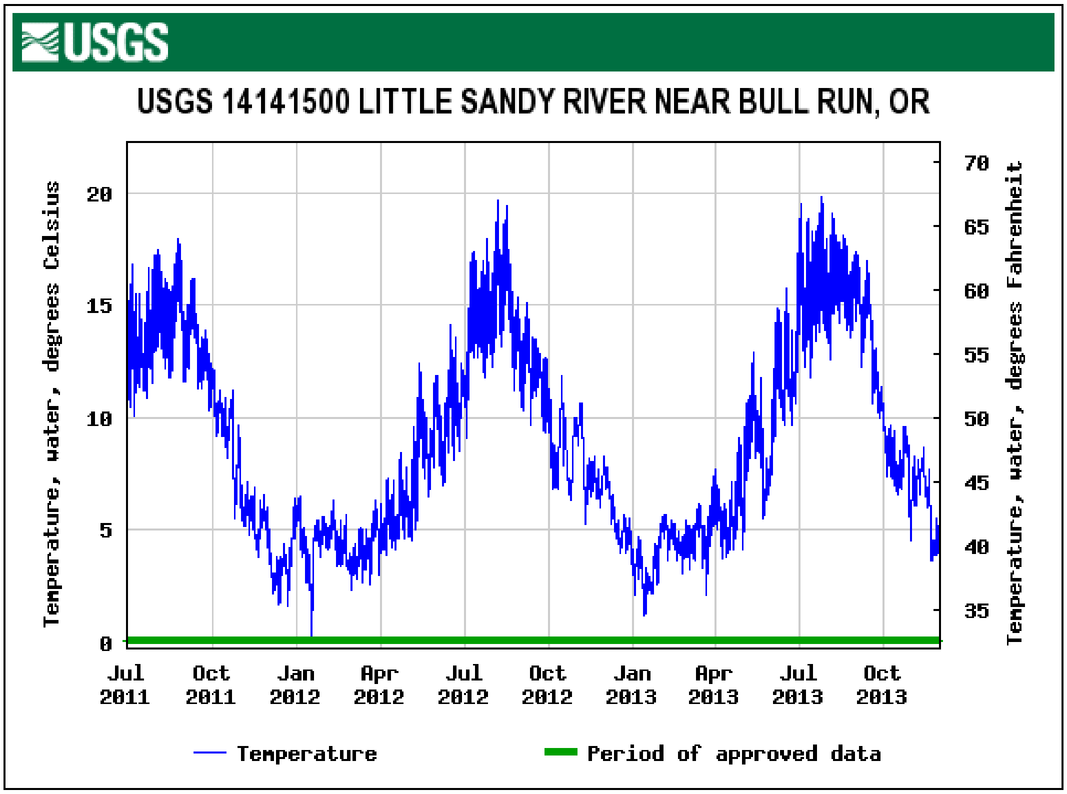

Figure 24. Water temperature as a daily mean for the Little Sandy River, which is spawning habitat for LCR coho salmon, from July 2011 through November 2013. Location: Mount Hood National Forest, 0.25 miles upstream from former Portland General Electric Co. dam and tunnel from Sandy River, 3.0 miles east of Bull Run and at mile 1.95. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=14141500&PARAmeter_cd=63680,00400,00095,00010,00300 (accessed October 3, 2014).

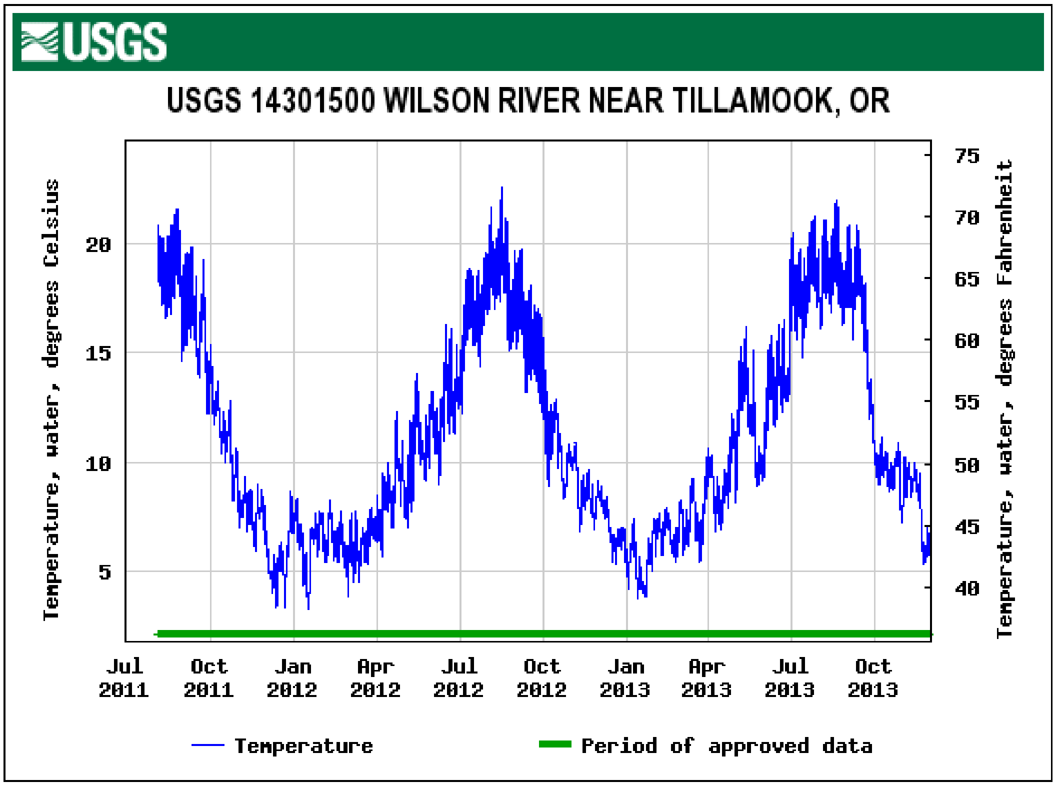

Figure 25. Water temperature as a daily mean in the Wilson River near Tillamook, Oregon. Location: 1.3 miles downstream from Ming Creek, 6.0 miles east of Tillamook and at mile 9.3. This station is located downstream of spawning habitat for OC coho salmon. Data from USGS at http://waterdata.usgs.gov/or/nwis/current/?type=quality&group_key=bas (Accessed October 3, 2014).

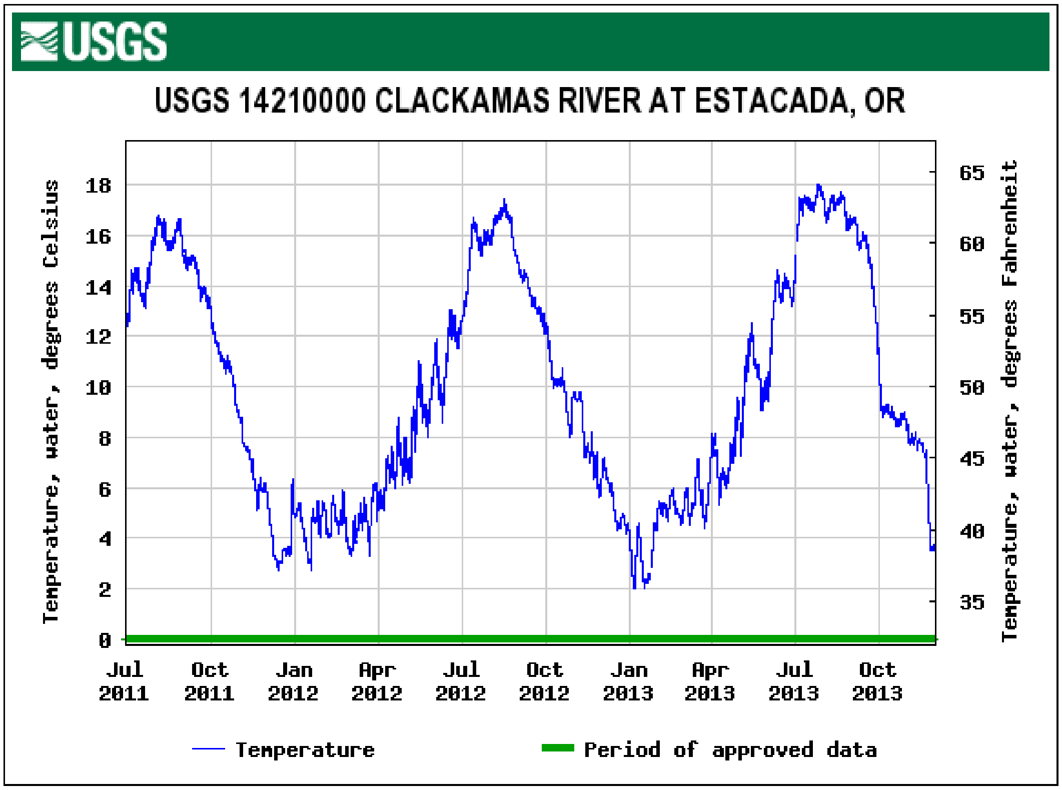

Figure 26. Water temperature as a daily mean for the Clackamas River at Estacada, which is spawning habitat for LCR coho salmon, from July 2011 through November 2013. Location: 0.2 miles downstream from River Mill Dam, 1.5 miles northwest of Estacada and at mile 23.1. Data from USGS at http://waterdata.usgs.gov/or/nwis/uv/?site_no=14210000&PARAmeter_cd=63680,00400,00095,00010,00300 (accessed October 3, 2014).

Because temperatures are falling rapidly during spawning of coho salmon, the highest 7DADM temperature allowed under the spawning and incubation criterion (13.0°C) likely would occur during one of the earliest weeks in the spawning period, when non-peak spawning generally occurs. For most of the spawning and incubation period, coho salmon would be exposed to waters colder than 13°C. Even during the warmest week of the spawning period (which would be used to determine whether temperatures exceed the warmest 7DADM temperature allowed under the criterion), the temperature during much of each day would be cooler than the daily maximum due to daily temperature fluctuations between nighttime and daytime. As spawning reaches cool in the fall, maximum temperatures will be at or below the 9 to 12°C recommended as a maximum temperature for optimal incubation by McCullough *et al.* (2001). Fry emerge from the gravel 50 to 350 days after spawning, with time to emergence decreasing with warmer incubation temperatures (Spence 1995). Therefore, the incubating fish effectively reduce their potential for exposure to warm water in the spring by accelerating emergence in warmer water.

Overall, the listed species of coho salmon are likely to be exposed to temperatures approaching 13°C for only a few hours a day during the warmest week of the entire spawning and incubation period. For all but these few hours, temperatures would be at or below the 12.8°C temperature as a 7DADM identified by McCullough *et al.* 2001 as adequate for spawning. For most of the incubation period in the fall and winter, temperatures would be in the optimal range identified by McCullough *et al.* (2001). Coho salmon may be exposed to temperatures slightly warmer than optimal under this criterion for brief periods during the start of spawning and incubation, and a few eggs or fry in each population are likely to die each year as a result. This is likely to be similar to natural rates of mortality, because water temperatures likely were not optimal for salmon at all places and times, even prior to human disturbance of the landscape (Reeves 1995; Poole *et al.* 2001a). The number of fish thus affected is likely to be too small to affect any of the VSP variables for any population.

Steelhead ― LCR, UWR, MCR, and SRB:

Richter and Kolmes (2005, p. 39) concluded that spawning and early development of steelhead fry occur "within the range protected by" their proposed criterion of 10°C as a weekly mean, but did not address a 7DADM criterion. McCullough *et al.* (2001, p. 36) concluded that "it appears that an optimal constant incubation temperature occurs below 51.8-53.6 °F (11-12°C). No specific research results were found that could be used to suggest a single daily maximum temperature limit for waters containing incubating steelhead."

Most steelhead populations spawn from March through May (Busby *et al.* 1996), although some begin spawning as early as January and some spawn as late as June. Because steelhead embryos and alevins from many populations incubate into the summer, they are at risk of adverse effects from elevated water temperatures.

The constant temperature of 10 to 12°C that likely is equivalent to the spawning criterion of 13°C as a 7DADM is within or colder than the range suggested by McCullough *et al.* (2001) for an optimal constant incubation temperature. Based on the studies we reviewed during development of the Temperature Guidance, the recommendation in the Temperature Guidance, and the information reviewed above, the subject criterion fully supports successful spawning and incubation in the subject listed species steelhead. Therefore, we do not expect approval of this criterion by EPA to increase deaths or injuries among individuals of these species or have any effects on the VSP variables at the population scale.

Eulachon:

There is no spawning standard specific to eulachon, so we are reviewing the effects of the salmonid spawning criterion on eulachon in this section. Eulachon typically spend 3 to 5 years in saltwater before returning to freshwater to spawn from late winter through mid-spring (Willson *et al.* 2006). Oregon waterways that NMFS considered occupied by eulachon at the time of listing under the ESA include the Columbia River, Sandy River, Tenmile Creek, and Umpqua River (USDC 2011). Eulachon in the Columbia River, its tributaries, and coastal rivers in Oregon spawn mostly in January, February, and March (Willson *et al.* 2006). Following spawning, eulachon eggs drift downstream for a short period of time and then adhere to sand grains and small gravels. Even after adherence, eggs may move downstream as the sand grains are mobilized by flowing water (Willson *et al.* 2006). Incubation is temperature-dependent, and the eggs hatch in 20 to 40 days (Gustafson *et al.* 2010). Because incubation is temperature-dependent, the appearance of larvae varies among rivers and years (McCarter and Hay 1999, Willson *et al.* 2006). Newly hatched larvae are poor swimmers and are rapidly carried downstream to estuarine portions of rivers and inlets within hours or days of hatching (Smith and Saalfeld 1955, Howell 2001, Gustafson *et al.* 2010). However, some larval eulachon remain in low-salinity surface waters of estuaries for weeks or months before entering the ocean (McCarter and Hay 1999, 2003).

Compared to salmon and steelhead, there is relatively little information available about thermal tolerance of eulachon. Adult eulachon generally enter the Columbia River to spawn when the temperature is between 4 and 10°C (Smith and Saalfeld 1955, Howell *et al.* 2001, WDFW and ODFW 2001).[37] In 1946, adult eulachon migrated up to and beyond the Cowlitz River (river mile 68) when the Columbia River was approximately 4.4°C (Smith and Saalfeld 1955). Water temperatures that are suitable for Pacific salmon and steelhead can be lethal to adult eulachon. For eulachon from the Cowlitz River that were acclimated to 5°C, an increase to 11°C (constant) for 6 days resulted in 50% mortality; by 8 days, all the test fish were dead (Blahm and McConnell 1971). For eulachon acclimated to 10°C, a 1-hour exposure to water at 18°C (designed to simulate a thermal plume large enough to cause a river to reverse flow) killed at least half of the fish within 50 hours (Blahm and McConnell 1971). All fish exposed to temperatures that were 3 to 22°C (constant) above the control (10°C) retained their gametes until death or conclusion of the test, but most fish in the control group deposited sperm and eggs in their tank as if spawning (Blahm and McConnell 1971, Snyder and Blahm 1971). Based on the information in this paragraph, a temperature of 10°C (constant) or less would protect migrating and spawning adult eulachon from adverse thermal effects. Waters meeting the salmon and steelhead spawning criterion of 13°C (7DADM) likely would provide temperatures that are warmer than optimal for spawning eulachon. We will examine how the application of this criterion in space and time through beneficial use designations affects eulachon adults after discussing effects of the spawning criterion on eulachon eggs and larvae immediately below.

Eulachon eggs can tolerate warmer water than adults. Eggs held in a laboratory at 4 to 8°C (control), 11°C, and 14°C developed and hatched normally (Parente and Ambrogetti 1970). At 17°C, eggs developed normally but did not hatch, and at 20, 23 and 26°C they did not develop normally or hatch. Half the fish held at 17°C died after 42 hours, and 100% died after 132 hours. Based on the information in this paragraph, a temperature of 14°C (constant) or less would protect eulachon eggs from adverse thermal effects. The spawning criterion of 13°C (7DADM) therefore is likely to prevent adverse thermal effects on eulachon eggs in areas and times that the eggs are exposed to waters meeting this criterion. We will examine this issue after discussing effects of the spawning criterion on larval eulachon immediately below.

We found no information about thermal tolerance of larval eulachon. We did find two studies about related species in the same family as eulachon (osmeridae). Rainbow smelt (*Osmerus mordax*) that occurs in rivers and coastal areas of eastern North America from Labrador Island

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[37] No information is available in these publications about what temperature metric these values represent (*e.g.*, instantaneous, daily mean).

to New Jersey, and on the west coast from Vancouver Island, Canada, to the Arctic Ocean[38] and shares an anadromous life history with eulachon. Rainbow smelt larvae held in freshwater at 13°C were exposed to temperature increases of 11.3 to 19.4°C for exposure lasting 5, 30 and 60 minutes. The larvae survived a temperature change of up to 13.6°C (*i.e.*, a temperature of 26.6°C) for up to 60 minutes (Barker *et al.* (1981).

Capelin (*Mallotus villosus*) is a circumpolar marine smelt that lives in high latitudes in the Atlantic and Arctic oceans. Most capelin spawn below the intertidal zone in the Barents Sea, but one population spawns in a long fjord in northern Norway in the intertidal zone. Davenport and Stene (1986) studied thermal tolerance of larval capelin from this population in laboratory experiments. In one experiment, they exposed groups of capelin eggs and larvae to seawater at each of the following temperatures for 24 hours before inspecting for survival: 5, 10, 15, 20, 22, 24, 26 and 30°C. They also kept 24 larvae in sea water at 18°C for a longer period to assess longer-term survival. Finally, they exposed groups of capelin larvae to sea water that was gradually warmed from 5 to 30°C to assess short-term, high-temperature tolerance.

From 5 to 20°C, survival of capelin eggs and larvae exposed for 24 hours varied from 85% to 100%. At 22°C and higher, survival of both eggs and larvae declined dramatically. The authors concluded that temperature above 20°C is lethal to capelin for exposures of this duration. Fish held at 18°C survived at a rate of 92% for the first 2 days, and then survival began to decline until all fish were dead on day 7. Fish in water that was gradually warmed survived up to 28°C, although they became motionless at temperatures above 25°C (Davenport and Stene 1986).

The research done on larval rainbow smelt by Barker *et al.* (1981) and on capelin by Davenport and Stene (1986) suggests that eulachon larvae may be able to tolerate exposures up to 20°C for exposures lasting somewhere between 1 and 24 hours, which are longer than we would expect in thermal plumes from point-source discharges, but shorter than the exposure to non-point sources which are on the order of weeks to months. Based on the limited information available for these two allied species, constant temperatures above 18°C for more than 1 to 24 hours are likely to increase deaths of larval eulachon. The spawning criterion of 13°C (7DADM) therefore is likely to prevent adverse thermal effects on eulachon larvae in areas and times that the larvae are exposed to waters meeting this criterion. Below we examine the potential exposure of adult, embryonic and larval eulachon to waters meeting the spawning criterion.

In the Columbia River, only the 2-mile long reach from Beacon Rock to upstream of Ives Island (RM 141.5 to RM 143.5) is subject to the salmon and steelhead spawning use, which is designated from October 15 to March 31 (DEQ 2003a). In the Columbia River, peak abundance of adult eulachon generally is from early February to late March (Gustafson *et al.* 2010, p. 256), although it may occur as late as April (Bargman *et al.* 2005). Non-peak spawning in the Columbia River can begin as early as December and extend into mid-May (Gustafson *et al.* 2010, p. 256).

Below, we discuss the timing and distribution of embryonic and larval eulachon. Romano *et al.* (2002) collected eulachon eggs with an artificial substrate in 2001, sampling between RM 29.8

[38] Species of concern fact sheet available at: http://www.nmfs.noaa.gov/pr/pdfs/species/rainbowsmelt_detailed.pdf (accessed on September 11, 2015).

and 85.1 from February 26 to March 20. They collected eggs from RM 35 to 73, with the greatest concentration between RM 56 and RM 61. Their highest catch per unit of sampling effort occurred on March 9 and 13.

James *et al.* (2014) sampled eulachon eggs and larvae in the Columbia River at an existing transect (RM 34). The transect crosses Clifton Channel from the Oregon shore to Tenasillahe Island and then crosses the shipping channel to Price Island on the Washington shore. They sampled the Columbia River 29 days during 19 weeks of a 20-week span in 2011 (weeks-of-the-year 3 to 22), 34 days during 25 consecutive weeks in late 2011 to mid-2012 (weeks 50 to 21), and 43 days during 29 weeks of a 30-week span in late 2012 to mid-2013 (weeks 48 to 25). Eulachon eggs and/or larvae were present in at least one sample for every day the Columbia River was sampled, except for the final week in 2011 to 2012 and the final week in 2012 to 2013. The densities of eulachon eggs and larvae peaked during week 12 (March 13 to 19) in 2011, during week 12 (March 11 to 17) in 2012, and during week 18 (April 28 to May 4) in 2013) (Figure 27). Water temperatures at the time of sampling during these weeks of peak densities ranged from 7 to 15°C (we assume these were instantaneous temperatures). No larvae were collected after week 22 (roughly the end of May to the beginning of June) in any of the sampling years.

Storch *et al.* (2014) sampled the eggs and larvae of eulachon on the Oregon side of the Columbia River at multiple sites spaced 3.7 miles apart between Cathlamet and North Bonneville, Washingon during the periods January 10 to May 31, 2011 and November 21 to July 24, 2012. They were not able to definitively identify any of the captured eggs as eulachon, but there did identify eulachon larvae. Most (93%) of the eulachon larvae were captured downstream of the Cowlitz River in March 2011. The peak capture of eulachon larvae in 2012 also occurred in March, although numbers were more than an order of magnitude lower than in 2011 (Figure 28). In 2012, small numbers of eulachon larvae were captured in April, May and July.

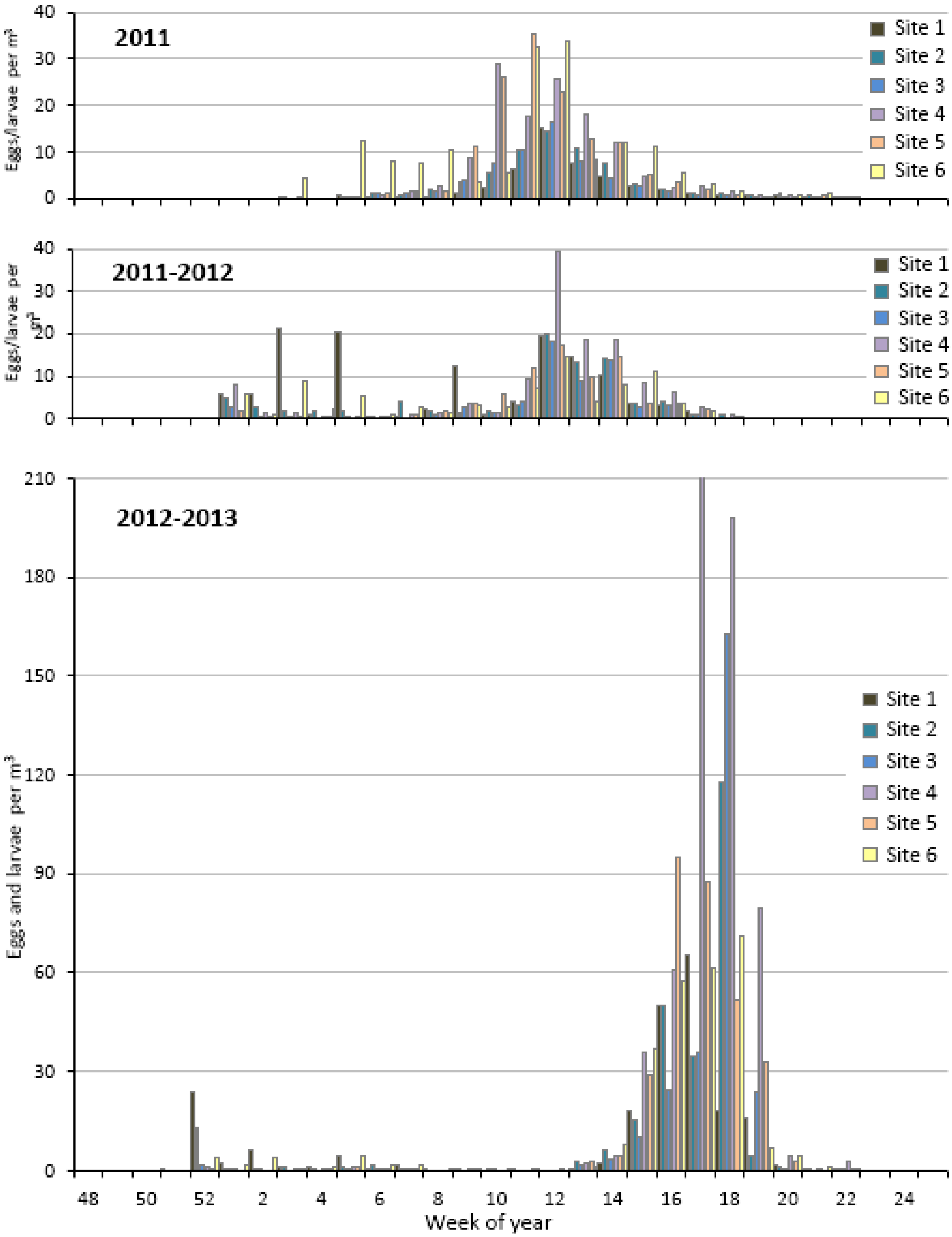

Figure 27. Weekly eulachon egg and larvae sample densities (values averaged if sampled twice in a week) by site along the Price Island/Clifton Channel transect, for 2011 (weeks 3 through 22), 2011-2012 (weeks 50 through 21), and 2012-2013 (weeks 48 through 25). Week 19 was May 1 through May 7 in 2011, May 6 through May 12 in 2012, and May 5 through 11 in 2013. Charts sized to maintain relatively equal scales. Figure from James *et al.* (2014).

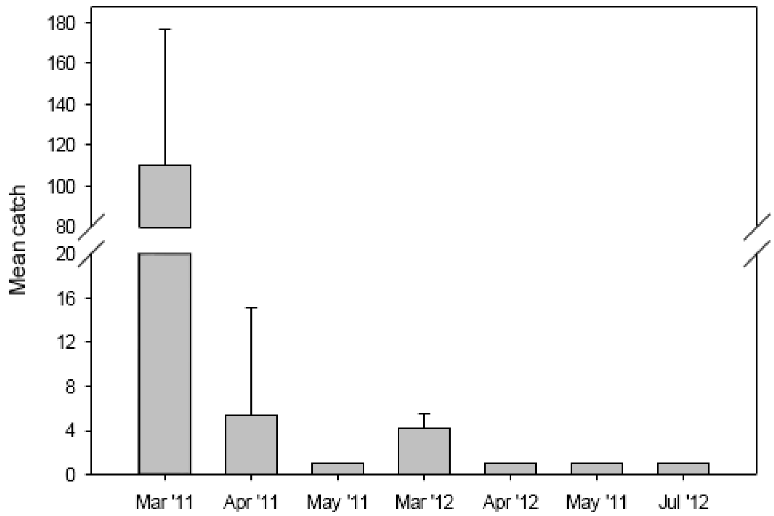

Figure 28. Temporal distribution of eulachon larvae encounters in the Columbia River below Bonneville Dam from 2011 to 2012. Error bars represent one standard deviation from the mean. Figure from Storch *et al.* (2014).

Based on the studies described above, peak abundance of eulachon eggs and larvae in the Columbia River occurs between early March and early May, and non-peak abundance can begin as early as late December and end as late as July. None of these studies had a way to distinguish eggs and larvae that came from tributaries vs. those that came from spawning in the Columbia River itself.

At Bonneville Dam (which is just upstream of the area of the Columbia River designated for the spawning criterion at RM 146), average daily mean temperatures were below the effects threshold for adult eulachon spawning of 10°C until roughly Julian Day 120 (which is April 30 in non-leap years and April 29 in leap years) for the period of 1990 to 1999 (Figure 29). For the modeled scenario of the Columbia River without dams,[39] average daily mean temperatures were predicted to surpass 10°C a few days earlier. In either scenario, regardless of the spawning criterion allowing temperatures up to 13°C between October 31 and March 31, the reach subject to the spawning criterion was likely to be below 10°C for the entire peak spawning period for eulachon and most of the non-peak spawning period. Data for 7DADM temperatures for 1994 to 2013 indicate a similar pattern (Figure 30). Based on the above information, approval of the spawning criterion and its application in the Columbia River is unlikely to increase mortality of adult eulachon.

[39] This was done using RBM10, a peer-reviewed, one-dimensional mathematical model of the thermal energy budget that simulates daily average water temperature under conditions of gradually varied flow. The RBM10 model is documented in an EPA report (Yearsley *et al.* 2001). A second paper (Yearsley 2009) explains the scientific foundation of the model.

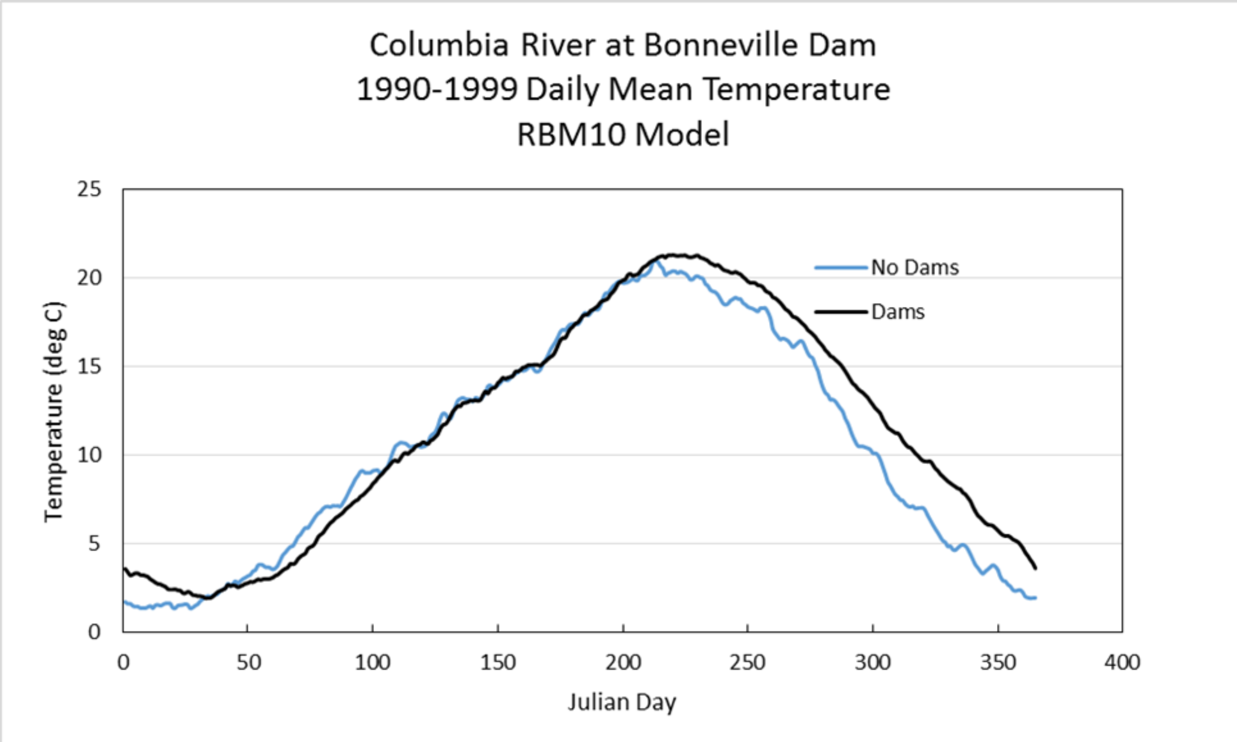

Figure 29. Daily mean temperatures at Bonneville Dam (RM 145) for 1990-1999 with and without mainstem Columbia River Dams. Julian day 200 is July 18 in non-leap years and July 19 in leap years. Source: RBM10 model runs in Excel spreadsheet provided by EPA (March 26, 2015 email from Rochelle Labiosa, EPA, to Jeff Lockwood, NMFS, regarding Columbia River temperature plots.

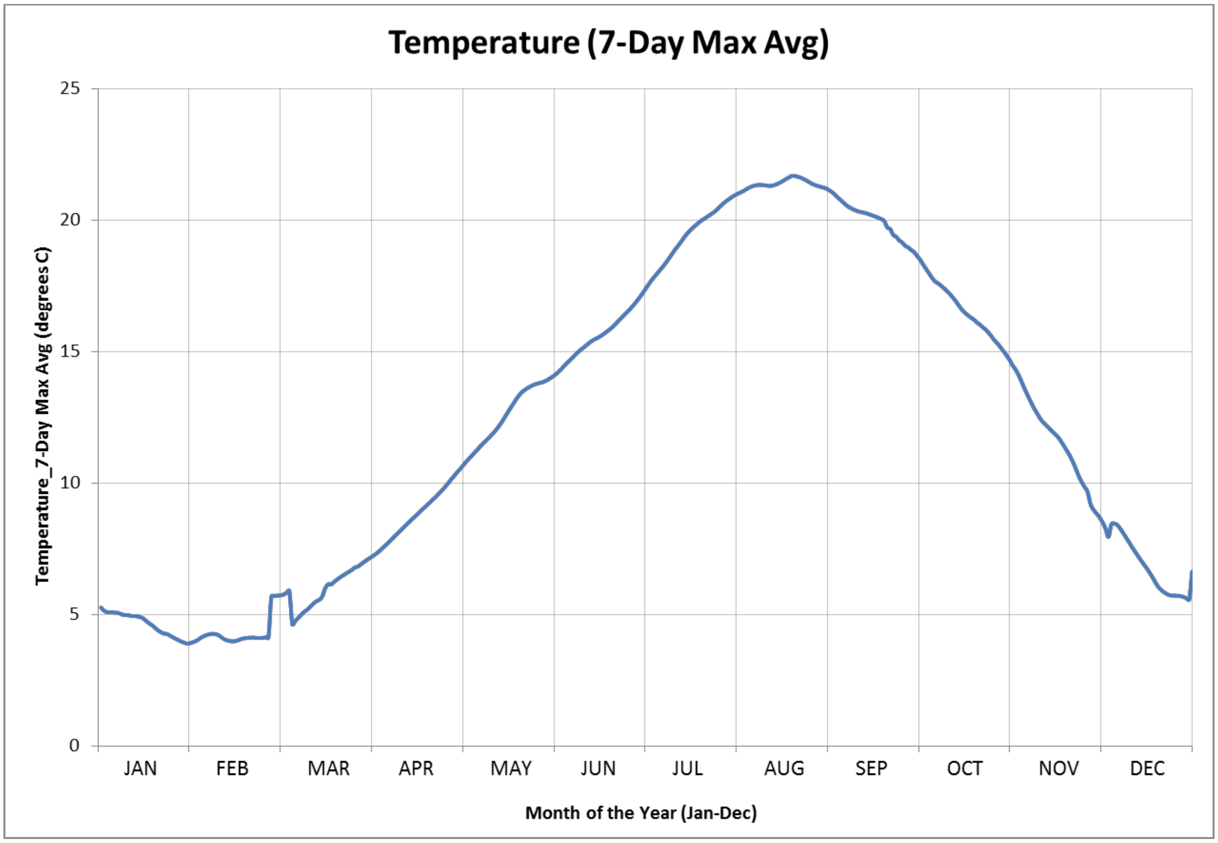

Figure 30. Ten-year average of 7DADM water temperature at Bonneville Dam forebay, 1994 to 2013. Data from Columbia River Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/river_graph_text (accessed August 14, 2014).

As explained above, the spawning criterion of 13°C (7DADM) is likely to prevent adverse thermal effects on eulachon eggs and larvae, including in the Columbia River, even if these life stages were to be exposed to waters at this criterion. In reality, on average, the Columbia river does not approach this value until mid-May (Figure 30), and by that time there are relatively few eggs and larvae left in the river (Figures 27 and 28 above). Overall, we do not expect approval of the 13°C spawning criterion and its application in the Columbia River to affect this species at the scale of the Columbia River subpopulation.

In the Sandy River, spawning generally occurs between late January and late April; peak spawning is in March and early April (Gustafson *et al.* 2010, p. 256). Assuming that eggs incubated for a maximum of 40 days, the approximate peak presence of larvae would be from April 10 (for fish that spawned in early March) to May 17 (for fish that spawned the first week in April). The approximate non-peak presence of larvae would be from March 4 to June 10. Various reports cited by Gustafson *et al.* (2009) estimate that eulachon spawn in the lower 2.5 or 5 miles of the Sandy River, and have been observed as far upstream as RM 13. We consider the area occupied by eulachon in the Sandy River to extend from the confluence of the Columbia

River upstream to the confluence of Gordon Creek which is approximately RM 12.4 (USDC 2011). This reach, which is occupied seasonally by eulachon, is subject to the salmon and steelhead spawning criterion from October 15 to May 15 (DEQ 2003b). This would cover the entire period when adults would be present, and the peak abundance period for eggs and larvae. The remainder of the year, this reach of the Sandy River is subject to the salmon and trout rearing and migration use with a criterion of 18°C as a 7DADM (DEQ 2003c).

We did not have temperature data for the part of the Sandy River occupied by eulachon, but data from the Little Sandy River (Figure 24 above) indicate that this tributary to the Sandy River is well below 10°C (as a daily mean) during the peak period that adult eulachon are present (March to early April). The Lower Sandy River may be somewhat warmer than this during this time, but is likely to be well below the spawning criterion value of 13°C, because as the river originates from glaciers on Mount Hood and is relatively intact in terms of its thermal regime; the segment of the river from Dodge Park to Dabney State Park was designated as a National Wild and Scenic River in October 1988 (USDC 2011).

Based on the above information, we would expect a small number of deaths in pre-spawn adults in the Sandy River. The number of adult deaths is likely to be small because eulachon spawning peaks by early April and generally is over by late April, and the vast majority of eulachon are likely to be present during the peak period. Water temperatures are likely to be cooler than the spawning criterion at this time, for reasons explained above. Also, to meet the salmon and steelhead spawning criterion on May 15 at the downstream extent of the use, the river needs to be cooler than 13°C in April, as well as cooler from the middle reaches to the upstream extent of the use. This will limit the time and space in which adult eulachon are exposed to less than optimal spawning temperatures.

We do not expect any adverse thermal effects on eulachon eggs and larvae due to approval of the spawning criterion and its application in the Sandy River, because adverse effects thresholds for these life stages are approximately 14°C (constant) for incubating eggs, and 18°C (constant) for larvae, both of which are warmer than the spawning criterion of 13°C as a 7DADM. Overall, we do not expect approval of the spawning criterion or its application in the Sandy River to kill enough eulachon to affect this species at the scale of the Columbia River subpopulation.

In Tenmile Creek, critical habitat for eulachon extends from the mouth of Tenmile Creek to the Highway 101 Bridge crossing (USDC 2011). This area, which is occupied seasonally by eulachon, is subject to the salmon and steelhead spawning use with the 13°C criterion from October 15 to May 15 (DEQ 2003d). In Tenmile Creek between 1992 and 2008, a total of 75 eulachon were caught in traps located 0.8 km upstream from the ocean that were designed to catch out-migrating salmonid smolts (unpublished data summarized by Gustafson *et al.* 2010, p. 16 to 17). Eulachon were caught in the traps in 1992 (24), 1993 (six), 1994 (one), 1995 (one), 1996 (one), 2001 (26), 2003 (three), 2005 (10), 2007 (one), and 2008 (two). Eulachon were collected in February (3 years), March (6 years), April (7 years) and May (1 year). The earliest observed arrival was the week of February 3 in 1992, and the last capture was the week of May 21 in 2001. Local biologists suspected the eulachon spawned in the creek based on the trapping location, fish size, and that some fish appeared to be spawned out.

Based on the above information, the peak presence for adults in Tenmile Creek appears to occur in March and April. Assuming the fish spawned soon after capture dates, the peak presence of eggs would be present most years from early February to approximately June 10, and non-peak presence would extend in some years to approximately June 30. Assuming that and that eggs incubated for a maximum of 40 days, and that larvae moved downstream with the river's flow soon after hatching, larvae would be present most years from approximately March 10 to mid-June, and occasionally (in small numbers) through July.

In Tenmile Creek under the spawning use, we would expect a small number of deaths in pre-spawn adult eulachon, only in the occasional years when eulachon adults are present into May. The number of adult deaths is likely to be small because eulachon are only rarely present past April in this stream. Also, to meet the salmon and steelhead spawning criterion on May 15 at the downstream extent of the use, the stream needs to be cooler than 13°C in April and the early part of May, as well as cooler at the upstream extent of the use. This will limit the time and space in which adult eulachon are exposed to less than optimal spawning temperatures.

Regarding eulachon eggs in Tenmile Creek, from early February to May 15 they will be subject to the 13°C spawning criterion, which as we previously explained would protect this life stage from adverse thermal effects. The remainder of the period when eggs likely would be present — from May 15 to June 10 (most years) or June 30 (occasional years) — eulachon eggs will be subject to the salmon and trout rearing and migration criterion of 18°C as a 7DADM (DEQ 2003d). We analyze effects of the 18°C criterion on eulachon following completion of the analysis of the spawning criterion.

The designation of the spawning use in Tenmile Creek from October 15 to May 15 is likely to prevent adverse effects in eulachon larvae. The remainder of the time when larvae are likely to be present (approximately June 11 to July 6), this reach is subject to the salmon and trout rearing and migration use with a criterion of 18°C as a 7DADM (DEQ 2003e), which we analyze following completion of the analysis of the spawning criterion.

The portion of the Umpqua River occupied by eulachon (24.2 miles of the lower Umpqua River) is not subject to the salmon and steelhead spawning criterion, which is only designated upstream. It is subject to the salmon and trout rearing and migration criterion of 18°C as a 7DADM (DEQ 2003f), which we analyze following completion of the analysis of the spawning criterion.

Core Cold Water Habitat Use – 16°C

There is not enough species-specific information to warrant analysis of this criterion by guilds. OAR 340-041-0028(4)(b) includes a 16°C, 7DADM criterion, which translates to an approximate maximum weekly mean temperature of 13°C and an equivalent constant temperature of 14.5°C for comparison to temperatures in laboratory studies of juvenile growth in salmon and steelhead. This criterion is identical to the criterion EPA recommended in the Temperature Guidance (EPA 2003). The intent of this criterion is to protect core cold water habitat, which includes waters that support core rearing for juvenile salmon and steelhead, and pre-spawn holding for adult salmon and steelhead. This criterion was designed to, and is adequate to:

- protect juvenile salmon and steelhead from lethal temperatures (23 to 26°C constant) (citations as in Table 31);
- provide conditions for juvenile growth that are in the optimal range when food is limited (10 to 16°C constant) (citations as in 25);
- protect against temperature-induced elevated disease rates (14 to 17°C constant) (citations as in Table 31);
- provide temperatures that juvenile salmon and trout prefer, as demonstrated by studies indicating fish occur in high densities at these temperatures (10 to 17°C constant, or <18°C 7DADM) (citations as in Table 31);
- protect salmon and steelhead from competitive disadvantage with warm-water species that can occur when mean temperatures are >15°C and maximum temperatures exceed 17 to 18°C (Reeves *et al.* 1987);
- provide conditions that protect Chinook salmon that are holding over the summer prior to spawning in late summer to early fall (EPA 2003); and
- provide a thermal regime that supports juvenile salmon and steelhead populations, as demonstrated by studies indicating moderate-to-high fish densities in waters within this thermal range (10-17°C constant or <18°C 7DADM).

Richter and Kolmes (2005) recommended this criterion along with a 15°C weekly mean criterion for juvenile rearing. However, the authors did not describe how they arrived at the value of 15°C as a weekly mean, or how this criterion specifically would reduce adverse temperature effects in salmon and steelhead relative to their proposed 16.0°C 7DADM criteria. Richter and Kolmes (2005) also did not attempt to analyze what challenges having two different criteria for migration would pose to implementation of the water temperature standard. Nevertheless, most streams meeting a 16°C 7DADM criterion would have a maximum weekly mean temperature of approximately 13°C and therefore meet the recommendations of Richter and Kolmes (2005). A possible exception would be large rivers such as the mainstem Columbia, Willamette and John Day Rivers that do not have much diurnal variation in temperature. However, the 16°C 7DADM criterion was designated only in smaller streams and rivers that commonly are higher in elevation and have colder temperatures.

Stream reaches in which this beneficial use is designated that meet the criterion will be cooler than 16°C most of the time. This is because the stream must meet this criterion as a maximum of daily maximum temperatures measured as a rolling average over the prior 7 days, meaning that all but one or a few, at most, 7-day periods will be cooler than this criterion over the course of a year. Also, the criterion must be met in the warmest years [except for unusually warm conditions as defined in per 340-041-0028(12)(c)], so most years will have 7DADM temperatures below the criterion. Finally, the criterion must be attained at the farthest point downstream where this use is designated, and temperatures generally will be cooler in upstream areas where the criterion applies due the effect of elevation on temperature and the general warming of streams moving from headwaters to larger rivers (Poole and Berman 2001).

We expect the following effects due to EPA approval of this criterion:

- Chinook salmon ― LCR, UWR, SR spring/summer-run, and SR fall-run: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.

- Coho salmon — LCR, OC and SONCC: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.
- Steelhead — LCR, UWR, MCR, and SRB: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.
- CR chum salmon: This criterion is not designated in waters where this species occurs. Therefore, this species will not be affected by EPA's approval of the criterion.
- UCR Chinook salmon, SR sockeye salmon, UCR steelhead, eulachon and green sturgeon: This criterion is not designated where these species occur or in their migratory corridor, so they will not be affected by it at the individual or population scale.

Salmon and Trout Rearing and Migration Use – 18°C

This criterion applies to salmon, steelhead and resident trout. OAR 340-041-0028(4)(c) includes an 18°C 7DADM criterion, which translates to an equivalent maximum weekly mean temperature of 15°C, and a constant temperature of approximately 16.5°C for comparison to juvenile growth studies at constant temperatures. This criterion is identical to the criterion recommended in the Temperature Guidance (EPA 2003). The intent of this criterion is to protect waters with low-to-moderate densities of rearing and migrating salmon and steelhead.

Salmon and Steelhead:

The criterion was designed to, and is adequate to:

- protect against lethal conditions for both juveniles and adults (21 to 22°C constant; citations as in Table 31);
- prevent migration blockage conditions for migrating adults (21 to 22°C average; citations as in Table 31);
- provide near-optimal juvenile growth conditions (under limited food conditions) during summer maximum conditions, and optimal growth conditions during the rest of the year (10 to 16°C constant; citations as in Table 31);
- protect adults and juveniles from high disease risk and minimize the duration of exposure to temperatures that can elevate disease rates (14 to 17°C constant; citations as in Table 31); and
- protect salmon and steelhead from competitive disadvantage with cool- and warm-water species that can occur when mean temperatures are >15°C and maximum temperatures exceed 17 to 18°C (Reeves *et al.* 1987).

For salmon rearing, Richter and Kolmes (2005) recommended a 16°C 7DADM criterion, along with a 15°C weekly mean criterion. For adult migration, Richter and Kolmes (2005) recommended a 18°C 7DADM criterion, along with a 15°C weekly mean criterion. However, the authors did not describe how they arrived at the value of 15°C as a weekly mean, or how this criterion specifically would reduce adverse temperature effects in salmon and steelhead relative to their proposed 16 and 18.0°C 7DADM criteria. Richter and Kolmes (2005) also did not attempt to analyze what challenges having two different criteria for migration would pose to implementation of the water temperature standard.

Salmon and steelhead use waters that are warmer than their optimal thermal range during the summer, and portions of rivers and streams in the Pacific Northwest that historically supported this use most likely were naturally warmer than the optimal thermal range for these fish during the period of summer maximum temperatures (Poole *et al.* 2001a, b). In these warm river reaches, adverse effects on some individual fish are likely to occur, but the criterion is likely to minimize their intensity, frequency and duration. These adverse effects include slower growth of juveniles, increased disease risk, and increased competition and predation from cool- and warm-water species during the period of summer maximum temperatures.

The rivers with the greatest potential for these adverse effects to occur are large rivers with small diurnal variation in temperature, in which fish are exposed to daily mean temperatures in the 16 to 18°C range for multiple days. However, this numeric criterion applies during the warmest times of the summer, the warmest years [except for unusual warm conditions as per 340-041-0028(12(c)], and throughout the water body, including the lowest downstream extent of the waterbody designated for this use, which means that the 7DADM temperatures will be cooler than 18°C most of the times and places where this use occurs. Thus, in many Oregon streams with this criterion, adverse effects on listed salmon and steelhead would be minimal. This is supported by data from DEQ that indicates that many rivers that meet this criterion will experience water temperatures above 15°C only for short periods during a summer, as discussed in the section later in this opinion that addresses effects of approving the beneficial use designations for criterion.

Eulachon:

There is no rearing and migration use specific to eulachon. However, eulachon occur in some waters where the salmon and trout rearing and migration criterion of 18°C applies, so in this section we analyze effects of that criterion on eulachon. We previously identified the following thresholds for adverse thermal effects in eulachon:

- For migrating and spawning adults: a temperature of 10°C (constant)
- For incubating eggs, a temperature of 14°C (constant)
- For larvae, a temperature of 18°C (constant)

Based on the number and relevance of studies we reviewed on thermal tolerance of the various life stages of eulachon, we have the highest confidence in the threshold of adults and the lowest confidence in the threshold for larvae. A temperature criterion of 18°C as a 7DADM in a river meeting this criterion would provide cooler temperatures most of the time than 18°C, and would not exceed 18°C. Based on the above thresholds, eulachon larvae probably will not suffer adverse effects. However, adults and eggs exposed to waters at the 18°C criterion are likely to suffer reproductive failure or death (adults), and abnormal development or death (eggs). The severity and extent of these adverse effects would depend on exposure of the species to waters at this temperature, which we now analyze.

Eulachon in the Sandy River are exposed to the rearing and migration criterion of 18°C as a 7DADM (DEQ 2003c) during the latter part of the period when their eggs likely would be present — from May 16 to June 10 (most years) or June 30 (occasional years). During this time, adults are unlikely to be present, but non-peak abundance of eggs and larvae occurs through early June. We would expect a small number of eggs and larvae (most likely <1% of the yearly run) to die under these conditions. The number of deaths is likely to be this small because the vast majority of eggs and larvae are produced during the peak period. Also, the available information suggests an adverse effects threshold of approximately 18°C for eulachon larvae, although there is some uncertainty around this number. Finally, there are several factors that will limit the time and space in which eulachon eggs will be exposed to harmful temperatures:

- The maximum 7DADM summer temperature of 18°C is unlikely to occur until late July to early August, so temperatures when eulachon eggs and larvae are present would be cooler than 18°C in order to meet the criterion later.
- To meet the 18°C criterion at the downstream extent of the use, the river needs to be cooler from the middle reaches to the upstream extent of the use.
- The stream is likely to climb only slowly above the 13°C mark that it must meet on May 15, as the river originates from glaciers on Mount Hood and is relatively intact in terms of its thermal regime.
- There is only one permitted point source of thermal pollution in the Sandy River — the City of Troutdale. According to DEQ, this source potentially discharges heated water in the January to June period when eulachon adults, eggs or larvae may be present. The Troutdale facility is subject to a thermal limit from the Sandy River TMDL that was designed to protect the beneficial uses related to salmonid fishes.[40] Although a limit related to the 18°C criterion would not fully protect eulachon eggs from adverse effects, the thermal plume criteria (analyzed later in this opinion) would help minimize the portion of the river subject to a mixing zone. Also, as mentioned earlier, limits related to the 18°C criterion would apply only during the non-peak period for eulachon eggs and larvae (during the peak period, the salmonid spawning criterion of 13°C applies).

Overall, we do not expect approval of the 18°C rearing and migration criterion and its application in the Sandy River to kill enough eulachon of any life stage to affect this species at the scale of the Columbia River subpopulation.

As described earlier, the peak presence for adults in Tenmile Creek appears to occur in March and April. Eggs likely are present most years from early February to approximately June 10, and in occasional years to approximately June 30. Assuming that larvae move downstream with the river's flow immediately after hatching, larvae would be present most years from approximately March 10 to June 10, and occasionally to the end of June. Eulachon in Tenmile Creek are exposed to the salmon and trout rearing and migration criterion of 18°C as a 7DADM (DEQ 2003e) during the latter part of the period when their eggs and larvae likely would be present — from May 16 to June 10 (most years) or June 30 (occasional years). We would expect a small number of eggs and larvae (most likely <1% of the yearly run) to die under these conditions. The number of deaths is likely to be this small because the vast majority of eggs and larvae are produced during the peak period. Also, the available information suggests an adverse effects threshold of approximately 18°C for eulachon larvae, although there is some uncertainty around

[40] December 18, 2014 email from Aron Borok, DEQ, to Jeffrey Lockwood, NMFS, regarding point source discharges in the Columbia River.

this number. Finally, there are several factors that will limit the time and space in which eulachon eggs will be exposed to harmful temperatures:

- The maximum 7DADM summer temperature of 18°C is unlikely to occur until late July to early August, so temperatures when eulachon eggs and larvae are present would be cooler than 18°C in order to meet the criterion later.
- The stream is likely to climb only slowly above the 13°C mark that it must meet on May 15, as the second half of May and early June generally are still cool and rainy on the Oregon coast.
- To meet the 18°C criterion at the downstream extent of the use, the stream needs to be cooler from the middle reaches to the upstream extent of the use.
- Point sources of thermal pollution are not a major concern in Tenmile Creek due to a lack of industrialization in the area (USDC 2011), so we do not expect additional deaths due to thermal plumes.

Overall, we do not expect approval of the criteria that apply in Tenmile Creek to kill enough eulachon of any life stage to affect this species scale of the Columbia River subpopulation.

The portion of the Umpqua River occupied by eulachon (24.2 miles of the lower Umpqua River) is subject to the salmon and trout rearing and migration criterion of 18°C as a 7DADM (DEQ 2003f). Various anecdotal evidence summarized by Gustafson *et al.* (2010, p. 16) suggest that in years when adult eulachon are present, they occur in the Umpqua River from December to July. Newspaper accounts reviewed by Gustafson *et al.* (2010) indicate a recreational fishery existed in the lower Umpqua River at least from 1969 to 1982 from January to April. The nearest stream to the Umpqua River for which we have data on eulachon run timing is Tenmile Creek. Assuming that run timing is generally similar in the Umpqua River, the peak presence for adults likely occurs in March and April, with non-peak presence extending into late May. Eggs likely are present most years from early February to approximately June 10, and in occasional years to approximately June 30. The anecdotal information summarized by Gustafson suggest that historically, eulachon adults were present as late as July. Assuming that larvae move downstream with the river's flow immediately after hatching, larvae are likely to be present most years from approximately March 10 to mid-June, and occasionally (in small numbers) through July (based on recent data) or into August (based on historical accounts of run timing).

The area which is occupied seasonally by eulachon extends from the mouth upstream to the confluence with Mill Creek, just below Scottsburg, at RM 24.2 (USDC 2011). In a scenario where the river met the 18°C criterion, water temperatures in this area during the peak presence of eulachon larvae (March 10 through early June) are likely to be less than the 18°C (constant) adverse effects threshold for larvae, since the maximum 7DADM is likely to occur in July or later (Figure 31). Also, numerous tributaries to the lower Umpqua River must meet the spawning criterion of 13°C from October 15 to May 15, providing cold water to the mainstem river. However, it is likely that temperatures will be warmer than the adverse effects thresholds of 10°C (constant) for spawning adults and 14°C (constant) for eggs during at least part of the periods of peak and non-peak presence for each life stage. At temperatures higher than these thresholds, increases in spawning failure and deaths are likely for adults, and increases in developmental abnormalities and deaths are likely for eggs.

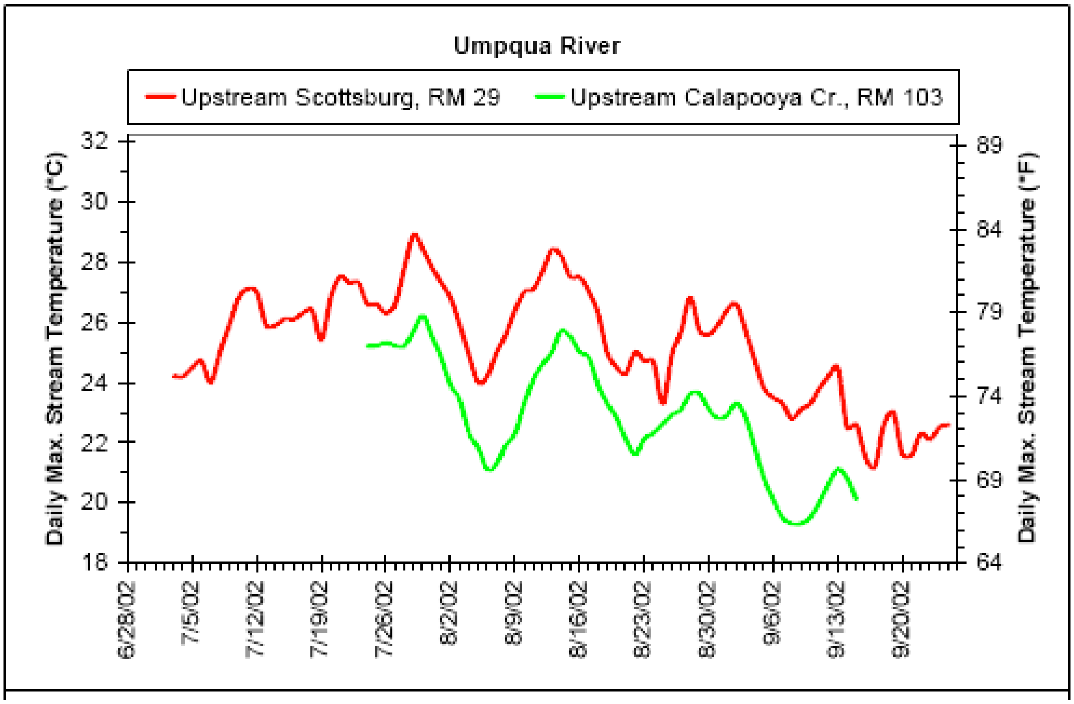

Figure 31. Daily maximum stream temperatures in the Umpqua River. The red line is for a location approximately 4.8 miles upstream of the the reach occupied by eulachon (no information was available for the occupied reach). Figure from DEQ (2006).

Even though adverse effects on eulachon (as described above) are likely in the Umpqua River in the scenario where it is meeting the 18°C criterion, this does not necessarily mean that the river "should be" cooler than this number to reduce these effects. Current maximum summer 7DADM water temperatures are well above 18°C criterion at RM 25 (approximately 27°C), and thermal modeling conducted by DEQ (2006) for the TMDL suggests that modeled natural thermal potenial[41] would be only slightly cooler than this (Figure 32). In other words, even if the model used by DEQ has an error of several degrees, it may not be possible to achieve the numeric criterion in the lower Umpqua River, let alone optimal temperatures for eulachon of <10 to 14°C throughout their spawning and incubation seasons.

[41] "Natural thermal potential" means the determination of the thermal profile of a water body using best available methods of analysis and the best available information on the site potential riparian vegetation, stream geomorphology, stream flows and other measures to reflect natural conditions (OAR 340-041-0002); DEQ (2006), p. 3-III.

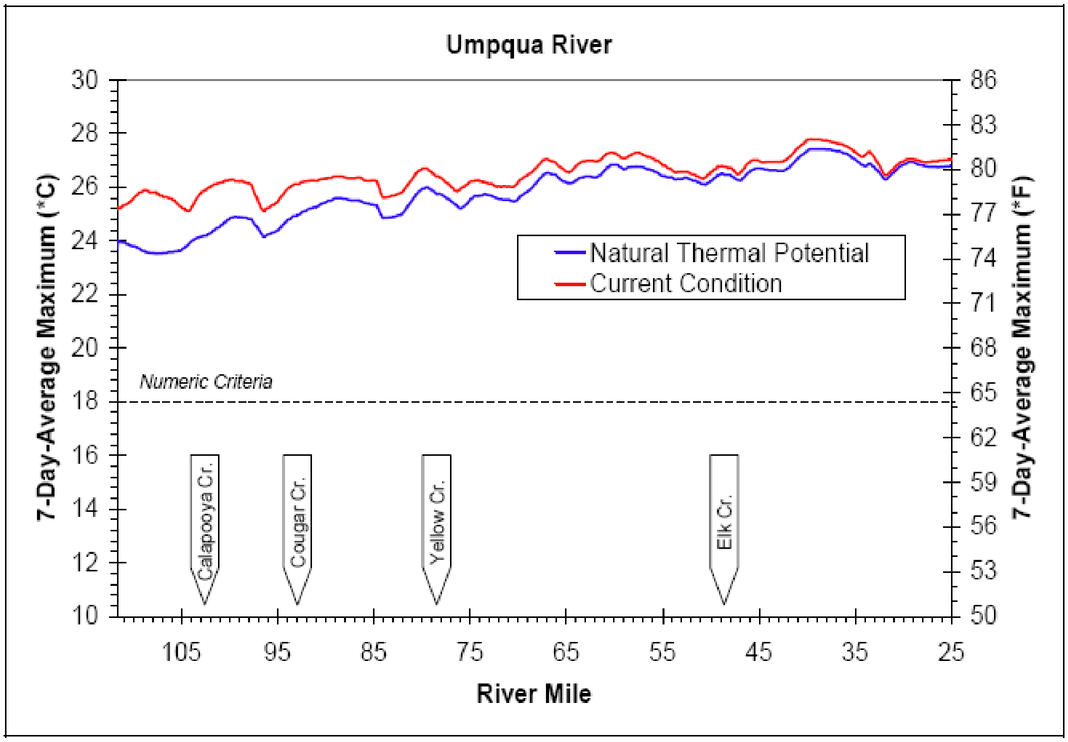

Figure 32. Current and modeled natural thermal potential temperatures for the Umpqua River. RM 25 is approximately 0.8 miles upstream of the reach occupied by eulachon. The DEQ did not model temperatures downstream of RM 25 due to tidal influence. Figure from DEQ (2006).

Eulachon would be at particular risk from thermal plumes from point source discharges that may heat the discharged water towarmer than the applicable criterion within their thermal mixing zones. There are no major NPDES dischargers (i.e, discharges > 106 gal day-1) classified by DEQ in the portion of the Umpqua River occupied by eulachon.[42] However, there are three minor dischargers: Brandy Bar Landing, Inc. (RM 19.8), Reedsport wastewater treatment plant (WWTP; RM 11.5), and Winchester Bay wastewater treatment plant (RM 0.6) (DEQ Umpqua TMDL, p. 3-49).[43] The DEQ provided a summary of information for the three facilities from their NPDES permit evaluation reports (Table 32).

[42] February 11, 2015 email from Aron Borok, DEQ to Jeffrey Lockwood, NMFS regarding NPDES permits in the Umpqua River.
[43] February 25, 2015 email from Aron Borok, DEQ, to Jeffrey Lockwood, NMFS, concerning temperature and IGDO questions.

Table 32. Discharges permitted under NPDES in the lower Umpqua River. Data from August 5, 2015 email from Aron Borok, DEQ to Jeffrey Lockwood, NMFS, regarding Umpqua River discharger data.

Discharge Details	Brandy Bar Landing, Inc.	Reedsport Sewage Plant	Winchester Bay Sewage Plant
Treatment Facility	Activated sludge	Activated sludge	Activated sludge
Discharge Point	Umpqua River – RM 18.8	Umpqua River – RM 11.3	Umpqua River – RM 0.7
Average Dry Weather Design Flow ((10^6 gal day^{-1}))	0.0225	1.9	0.16
7Q10 River Discharge (10^6 gal day^{-1})	80.5	Not available	Not available
Available Dilution	3577:1	35:1	53:1
Maximum Effluent Temperature	23.8°C	20°C	20°C
Maximum Temperature Increase – Edge of Mixing Zone	0.30°C	0.06°C	0.04°C

The discharge at Brandy Bar is small both in absolute terms (0.0225 • 10^6 gal day^{-1}) and relative to the flow of the river (available dilution 3577:1 under dry weather design flow and 7Q10 river discharge). Therefore, it is likely to kill or injure few, if any, eulachon adults, eggs or larvae.

The DEQ has submitted information demonstrating that dilution for the Reedsport sewage treatment plant (STP) likely is very rapid, and that the average effluent temperture of the temperature is warmer than the river temperature during January to April, approximately equal in May, and similar or slightly cooler in June. Data from the USGS stream flow gauge on the Umpqua River in Elkton (which is approximately 45 to 50 miles upstream of Reedsport) show discharges from 9 • 10^9 gal day^{-1} in March to 2 • 10^9 gal day^{-1} in June. The effluent discharge from the Reedsport STP is far less than 1/1000th of that at any given time; also, additional tributaries enter the river below Elkton, likely increasing the river's discharge. Therefore, the thermal plume from the discharge likely would be diluted very quickly. Moreover, the ambient river temperature appears to stay below the 10°C adverse effect threshold for adult eulachon until approximately April. At that time, effluent temperature appears to be only about 2 to 3°C degrees warmer than the river on average, so the effluent should be diluted very rapidly, especially after factoring in the flow of the river. The thermal plume should be less pronounced or non-existent during May and June, when effluent temperatures are similar to river temperatures. Based on the above information, the Reedsport STP may cause some physiological stress to adult (only) eulachon in a small area near the discharge point during the month of April, but is unlikely to kill or injure a biologically significant number of eulachon.

The discharge at Winchester Bay has a fairly high dilution rate (53:1), and a fairly low effluent temperature of 20°C. Also, the discharge is at RM 0.7 where there will be strong tidal currents and marine intrusion, which should quickly disperse the heat under most conditions. Therefore, this discharge is likely to kill or injure few, if any, eulachon adults, eggs or larvae.

In summary, there are only a few point source discharges currently in the Umpqua River reach occupied by eulachon, and none of them are likely to kill or injure a biologically significant number of eulachon. However, new sources that could increase the adverse effects on eulachon are possible. To counter this risk, EPA has developed a conservation measure as part of its proposed action that would highlight to DEQ the importance of minimizing the adverse effects of future discharges on eulachon. The EPA will send a letter to DEQ within 6 months of the signing of this opinion regarding thermal discharges permitted under the NPDES in the Columbia, Umpqua, and Sandy rivers and the protection of eulachon. EPA's letter will raise the importance of applying Oregon's mixing zone water quality standards in order to minimize adverse effects on eulachon, including reference to critical timeframes and temperature thresholds for eulachon identified in this opinion, and highlighting the importance of usin.g technologies (including submerged ports and multi-port diffusers) to limit mixing zone sizes to the smallest extent practicable.

Also, for the lower 24.2 miles of the Umpqua River that exceed 1 million gallons per day in flow and 20°C in temperature, the EPA will request that DEQ provide EPA a copy of all draft NPDES permits, fact sheet and mixing zone analyses for EPA's review consistent with the NPDES memorandum of agreement with DEQ. The EPA will notify NMFS of each draft permits it plans to review by email. The EPA also will provide an annual email status report to NMFS on the implementation of this measure that will include a summary of how each permit issued in the preceding year will minimize adverse effects on eulachon.

The EPA will review all of the draft permit documents subject to this conservation measure that are received over the next 5 years and use its CWA authorities, as necessary, to ensure Oregon's mixing zone water quality standards are applied to minimize adverse effects on eulachon. The 5-year timeframe will provide a record of how to effectively implement the mixing zone limitations to protect eulachon, and will serve as a basis for DEQ's future interpretation and implementation of the limitations. The record also will facilitate EPA's continuing oversight of NPDES permitting actions beyond the 5 years, consistent with EPA's memorandum of agreement on NPDES permits with DEQ (State of Oregon and United States Environmental Protection Agency 2010). We assisted EPA with the development of these measures, and are confident that they are adequate to ensure adverse effects from future discharges in the Umpqua River will be adequately controlled.

Green Sturgeon:

In Oregon, tidal areas of rivers and streams draining into Coos Bay (*i.e.*, Coos River), Winchester Bay (*i.e.*, Umpqua River), Yaquina Bay (*i.e.*, Yaquina River), and the lower Columbia River estuary from the mouth upstream to river kilometer 74, are occupied by green sturgeon (USDC 2009). Based on tagging studies in Willapa Bay, Washington and the Columbia River estuary (Moser and Lindley 2007), green sturgeon likely are present in these estuarine areas from June through September, and thus are likely to be exposed to the 18°C rearing and migration criterion in rivers where it has been applied by DEQ (*e.g.*, Umpqua and Yaquina rivers).

Southern DPS green sturgeon migrate into Oregon from the Sacramento River via the Pacific Ocean and generally are immature (sub-adult) fish, or mature fish that will not spawn in Oregon.[44] One fish of 11 tagged and released by Moser and Lindley (2007) in the Columbia River was a mature female with eggs. Green sturgeon can begin their coastal migration as early as 1 year of age (Moser and Lindley 2007), so data from studies using age 1 fish is relevant to this opinion.

The salmonid rearing criterion is 18° as a 7DADM, and applies in the coastal rivers where green sturgeon occur, other than the Columbia River and several small reaches of the lower Coos River (where the migration corridor criterion of 20° as a 7DADM applies instead). Age 1 green sturgeon held at 24°C (after acclimation to 25°C) had decreased swimming performance compared to those held at 19°C (all constant temperatures), as well as increased metabolic costs and deaths after holding (Mayfield and Cech 2004). Based on the above information, adverse thermal effects for sub-adult green sturgeon are likely to emerge above 19°C (constant). There is no experimental information available for thermal tolerances of sub-adult fish older than 1 year, so we must rely on the information available for age 1 fish, even though these are likely to be a small proportion of the green sturgeon in Oregon.

Juvenile green sturgeon collected in the Klamath River estuary exhibited fast growth at median temperatures between approximately 18°C and 23°C (NMFS 2015c). Adult green sturgeon that reside in the Klamath River over the summer are exposed to similar temperatures and appear to be healthy.[45] In 2004, green sturgeon occurred in Willapa Bay, Washington when mean water temperatures were 11.9 to 21.9°C (Moser and Lindley 2007). Based on the experiments, field data and observations described above, a temperature of 18°C as a 7DADM is unlikely to kill or injure sub-adult or adult green sturgeon. Overall, adverse effects on this species due to approval of the 18°C criterion as a 7DADM and its application in beneficial use designations are unlikely.

<u>Migration Corridor − 20°C With Sufficiently Distributed Cold Water Refugia</u>

Under this criterion "the 7DADM temperature of a stream identified as having a migration corridor use on subbasin maps and tables OAR 340-041-0101 to 340-041-0340: Tables 101B, and 121B, and Figures 151A, 170A, 300A, and 340A, may not exceed 20.0 degrees Celsius (68.0° degrees Fahrenheit). In addition, these water bodies must have CWR that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. Finally, the seasonal thermal pattern in the Columbia and Snake Rivers must reflect the natural seasonal thermal pattern" (OAR 340-041B0001(10)). Oregon defines CWR as portions of a waterbody where, or time

[44] Telephone discussion between Jeff Lockwood, Fishery Biologist, NMFS, and David Woodbury, Green Sturgeon Recovery Coordinator, NMFS, on April 22, 2015

[45] Attachment to April 23, 2015 email from David Woodbury, green sturgeon recovery coordinator, NMFS to Jeffrey Lockwood, NMFS, regarding green sturgeon and water quality criteria.

during the diel temperature cycle when, the water temperature is at least 2°C colder than the daily maximum temperature.

The intent of this criterion is to protect migrating juvenile and adult salmonid fish from lethal temperatures and prevent migration blockage due to thermal conditions. The numeric and narrative provisions of this criterion are consistent with those recommended in the Temperature Guidance (Table 3 in EPA 2003). This criterion applies only in the following river reaches:

- Lower Willamette River (from the mouth to river mile 50)
- Lower John Day River (from the mouth to the confluence with the North Fork John Day River)
- Columbia River mainstem from the mouth to the Washington-Oregon border
- Snake River from the Washington-Oregon border to Hells Canyon Dam
- Lower Little Creek and Catherine Creek in the Grand Ronde River basin
- A short reach of the lower Coos River and two mid- to lower reaches of tributaries to the lower Coos River.

We analyze effects of approving the 20.0°C migration corridor criterion below for (1) salmon and steelhead, (2) eulachon and (3) green sturgeon.

Salmon and Steelhead

There is not enough species-specific information to warrant analysis of this criterion by guilds. Richter and Kolmes (2005, p. 37) reviewed the same information available to the participants in EPA's Temperature Guidance project (as well as information generated in the project) and recommended a 18.0°C criterion (7DADM) for adult migration. However, they also recommended an additional criterion of 16°C measured as a weekly mean to "provide an additional layer of insurance against global and regional environmental challenges including altered flow regimes and water temperatures associated with human activities and projected regional population growth" (Richter and Kolmes 2005, p. 37). However, the authors did not describe how they arrived at the value of 16°C as a weekly mean, or how this criterion specifically would reduce adverse temperature effects in salmon and steelhead relative to their proposed 18.0°C criterion (7DADM). Richter and Kolmes (2005) also did not attempt to analyze what challenges having two different criteria for migration would pose to implementation of the water temperature standard.

Although we too are concerned about the effects of climate change and human population growth on water temperatures, we do not agree that sufficient information is available to support an additional migration criterion based on weekly mean temperatures. Climate change is likely to make it more difficult to attain a biologically protective temperature in migration corridors, but it is not likely to change what constitutes a biologically protective temperature for this use.

For listed salmon and steelhead, the 20°C criterion migration corridor criterion is adequate to: (1) protect against lethal conditions for both juveniles and adults (21 to 22°C constant), and (2) prevent migration blockage conditions for migrating adults (21 to 22°C average) (citations as in Table 31). However, salmon and steelhead exposed to these temperatures are at risk of experiencing the following adverse effects (Reeves et. al. 1987; Berman 1990; Marine 1992; McCullough 1999; Materna 2001; McCullough *et al.* 2001; Sauter *et al.* 2001; Marine and Cech 2004; Laetz *et al.* 2014):

- Increased adult mortality and reduced gamete survival during pre-spawn holding
- Increased disease risk due to increased virulence and reduced resistance
- Reduced growth of juveniles
- Reduced competitive success of rearing juveniles relative to non-salmonid fishes
- Increased predation on juveniles due to increased abundance of non-native, warm-water species
- Delay, prevention, or reversal of smoltification
- Harmful interactions with other habitat stressors such as pH and certain toxic chemicals, the toxicity of which is affected by temperature
- Reduced swimming performance

The severity and extent of these adverse effects would depend on exposure of the species to waters at this temperature, which we analyze later in the discussion of beneficial uses.

The probability that the adverse effects listed above will occur for salmon and steelhead depends not only on the criterion value but also on the exposure of the species, which in turn depends their life history and migration patterns, as well as the effectiveness of the narrative criteria in protecting CWR and ensuring that the natural seasonal thermal pattern exists in the Columbia and Snake Rivers. We assess the effectiveness of the narrative criteria for protecting salmon and steelhead immediately following discussions of the effects of approving the 20°C migration corridor criterion numeric criteria on eulachon and green sturgeon. We then assess the likelihood of exposure of the listed species of salmon and steelhead to the numeric migration corridor criterion in an evaluation of the beneficial use designations for the numeric criteria.

Eulachon

Columbia River: As explained earlier, In the Columbia River, only the 2-mile long reach from Beacon Rock to upstream of Ives Island (RM 141.5 to RM 143.5) is subject to the salmon and steelhead spawning criterion, which is designated from October 15 to March 31 (DEQ 2003a). The remainder of the year, and in the rest of the Columbia River, the river reach seasonally occupied by eulachon is covered by the salmon and steelhead migration corridor criterion of 20°C as a 7DADM (DEQ 2003a).

In the Columbia River, peak abundance of adult eulachon generally is from early February to late March (Gustafson *et al.* 2010, p. 256), although it may occur as late as April (Bargman *et al.* 2005). Non-peak spawning in the Columbia River can begin as early as December and extend into mid-May (Gustafson *et al.* 2010, p. 256).

As stated earlier, we previously identified the following thresholds for adverse thermal effects in eulachon:

- For migrating and spawning adults: a temperature of 10°C (constant)
- For incubating eggs, a temperature of 14°C (constant)
- For larvae, a temperature of 18°C (constant)

Based on the number and relevance of studies we reviewed on thermal tolerance of the various life stages of eulachon, we have the highest confidence in the threshold of adults and the lowest confidence in the threshold for larvae. Based on the above thresholds, eulachon exposed to waters at the 20°C criterion are likely to suffer reproductive failure or death (adults), abnormal development or death (eggs) or death (larvae).

Under recent conditions (2010 to 2014), the 7DADM temperature of the Columbia River (as measured at Bonneville Dam) generally were below 10°C (7DADM) during the peak spawning period of March to April (Table 33). Therefore, conditions likely were cooler than the 10°C (constant) threshold for adverse effects on spawning adult eulachon. However, the criterion does not ensure that this condition will continue, and point source discharges are allowed to bring the river temperature to 20°C at the edge of their thermal mixing zones or to higher temperatures inside their mixing zones outside of the summer maximum period and outside of active salmonid spawning areas, which only occur in the 2-mile long reach from Beacon Rock to upstream of Ives Island (RM 141.5 to RM 143.5). The narrative criterion pertaining to thermal plumes (which we analyze later in this opinion) may reduce effects from point-source discharges to some extent, but that criterion was not designed to protect eulachon. As a result eulachon are at risk of increased reproductive failure and death (adults), developmental abnormalities and death (eggs), and increased death (larvae).

Table 33. Summary of 7DADM water temperature patterns during the late spring and early summer in the Columbia River at Bonneville Dam, 2010-2014. Data from Columbia River DART program via August 20, 2014 email from Chris Van Holmes, DART Coordinator, to Jeffrey Lockwood, NMFS.

Temperature Event	**2010**	**2011**	**2012**	**2013**	**2014**
Date 7DADM temperature exceeded 10°C		08 May	26 April	27 April	22 April
Date 7DADM temperature exceeded 13°C	14 May	06 June	20 May	12 May	18 May
Date 7DADM temperature exceeded 14°C	06 June	14 June	06 June	16 May	23 May
Date 7DADM temperature exceed 18°C	11 July	25 July	15 July	02 July	04 July
Date of maximum 7DADM temperature in July	31 July (20.9°C)	31 July (18.9°C)	31 July (19.5°C)	30 July (21.3°C)	31 July (21.1°C)

The NPDES discharges in the vicinity of the Columbia River are shown in Figures 33 and 34. They include:

- City of Gresham (discharges to Columbia River)
- Boise White Paper/City of Saint Helens (discharges to Multnomah channel)
- Dyno Nobel (discharges to Columbia River)
- Port of Saint Helens (discharges to Columbia River)
- Georgia-Pacific Wauna Mill (discharges to Columbia River)
- City of Astoria sewage treatment plant (discharges to Columbia River)

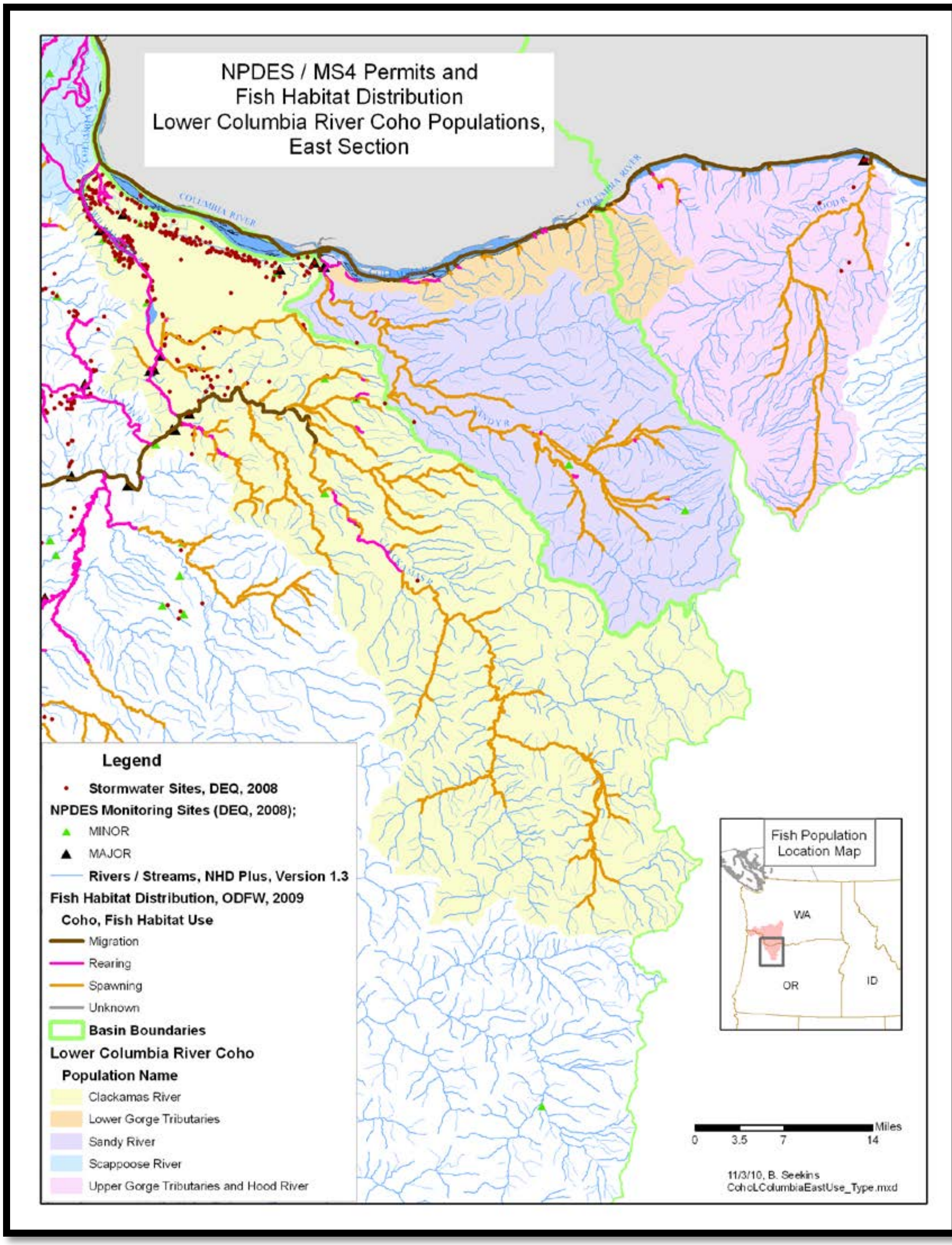

Figure 33. NPDES and stormwater discharges in the Lower Columbia River, east section.

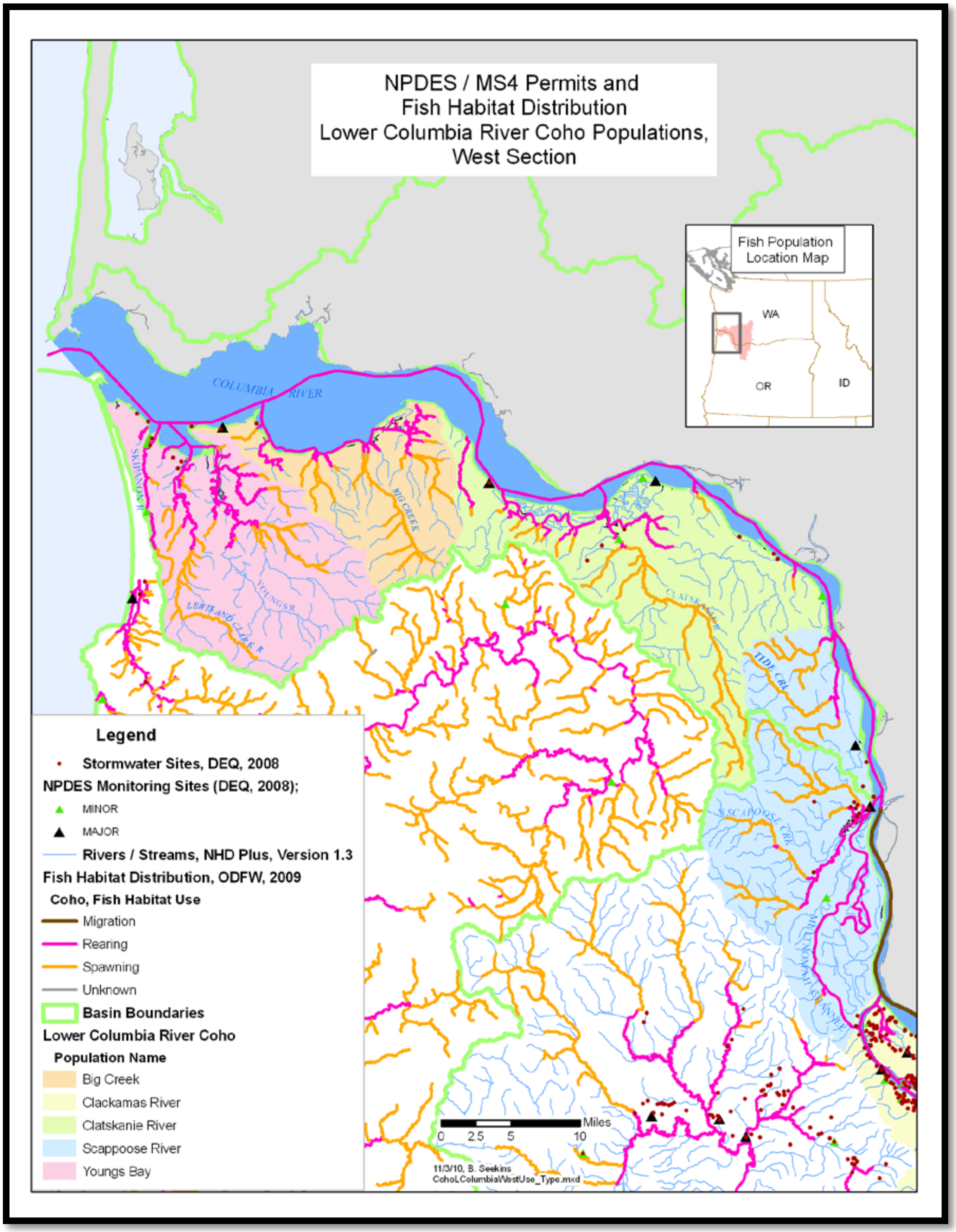

Figure 34. NPDES and stormwater discharges in the Lower Columbia River, west section.

At our request, EPA analyzed six point-source discharges to the lower Columbia River in Oregon that NMFS identified as affecting eulachon. It obtained the mixing zone reports for five major dischargers and a dilution analysis conducted for a hypothetical discharge by the National Council for Air and Stream Improvement (NCASI). A report was not readily available for the sixth point source identified by NMFS (i.e., Port of Saint Helens); however, monitoring information indicated that this facility has a significantly lower flow than the other facilities, and therefore EPA did not include it in the analysis.

The EPA used dilution-with-distance and plume-width estimates from the mixing zone reports, which are typically found in model output data in the report appendices, and similar information from the NCASI report. Using these dilution estimates, EPA evaluated the plumes with respect to ambient water temperature and thresholds of concern for eulachon. The EPA estimated plume conditions and sizes with the ambient river temperature at 8°C (to address eulachon adults from February to April), 10°C (to address eulachon adults and eggs in April), and 14°C (to address eulachon larvae in late May). For the 14°C run, EPA estimate the upstream and downstream distances and river widths where the plume temperatures drop below the 18°C threshold that NMFS identified for eulachon larvae. For the 10°C run, EPA estimated the upstream and downstream distances and river widths where the plume temperatures drop below 12°C (a threshold EPA selected) and below the 14°C threshold NMFS identified for eulachon eggs. For the 8°C run, EPA estimated the upstream and downstream distances and river widths where the plume temperatures drop below the 10°C threshold that NMFS identified for eulachon adults. EPA did not possess the model files for the mixing zone studies nor the resources to re-analyze all discharges, so it could not run the models under the specific ambient conditions and scenarios of concern. Therefore, the calculations were a screening-level extrapolation to seasons/conditions (spring) that are different from the conditions of concern for the permits (period of lowest river flow). For this reason, they are not necessarily the worst case estimates. Although generally higher flows in spring could mean that the plumes are subject to higher dilution at that time of year than EPA assumed, it is difficult to generalize the effect of higher flows on the thermal plume dimensions, because each outfall design will respond differently to changes in flow.

The summary results of this analysis are included in Table 34. Additional details for each facility are contained in Appendix A.

Table 34. Summary of discharge characteristics and thermal plume dimensions for major NPDES permits and a hypothetical NPDES permit in the Columbia River. Table from September 30, 2015 memorandum from Ben Cope, EPA to Rochelle Labiosa and John Palmer, EPA, as transmitted in September 30, 2015 email from Rochelle Labiosa, EPA to Jeff Lockwood, NMFS.

Facility	Multi-Port Diffuser?	Facility Flow (10^6 gal day^{-1})	Discharge Temp. (°C)	Ambient Temp. (°C)	Temp. Threshold (°C)	Downstream Distance to Threshold (m)	Width of Plume (m)	Plume as % of River Width
Georgia - Pacific Wauna Mill	Y	41	33.6	14	18	7	54	6%
				10	14	7	54	6%
				10	12	56[4]	54	6%
				8	10	47[4]	54	6%
Dyno Nobel	N	22	30.4[1]	14	18	221[4]	226[4,6]	25%
			26.4[1]	10	14	221[4]	226[4,6]	25%
			26.4[1]	10	12	333	291[6]	32%
			24.4[1]	8	10	333	291[6]	32%
Boise White Paper/City of Saint Helens	Y	11.4	27.1	14	18	2	10	1%[3]
				10	14	2	10	1%[3]
				10	12	3	17	2%[3]
				8	10	3	17	2%[3]
City of Gresham	Y	25	25.4	14	18	2	18	7%[2]
				10	14	2	22	9%[2]
				10	12	3	29	12%[2]
				8	10	3	29	12%[2]
City of Astoria	N	4.2[5]	25	14	18	2	1	< 0.1%
				10	14	2	1	< 0.1%
				10	12	4	2	< 0.1%
				8	10	5	2	< 0.1%
NCASI Hypothetical	Y	43	36	14	18	2	87	9%[3]
				10	14	2	87	9%[3]
				10	12	3	87	9%[3]
				8	10	3	87	9%[3]

[1] EPA assumed effluent temperature to be 16.4°C greater than the ambient temperature based on data submitted by the facility in discharge monitoring reports. The mixing zone modeling report estimated this differential to be 6 to 10°C.
[2] Percent of river channel between outfall and McGuire Island (244 m).
[3] River width not reported. EPA assumed river width is 1000 m.
[4] Model output is not detailed in terms of dilution-with-distance. Value is interpolated.
[5] Value shown is permitted design flow of facility. Model results are for a flow of 3.4 x 10^6 gal day^{-1}.
[6] These values are based on a doubling of the values labeled as plume "top hat half-width" in the model output. See discussion of this issue in Appendix 1 for more information.

For the facility plumes examined, downstream distance to threshold, width of plume, and plume as percent of river width generally were related to discharge volume and temperature. Plumes from Boise White Paper/City of Saint Helens, City of Gresham, and City of Astoria appear to be rapidly dispersed and are unlikely to kill many eulachon or significantly interfere with migration. The plume from Georgia Pacific's Wauna Mill is large enough to kill or injure some eulachon or interfere with their migration, but at 6% of the river width likely is too small to reduce the abundance or productivity of eulachon at the scale of the Columbia River subpopulation as most of the fish will be found in the larger unaffected portion of the river. The NCASI plume is roughly similar to the plume from Georgia Pacific's Wauna Mill, and confirms to some extent that EPA's projections for the latter plume are reasonable.

The plume from the Dyno Nobel facility stands out from those of the other facilities as significantly greater in all three dimensions, and this is most likely because this facility discharges to the Columbia River through a 6-m wide surface canal, rather than through a multi-port diffuser like the other facilities. Since there is no diffuser, the dilution-with-distance from the outfall (canal) is much lower than a submerged diffuser outfall would provide, and the surface expression of the plume is more pronounced (see Figure 2 in Appendix A). Depending on ambient temperature and the temperature threshold of interest, the plume cools to the threshold at a distance of 221 to 333 m downstream from the point of discharge, is 226 to 291 m wide, and occupies 25 to 32% of the river's width. Even though this plume is above threshold temperatures for a quarter to almost a third of the river's width, and is large enough and warm enough to kill or injure some eulachon or interfere with their migration, it has been in place since 1966, and has been about as warm and as large as it is now for at least 20 years.[46] We do not have data on exactly how many eulachon this discharge actually kills or injures. However, the available data shows abundance of eulachon has varied by over two orders of magnitude while this discharge has been in place (Figure 3). This discharge, in combination with other Columbia River discharges, is unlikely to be the driving cause of this population-scale variability in the Columbia River subpopulation of eulachon.

The current NPDES discharges in the Columbia River together are not large enough to reduce the abundance or productivity of eulachon at the scale of the Columbia River subpopulation, and are spaced far enough apart that their mixing zones do not overlap. The temperature standard does not prevent additional future point-source discharges that could affect eulachon. However, the EPA has developed a conservation measure as part of its proposed action that would highlight to DEQ the importance of minimizing the adverse effects of future discharges on eulachon. The EPA will send a letter to DEQ within 6 months of the signing of this opinion regarding thermal discharges permitted under the NPDES in the Columbia, Umpqua, and Sandy rivers and the protection of eulachon.[47] EPA's letter will raise the importance of applying Oregon's mixing zone water quality standards in order to minimize adverse effects on eulachon, including reference to critical timeframes and temperature thresholds for eulachon identified in this opinion, and highlighting the importance of usin.g technologies (including submerged ports and multi-port diffusers) to limit mixing zone sizes to the smallest extent practicable. The letter will request that the DEQ issue an administrative order or re-issue the NPDES permit for Dyno

[46] September 17, 2015 email from Debra Sturdevant, DEQ, to Jeff Lockwood, NMFS, regarding eulachon RPM.
[47] October 27, 2015 letter from Christine Psyk, EPA to Kim Kratz, NMFS, regarding an amendment to EPA's proposed action to include a conservation measure to protect eulachon from thermal plumes in Oregon waters.

Nobel within 2 years of the issuance of this opinion to address the current adverse effects on eulachon from the thermal plume associated with this discharge. The EPA also will recommend that the DEQ prioritize the NPDES permit for Georgia Pacific's Wauna Mill for reissuance.

Also, for Columbia River discharges below Bonneville Dam and in the lower 24.2 miles of the Umpqua River that exceed 1 million gallons per day in flow and 20°C in temperature, the EPA will request that DEQ provide EPA a copy of all draft NPDES permits, fact sheet and mixing zone analyses for EPA's review consistent with the NPDES memorandum of agreement with DEQ.[48] The EPA will notify NMFS of each draft permits it plans to review by email. The EPA also will provide an annual email status report to NMFS on the implementation of this measure that will include a summary of how each permit issued in the preceding year will minimize adverse effects on eulachon.

The EPA will review all of the draft permit documents subject to this conservation measure that are received over the next 5 years and use its CWA authorities, as necessary, to ensure Oregon's mixing zone water quality standards are applied to minimize adverse effects on eulachon. The 5-year timeframe will provide a record of how to effectively implement the mixing zone limitations to protect eulachon, and will serve as a basis for DEQ's future interpretation and implementation of the limitations. The record also will facilitate EPA's continuing oversight of NPDES permitting actions beyond the 5 years, consistent with EPA's memorandum of agreement on NPDES permits with DEQ (State of Oregon and United States Environmental Protection Agency 2010). We assisted EPA with the development of these measures, and are confident that they are adequate to ensure adverse effects from future discharges in the Columbia River will be adequately controlled.

Outside of thermal mixing zones, under current conditions the few larvae from late-spawning eulachon that remain in the river until July will be exposed to potentially lethal temperatures above 18°C beginning in early to mid-July most years (Figure 29). This is unlikely to change much, if any, if the river were to meet the 20°C criterion, or even if it was restored to pre-dam conditions (Figure 29). These temperatures likely are lethal to eulachon larvae for exposures exceeding 1 to 24 hours. However, very few larvae, if any, are present in July (Figures 27 and 28).

Green Sturgeon:

Green sturgeon are likely to be exposed to the 20°C 7DADM criterion where it is designated in the Columbia River from the mouth of the river upstream to Bonneville Dam, and in several small reaches of the lower Coos River. As stated above, experimental evidence suggests adverse thermal effects for green sturgeon are likely to emerge above 19°C (constant), so adverse effects on this species due to approval of the 20°C criterion as a 7DADM are possible. These adverse effects (reduction in swimming speed, increased metabolic costs and delayed mortality; Mayfield and Cech 2004) occurred at a test temperature of 24°C (constant) compared to 19°C (constant), and there was no data specific to a temperature of 20°C. Adverse effects at 20°C could include

[48] October 27, 2015 letter from Christine Psyk, EPA to Kim Kratz, NMFS, regarding an amendment to EPA's proposed action to include a conservation measure to protect eulachon from thermal plumes in Oregon waters.

slight reductions in swimming performance or increases in metabolic costs that are so small that they are likely to be insignificant in terms of effects on survival or eventual reproductive success.

Adult green sturgeon that reside in the Klamath River over the summer are exposed to similar temperatures and appear to be healthy.[49] In 2004, green sturgeon occurred in Willapa Bay, Washington when mean water temperatures were 11.9 to 21.9°C (Moser and Lindley 2007). Based on the experiments, field data and observations described above, it is unlikely that approval of the migration corridor criterion of 20°C as a 7DADM and its application through beneficial use designations in the Columbia and Coos Rivers will reduce the numbers, reproduction or distribution of green sturgeon at any scale.

Effectiveness of Narrative Criterion for Migration Corridor Use:

The narrative criterion for the migration corridor states that:

> In addition, these water bodies must have coldwater refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. Finally, the seasonal thermal pattern in the Columbia and Snake Rivers must reflect the natural seasonal thermal pattern.

Oregon defines CWR as portions of a waterbody where, or time during the diel temperature cycle when, the water temperature is at least 2°C colder than the daily maximum temperature.

The EPA's BE states that "USEPA expects the cold water refugia provision to be primarily considered in NPDES permits and TMDLs." In our November 25, 2013 letter to EPA, we asked EPA if it was aware of CWR being incorporated into any existing NPDES permits. In its February 21, 2014 response to our letter, EPA stated that "EPA has no direct information that cold water refugia have been included in NPDES permits. EPA would expect that consideration of cold water refugia would, if incorporated, be included in permits located on the Lower Willamette and John Day (although few permitted sources are located in the John Day), Snake, and Columbia Rivers." In a March 27, 2014 email from John Palmer, EPA, to Jeff Lockwood, NMFS, EPA explained that it had examined four NPDES permits/fact sheets pertaining to the lower Willamette River where the CWR criterion applies.[50] In only one permit was the CWR narrative criterion addressed — Blue Heron paper. The fact sheet for that permit refers to a study that found no CWR in the area surrounding the permitted outfall.[51] Based on these examples, we surmise that DEQ has not implemented the narrative criterion for NPDES permits consistently, if at all.

Regarding TMDLs, the BE states that:

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[49] Attachment to April 23, 2015 email from David Woodbury, Green Sturgeon Recovery Coordinator, NMFS to Jeffrey Lockwood, Fishery Biologist, NMFS, regarding green sturgeon and water quality criteria.

[50] These were for Blue Heron Paper Company, the City of Canby, the City of Newberg, and the City of Wilsonville.

[51] Fact sheet available at http://www.deq.state.or.us/wqpr/2232_2009121700007CS04.PDF

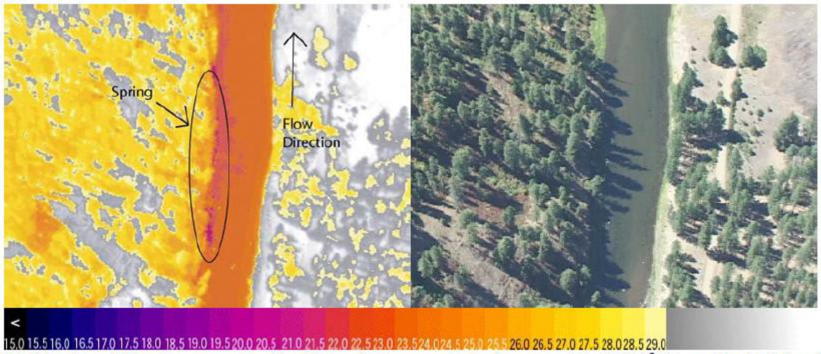
> When applying this narrative criterion in the context of a TMDL, the existing cold water refugia will be identified and determined [*sic*] whether or not they are sufficient to protect the use… If the existing cold water refugia is insufficient to protect the use, then additional cold water refugia sufficient to protect the use would also be identified and expressed in numeric terms in the TMDL.

We received additional information on DEQ's iplementation of the narrative criterion in a February 21, 2014 letter from Christine Psyk, EPA to Paul Henson, U.S. Fish and Wildlife Service, and Kim Kratz, NMFS. The information in this section is based on that letter.

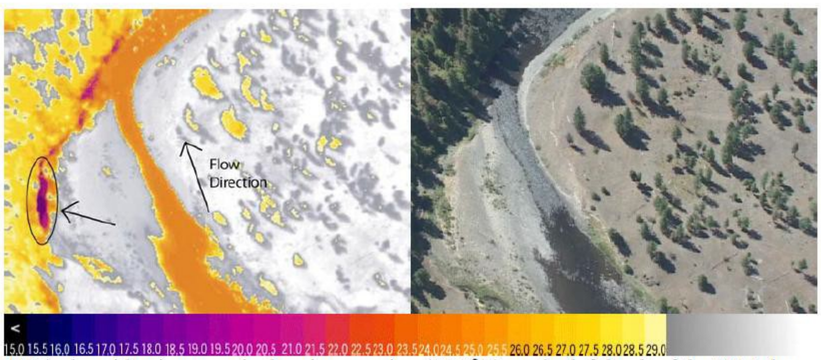
The DEQ has completed two TMDLs that were subject to this criterion: the Willamette Basin TMDL in 2008, and the John Day Basin TMDL in 2010. The Willamette River TMDL discusses on p. 4 to 11 the CWR criterion and types of possible CWR in the lower 50-mile portion of the Willamette River where the criterion applies. However, it only identifies two specific sources of cold water (Tryon Creek and Stephens Creek), and does not state whether these streams meet the definition of CWR or whether the would be protected through implementation of the TMDL.

The Willamette River TMDL implementation plan states that the designated management agencies (DMAs) need to address CWR in their TMDL implementation plans. DMAs that may be covered by this requirement include cities and counties, Oregon Department of Transportation, and the U.S. Army Corps of Engineers. The EPA's February 21, 2014 letter states that it is not aware of a specific action in any DMA implementation plan to address CWR.

The John Day Basin Temperature TMDL did not explicitly discuss the CWR criterion. However, the TMDL did identify springs supplying cold water to the river, some of which meet DEQ's definition of CWR (DEQ 2010, p. 52). The DEQ used airplanes to collect thermal infrared (TIR) data on temperatures of mainstem rivers and significant tributaries in the basin. Figure 35 below shows two examples of TIR results from the North Fork John Day River basin. The pink areas show where water cooler than ambient temperatures water is present in the river. The DEQ used the data from the six coldest springs to calibrate the HeatSource water temperature model.



TIR/color video image pair showing what appears to be a spring (20.4°C) on the left bank of the NF John Day River (22.3°C) at river mile 49.1 The apparent source of the spring is in the shadows on the color video image, which confounds the interpretation. However, a cool water plume extends downstream beyond the visible shadows suggesting an inflow *(frame: nfjd1339).*



TIR/color video image pair showing a spring (22.3°C) on the left bank of the NF John Day River (23.4°C) at river mile 46.3 *(frame: nfjd1445).*

Figure 35. Examples of thermal infrared images from the North Fork John Day River basin. Source: DEQ (2010).

The TMDL implementation management plan for the John Day River does not specifically discuss CWR; however, on p. 140-141 it does describe riparian restoration and channel condition improvements needed for restoring temperatures in the John Day River that could increase the availabilty and function of CWR. In the load allocation surrogate for channel morphology, the plan calls for “all reasonable efforts toward achieving a natural channel form, in terms of sinuosity, complexity, floodplain connectivity and cross-sectional dimension.” Achieving these channel attributes likely would increase the availability of CWR.

According to EPA’s February 21, 2014 letter, DEQ river basins subject to the CWR criterion where TMDLs have not been completed include the Columbia River and the South Coast, which includes the lower portions of the Coos and Coquille Rivers. Temperature TMDLs for the Snake River (Hells Canyon) and Upper Grande Ronde (Catherine Creek) were issued before the CWR provison was in effect. When these TMDLs are revised in the future they will need to address this criterion.

Overall, the narrative criterion pertaining to CWR does not, to date, appear to be an effective means for minimizing the adverse effects likely to be experienced by migrating salmon and steelhead under the 20°C migration corridor criterion. In the Willamette River TMDL, the DEQ mentions only two specific streams as possibly providing refugia, even though substantial research on off-channel habitats that may provide such refugia has been done in this river. The John Day River TMDL does not even attempt to directly address the narrative criterion. Also, according to EPA, the state has not provided any analyses of or determinations as to the part of the narrative criterion that requires that CWR "are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body".[52] The DEQ apparently has not released any work on CWR in the Columbia River.

In our November 25, 2013 letter to EPA, we also asked EPA if it had any information about how the narrative provision regarding the natural seasonal thermal pattern (NSTP) in the Columbia and Snake Rivers has affected water temperatures in these rivers since 2004. The EPA explained that the NSTP criterion is under consideration in Oregon's CWA section 401 certification of the Hells Canyon Complex FERC re-license. The EPA and NMFS have been actively involved in the Hells Canyon Complex FERC re-license process and have provided comment to Oregon and the Idaho Power Company on the application of the NSTP.

The Hells Canyon Snake River Temperature TMDL was completed prior to adoption of the NSTP, so NSTP was not addressed in that TMDL. The EPA initiated work on a Columbia/Lower Snake temperature TMDL prior to the adoption of the NSTP, but that work has been suspended. Therefore, the only regulatory context in which the NSTP has been considered since 2004 is in the Hells Canyon Complex FERC re-licensing. The NSTP should also be considered in the Army Corps of Engineers' operational plan for the Columbia River Federal dams for compliance with water quality standards, but EPA said it is unware of the extent to which it has been addressed in this plan.

The final beneficial use provision from OAR 340-041-0028 that the EPA proposes to approve is shown in the numbered, indented paragraph below:

> (5) Unidentified Tributaries - For waters that are not identified on the fish use maps and tables referenced in Section (4) of Oregon's rule, the applicable criteria for these waters are the same criteria as is applicable to the nearest downstream water body depicted on the applicable map.

As explained earlier, DEQ used biologically conservative rules for designating beneficial uses, and we are not aware of any significant tributaries that were not designated for the appropriate fish uses. We do not expect this aspect of the beneficial use designations to result in any deaths or injuries of individual fish of any listed species, or to have any effects at the population scale for any of these species.

[52] June 10, 2014 conference call between Jeff Lockwood and others (NMFS) and John Palmer and others (EPA) regarding the Oregon water temperature consultation.

Narrative Criterion for Protecting Cold Water

The EPA proposes to approve the following narrative criterion for protecting cold water from OAR 340-041-0028 shown in the numbered, indented paragraphs below:

> (11) Protecting Cold Water
>
> (a) Except as described in Subsection (c) of Oregon's rule, waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria in Section (4) of Oregon's rule, may not be warmed by more than 0.3°C (0.5°F) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present.
>
> (b) A point source that discharges into or above salmon & [*sic*] steelhead spawning waters that are colder than the spawning criterion, may not cause the water temperature in the spawning reach where the physical habitat for spawning exists during the time spawning through emergence use occurs, to increase more than the following amounts after complete mixing of the effluent with the river:
>
> (A) If the rolling 60 day average maximum ambient water temperature, between the dates of spawning use as designated under Subsection (4)(a) of Oregon's rule, is 10 to 12.8°C , the allowable increase is 0.5°C above the 60 day average; or
>
> (B) If the rolling 60 day average maximum ambient water temperature, between the dates of spawning use as designated under Subsection (4)(a) of Oregon's rule, is less than 10°C , the allowable increase is 1.0°C above the 60 day average, unless the source provides analysis showing that a greater increase will not significantly impact the survival of salmon or steelhead eggs or the timing of salmon or steelhead fry emergence from the gravels in downstream spawning reach.
>
> (c) The cold water protection narrative criteria in Subsection (a) of Oregon's rule does not apply if:
>
> (A) There are no threatened or endangered salmonids currently inhabiting the water body;
>
> (B) The water body has not been designated as critical habitat; and
>
> (C) The colder water is not necessary to ensure that downstream temperatures achieve and maintain compliance with the applicable temperature criteria.

The above narrative criterion for "protecting cold water" is consistent with a recommendation in the Temperature Guidance (EPA 2003) to include a provision in water quality standards to protect waters that are currently colder than the biologically-based numeric criteria.

According to EPA, in many TMDLs, the cold water protection provisions are cited as an applicable criterion that the TMDLs must meet. For example, the John Day Basin TMDL (p. 59, 65, and 72), Willamette Basin TMDL (p. 4-85 and 4-100), Umpqua Basin TMDL (p. 3-24, 3-56, and 3-75), Rogue Basin TMDL (p. 2-5), and Lower Grande Ronde TMDL (p. 2-1) all include references to the protection of cold water. TMDLs, however, are focused on restoring temperature for waters that currently exceed temperature criteria. For rivers where the cold water protection criterion applies (*e.g.*, rivers with salmon where current temperatures are below the numeric criteria) either the existing temperature functions as the effective temperature criterion, or the TMDL surrogate load allocation (*e.g.*, site potential vegetation and natural flow and channel morphology) applies if DEQ estimates it will result in temperatures cooler than existing temperatures.

The EPA analyzed Oregon DEQ temperature data from 2000 to 2010 (from May 1 to October 31, only sites with data spanning the months of July and August) to characterize the extent to which the cold water criterion is applicable in waters where the 18°C numeric criterion applies. All of the temperature data was collected continuously for at least 7 days, is of known quality (either A+ level data collected by DEQ that meets quality control limits, or A level data submitted by entities outside of DEQ that meets quality control limits), and was submitted to Oregon DEQ's Laboratory Storage and Retrieval database. For each continuous sample event the 7DADM temperature (°C) was computed. EPA found 25 sample locations (32 sampling events) where the 7 DADM temperature was <15°C (see Table 2 in EPA supplemental information, Appendix A). EPA also found 52 sample locations (62 sample events) where the 7 DADM temperature was equal to or >15°C, but <18°C (see Table 3 in Appendix A).

The data discussed above indicate stream reaches in Oregon that currently that attain the 18°C criterion, so the "protecting cold water" criterion likely would apply in these reaches (assuming other conditions of the criterion are met, such as the presence of listed species). The "protecting cold water" criterion is an important backstop to the rearing and migration criterion of 18°C. In waters where there are listed salmonid fishes or where critical habitat has been designated, Oregon's cold water protection provision is an effective means to maintain current summer maximum temperatures that are colder than the biologically-based criteria and only allow a 0.3°C cumulative increase for all sources of thermal pollution combined at the point of maximum impact. For reasons discussed below for the human use allowance, the allowable 0.3°C increase in water temperature for all sources at the point of maximum impact is unlikely to cause a biologically significant number of deaths or injuries in any of the listed species. Further, the cold water provisions limit the warming of rivers during other times of year besides the summer maximum period.

Since the "protecting cold water" criterion helps protect the diversity of thermal habitats across the landscape that historically supported viable populations of listed species and limits the warming of waters that are colder than the biologically-based criteria, we expect it will help avoid and minimize any adverse effects from the numeric criteria. This narrative criterion is unlikely to result in any adverse effects on listed species at the individual or population scale.

Implementation of Temperature Criteria

The EPA proposes to approve the following narrative criteria for implementation of the temperature criteria from OAR 340-041-0028 shown in the numbered, indented paragraphs below:

(12) Implementation of the Temperature Criteria

(b) Human Use Allowance - Insignificant additions of heat are authorized in waters that exceed the applicable temperature criteria as follows:

(A) Prior to the completion of a temperature TMDL or other cumulative effects analysis, no single NPDES point source that discharges into a temperature water quality limited water may cause the temperature of the water body to increase more than 0.3°C (0.5°F) above the applicable criteria after mixing with either twenty five (25) percent of the stream flow, or the temperature mixing zone, whichever is more restrictive;
(B) Following a temperature TMDL or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (0.5°F) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact;
(C) Point sources must be in compliance with the additional mixing zone requirements set out in OAR 340-041-0053(2)(d) (Note: this references the thermal plume provisions.)

(c) Air Temperature Exclusion - A water body that only exceeds the criteria set out in this rule when the exceedance is attributed to daily maximum air temperatures that exceed the 90th percentile value of annual maximum seven-day average maximum air temperatures calculated using at least 10 years of air temperature data, will not be listed on the section 303(d) list of impaired waters and sources will not be considered in violation of this rule.

The above provision is consistent with the recommendations in the Temperature Guidance (EPA 2003) to include a provision in water quality standards that allows the water temperatures in a waterbody to be insignificantly higher than the applicable criteria. The purpose of such a provision is to allow an insignificant level of heat into the river from human activities above the applicable biologically-based numeric criterion. Absent such a provision, no heat would be allowed from human activities when stream temperatures are above the applicable biologically-based criterion. Also, NPDES dischargers might be required to meet effluent limits would have to be numeric criteria end-of-pipe. According to the BE, EPA concluded that both of these results would be unnecessarily restrictive, would lead to unnecessary costly expenditures, and are not consistent with the goals of the CWA, which is why it recommended such a provision in its Temperature Guidance (EPA 2003). Also, for the reasons described below, EPA concluded that this provision does not undermine the protection of uses provided by the numeric criteria.

As described in OAR 0028(12)(b)(A), an individual point source in a temperature impaired waterbody may only increase the temperature of 25% of the river by 0.3°C above the applicable criteria, which means a given point source cannot cause the whole river to experience a temperature increase of more than 0.075°C above the applicable criteria (assuming that the heat input from the source is mixed across the river moving downstream). For purposes of calculating an NPDES effluent limit in accordance with this provision, DEQ assumes that the upstream river temperature is exactly at the applicable numeric criterion, even if the current river temperature is higher. Assuming this, it is then possible to calculate, using a mass-balance equation and the river and point-source discharge flow rates, the effluent discharge temperature that would result in the river temperature increasing by 0.075°C. The result of this approach is that the DEQ establishes the NPDES limit in such a way that the point source meets the water quality standard (including the allowance for human use) even if the upstream temperature of the river exceeds the water quality standard due to other sources. Eventually, as heat from non-point sources is reduced and other NPDES sources are limited in a similar way, the river will attain the water temperature standard (*i.e.*, at no point in the river will the temperature be higher than 0.3°C above the applicable criteria).

Theoretically, under provision OAR 0028(12)(b)(A), if five or more point sources were discharging into a river at the same location, it would be possible for the cumulative temperature increase to be more than 0.3°C. Although theoretically possible, EPA's BE states that EPA is not aware of such a situation, and that NPDES discharges likely are spaced far enough apart in Oregon that this concern is discountable. Also, a 0.075°C increase for the waterway from a single source is well below the 0.3°C increase, which as described below, is likely to produce only minor adverse effects.

As described in OAR 0028(12)(b)(B), after a completion of a TMDL, the maximum allowable temperature increase for all sources cumulatively in a watershed is 0.3°C above the applicable criteria. This provision ensures when point and non-point sources are considered together, the allowable increase above the applicable criteria creates only minor adverse effects. Adverse effects related to the human use allowance are particularly likely to occur within the mixing zones of point source discharges. However, these adverse effects will be minimized by the narrative criterion pertaining to thermal plumes, which we analyze later in this section.

The effects of a 0.3°C or less temperature increase are likely to be minor for two reasons. First, the accuracy of commonly used water temperature recording instruments is about +/- 0.2°C.[53] Therefore, the allowable increase is close to the limit of change that can be accurately measured. Second, a 0.3°C temperature increase is within the range of uncertainty of our understanding of the thermal requirements of salmonid fishes, which is at least +/- 0.5°C. In other words, the 16°C numeric criterion apparently will protect against adverse effects on the listed species of salmon and steelhead, but the uncertainty around the scientific information would not allow use to conclude with high certainty that a temperature of 15.5°C or 16.5°C would offer a biologically signficant difference in the amount of protection. Poole *et al.* (2001, p. 4-5) discusses sources of uncertainty in recommending temperature criteria, and provides ranges of 1 to 7°C for most of its temperature recommendations, in part because of this uncertainty.

The minor adverse effects due to approval of human use allowance are likely to include:

- For juveniles that rear during summer, a slight decrease in growth, and a slight increase in disease risk.
- For adults that migrate or hold in summer, a slight decrease in gamete viability and a slight increase in disease risk.
- For eulachon, a slight increase in mortality beyond the deaths due to approval of the numeric criteria and beneficial use designation.

[53] *E.g.*, HOBO water temperature Pro v2 data logger model U22-001; http://www.onsetcomp.com/products/data-loggers/u22-001 (accessed April 23, 2015).

Regarding the air temperature exclusion, this provision would not materially affect the numeric criteria. Rather, if an unusually hot period resulted in an exceedance of the applicable criteria and if during all other periods the water body attained the applicable criteria, the water body would not be listed on the 303(d) list nor require a TMDL. According to the BE, EPA has not seen an instance to date where Oregon has used this provision to keep a waterbody from being listed. The EPA last approved DEQ's 303(d) list in 2004, and EPA partially disapproved, and partially approved DEQ's 2010 303(d) list.[54] In EPA's redo of the disapproved portions of DEQ's 2010 list, it did not screen out any waterbodies from the list based upon the above provision. Based on the above information, this provision does not appear to be an impediment to adding water bodies to the 303(d) list or completing TMDLs. Even if DEQ did use it at some point, the subject water body would still be meeting the applicable criteria in most years. Therefore, we do not expect approval of this criterion to increase adverse effects on any of the listed species or their critical habitats.

Site-Specific Criteria

The EPA proposes to approve the following narrative criterion for site-specific criteria from OAR 340-041-0028 shown in the numbered, indented paragraph below:

> (13) Site-Specific Criteria - The Department may establish, by separate rule-making, alternative site-specific criteria for all or a portion of a water body that fully protects the designated use.
> (a) These site-specific criteria may be set on a seasonal basis as appropriate.
> (b) The Department may use, but is not limited by the following considerations when calculating site-specific criteria:
> (A) Stream flow;
> (B) Riparian vegetation potential;
> (C) Channel morphology modifications;
> (D) Cold water tributaries and groundwater;
> (E) Natural physical features and geology influencing stream temperatures; and
> (F) Other relevant technical data.
> (c) DEQ may consider the thermal benefit of increased flow when calculating the site-specific criteria.
> (d) Once established and approved by USEPA, the site-specific criteria will be the applicable criteria for the water bodies affected.

According to the BE (p. 180 to 181), EPA would enter into ESA section 7 consultation with NMFS prior to approving any individual site-specific criteria. We are unable to predict what the effects of a site-specific criterion would be without knowing the details, and therefore do not attribute to this narrative criterion any adverse effects at the individual or population scale for

[54] DEQ submitted Oregon's 2010 Integrated Report and 303(d) list to EPA in May 2011. EPA approved the submitted 303(d) listings and de-listings on March 15, 2012. EPA also disapproved DEQ's submittal for not including other waters and proposed adding other waters to Oregon's 303(d) list. On Dec. 14, 2012, after a public review process, EPA took final action to add 870 listings to the 2010 303(d) list. The 2010 303(d) list is effective for Clean Water Act purposes. Source: DEQ at http://www.deq.state.or.us/wq/assessment/assessment.htm (accessed March 26, 2015).

any of the listed species addressed in this opinion. We would consider any effects on listed species or critical hbaitat from approving a site-specific criterion in a separate ESA section 7 consultation.

Mixing Zones

The EPA proposes to approve the following narrative criteria for mixing zones that were amended by DEQ in 2003 and are shown in bold font from OAR 340-041-0053 in the numbered, indented paragraphs below:

> (1) The Department may allow a designated portion of a receiving water to serve as a zone of dilution for wastewaters and receiving waters to mix thoroughly and this zone will be defined as a mixing zone;
> (2) The Department may suspend all or part of the water quality standards, or set less restrictive standards in the defined mixing zone, provided that the following conditions are met:
> **(a) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following:**
> (A) Materials in concentrations that will cause acute toxicity to aquatic life as measured by a Department approved bioassay method. Acute toxicity is lethal to aquatic life as measured by a significant difference in lethal concentration between the control and 100 percent effluent in an acute bioassay test. Lethality in 100 percent effluent may be allowed due to ammonia and chlorine only when it is demonstrated on a case-by-case basis that immediate dilution of the effluent within the mixing zone reduces toxicity below lethal concentrations. The Department may on a case-by-case basis establish a zone of immediate dilution if appropriate for other parameters;
> (B) Materials that will settle to form objectionable deposits;
> (C) Floating debris, oil, scum, or other materials that cause nuisance conditions; and
> (D) Substances in concentrations that produce deleterious amounts of fungal or bacterial growths.
> **(b) A point source for which the mixing zone is established may not cause or significantly contribute to any of the following conditions outside the boundary of the mixing zone:**
> (A) Materials in concentrations that will cause chronic (sublethal) toxicity. Chronic toxicity is measured as the concentration that causes long-term sublethal effects, such as significantly impaired growth or reproduction in aquatic organisms, during a testing period based on test species life cycle. Procedures and end points will be specified by the Department in wastewater discharge permits;
> (B) Exceedances of any other water quality standards under normal annual low flow conditions.
> **(c) The limits of the mixing zone must be described in the wastewater discharge permit. In determining the location, surface area, and volume of a mixing zone area, the Department may use appropriate mixing zone**

guidelines to assess the biological, physical, and chemical character of receiving waters, effluent, and the most appropriate placement of the outfall, to protect instream water quality, public health, and other beneficial uses. Based on receiving water and effluent characteristics, the Department will define a mixing zone in the immediate area of a wastewater discharge to:

(A) Be as small as feasible;

(B) Avoid overlap with any other mixing zones to the extent possible and be less than the total stream width as necessary to allow passage of fish and other aquatic organisms;

(C) Minimize adverse effects on the indigenous biological community, especially when species are present that warrant special protection for their economic importance, tribal significance, ecological uniqueness, or other similar reasons determined by the Department and does not block the free passage of aquatic life;

(D) Not threaten public health;

(E) Minimize adverse effects on other designated beneficial uses outside the mixing zone.

(d) Temperature Thermal Plume Limitations. Temperature mixing zones and effluent limits authorized under 340-041-0028(12)(b) will be established to prevent or minimize the following adverse effects to salmonids inside the mixing zone:

(A) Impairment of an active salmonid spawning area where spawning redds are located or likely to be located. This adverse effect is prevented or minimized by limiting potential fish exposure to temperatures of 13 degrees Celsius (55.4 Fahrenheit) or more for salmon and steelhead, and 9 degrees Celsius (48 degrees Fahrenheit) or more for bull trout;

(B) Acute impairment or instantaneous lethality is prevented or minimized by limiting potential fish exposure to temperatures of 32.0 degrees Celsius (89.6 degrees Fahrenheit) or more to less than 2 seconds);

(C) Thermal shock caused by a sudden increase in water temperature is prevented or minimized by limiting potential fish exposure to temperatures of 25.0 degrees Celsius (77.0 degrees Fahrenheit) or more to less than 5 percent of the cross section of 100 percent of the 7Q10 low flow of the water body; the Department may develop additional exposure timing restrictions to prevent thermal shock; and

(D) Unless the ambient temperature is 21.0 degrees of greater, migration blockage is prevented or minimized by limiting potential fish exposure to temperatures of 21.0 degrees Celsius (69.8 degrees Fahrenheit) or more to less than 25 percent of the cross section of 100 percent of the 7Q10 low flow of the water body.

(e) The Department may request the applicant of a permitted discharge for which a mixing zone is required, to submit all information necessary to define a mixing zone, such as:

(A) Type of operation to be conducted;

(B) Characteristics of effluent flow rates and composition;

(C) Characteristics of low flows of receiving waters;

(D) Description of potential environmental effects;
(E) Proposed design for outfall structures.

(f) The Department may, as necessary, require mixing zone monitoring studies and/or bioassays to be conducted to evaluate water quality or biological status within and outside the mixing zone boundary;
(g) The Department may change mixing zone limits or require the relocation of an outfall, if it determines that the water quality within the mixing zone adversely affects any existing beneficial uses in the receiving waters.

The EPA did not analyze criteria (2)(a) and (2)(b) above in its BE, as it viewed them as non-substantive word changes that had no effect for ESA purposes.[55] Technically, they were revisions, but we viewed them as non-substantive word changes and therefore no effect for ESA purposes We read provision (a) as prohibiting discharge of materials in concentrations that will cause acute toxicity to aquatic life as measured by a Department approved bioassay method or of the various pollutants listed in (B) through (D). We read provision (b) as prohibiting a point source for which a mixing zone is established from causing or significantly contributing to exceedances of any other water quality standards outside of the mixing zone under normal annual low flow conditions. This seems to be the only logical meaning for these provisions, and the provisions seem adequate for the purpose of minimizing effects of mixing zones outside of their boundaries. We do not expect these provisions to cause any adverse effects on any listed species at either the individual or population scale.

The thermal plume provisions under (d) are consistent with the recommendations that NMFS helped develop in the Temperature Guidance (EPA 2003) to include in water quality standards thermal plume limitations to protect salmonid fishes in the vicinity of point-source discharges. Acute thermal shock leading to death can be induced by rapid shifts in temperature (McCullough 1999). The effect of the shock depends on acclimation temperature, the magnitude of the temperature shift, and exposure time (Tang *et al.* 1987). Juvenile Chinook salmon and rainbow trout acclimated to 15 to 16°C and transferred to temperature baths in the range of 26 to 30°C suffered significantly greater predation than controls (Coutant 1973). Coho salmon and steelhead trout acclimated to 10°C and transferred to 20°C water suffered sublethal physiological changes including hyperglycemia, hypocholestorolemia, increased blood hemoglobin, and decreased blood sugar regulatory precision (Wedemeyer 1973). Based on this information, sublethal adverse effects from shifts of 10°C are possible at end temperatures cooler than 25.0°C. Provision (C) above therefore limits the area where thermal shock could occur to 5% of the cross section of 100% of the 7Q10 low flow of the water body, but only in situations where the end temperature is 25.0°C or more. Although this is consistent with the Temperature Guidance, it does not completely avoid creating conditions that would cause adverse effects on listed salmon and steelhead, such as may occur in the 5% of the river’s cross section where there are no limits, or in situations where the end temperature is below 25.0°C.

Provision (D) limits potential migration blockage conditions to <25% of the cross section of 100% of the 7Q10 low flow[56] of the water body and to a temperature of < 21.0°C. Migrating

[55] March 25, 2015 email from John Palmer, EPA, to Jeff Lockwood, NMFS, regarding a question on the Oregon temperature BE.
[56] The 7Q10 low flow is the lowest 7-day average flow that occurs (on average) once every 10 years.

salmon and steelhead are likely to eventually find their way past such conditions, so any impairment of migration is likely to be temporary and unlikely to affect long-term survival.

We previously identified the following thresholds for adverse thermal effects in eulachon:

- For migrating and spawning adults: a temperature of 10°C (constant)
- For incubating eggs, a temperature of 14°C (constant)
- For larvae, a temperature of 18°C (constant)

For eulachon, we do not have data for short-term exposures to high temperatures such as occur in some mixing zones. However, the information we do have raises some concerns about the narrative criteria for mixing zones. The threshold temperature for adverse effects in adult eulachon is considerably colder than for adult salmon and steelhead. There is no information available on short-term exposures to relatively high temperatures (*i.e.*, 32°C) or thermal shock, although the generally colder threshold for eulachon adults relative to adult salmon and steelhead suggests that adverse effects at such temperatures are likely to be more severe than for salmon and steelhead, and deaths at these temperatures seem likely. Also, although the thresholds for adverse effects for long-term exposures in eggs and larvae are not dissimilar to those of eggs and juveniles respectively in salmon and steelhead, there is a major difference in that the eggs of eulachon are mobile on the bottom of rivers (where effluent diffusers often are located), rather than buried in gravel, and that the larvae are poor swimmers that are unlikely to be able to actively flee a thermal plume as juvenile salmon and steelhead may be able to do.

For green sturgeon, we previously documented that bioenergetic performance of age 1 juveniles was optimal at 15 to 19°C (constant), and that age 1 juvenile green sturgeon held at 24°C (constant) had decreased swimming performance compared to those held at 19°C (constant), as well as increased metabolic costs (Mayfield and Cech 2004). We do not have experimental data for older sub-adult fish that likely are present in Oregon waterways inhabited by this species, nor do we have data for short-term exposures to high temperatures such as occur in some mixing zones. That said, the information we do have suggests that, broadly generalizing, green sturgeon are not more sensitive that salmon and steelhead with respect to thermal thresholds for long-term exposures. However, there is no information available on short-term exposures to relatively high temperatures (*i.e.*, 32°C) or thermal shock.

Based on the above information, adverse effects on all listed species of salmon, steelhead, eulachon and green sturgeon are likely under this narrative criterion due to the likelihood of thermal shock, which will lead to localized, short-term adverse effects including delayed migration, sublethal adverse physiological effects, and increased predation susceptibility in thermal mixing zones. For salmon, steelhead, and green sturgeon, a small number of fish are likely to succumb to delayed physiological effects or increased predation, but the number of fish so affected is likely to be too small to affect these species at the population scale, due to limited exposure (*i.e.*, 5% of the of 100% of the 7Q10 low flow of the water body for thermal shock, and <25% of the cross-sectional area of 100% of the 7Q10 low flow of the water body for migration blockage). The available information for eulachon and green sturgeon is less conclusive than for salmon and steelhead. The mixing zone provisions are not adequate by themselves to prevent increased mortality for all life stages of eulachon in the Sandy, Umpqua, and Columbia rivers.

However, considering the conservation measures proposed by EPA to minimize adverse effects on eulachon from point-source discharges as described above in the discussions of the 18°C and 20°C criteria, and the characteristics of the current discharges in these rivers, any effects of the mixing zone provisions will not be large enough to reduce the abundance or productivity of eulachon at the scale of the Columbia River subpopulation. However, the determinations assumptions of this opinion with respect to adverse effects on eulachon in these two rivers , and the conclusion with respect to this species, may no longer be valid if the measures are not timely implemented and demonstrated to be successful.

Water Quality Variances

The EPA proposes to approve the following narrative criteria for water quality variances from OAR 340-041-0061 as shown in the numbered, indented paragraphs below:

(2) Water Quality Variances - The Commission may grant point source variances from the water quality standards in this Division where the following requirements are met:

(a) The water quality variance applies only to the point source requesting the variance and only to the pollutant or pollutants specified in the variance; the underlying water quality standard otherwise remains in effect.

(b) A water quality standard variance shall not be granted if:

(A) Standards will be attained by all point source dischargers implementing effluent limitations required under sections 301(b) and 306 of the federal Clean Water Act, and by nonpoint sources implementing cost-effective and reasonable best management practices; or

(B) The variance would likely jeopardize the continued existence of any threatened or endangered species listed under section 4 of the Endangered Species Act, or result in the destruction or adverse modification of such species' critical habitat.

(c) Prior to granting a variance, the point source must demonstrate that attaining the water quality standard is not feasible because:

(A) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(B) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(C) Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(D) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way which would result in the attainment of the use; or

(E) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like unrelated to water quality, preclude attainment of aquatic life protection uses; or

(F) Controls more stringent than those required by sections 301(b) and 306 of the federal Clean Water Act would result in substantial and widespread economic and social impact.

(d) Procedures - An applicant for a water quality standards variance shall submit a request to the Department. The application shall include all relevant information showing that the requirements for a variance have been satisfied. The burden is on the applicant to demonstrate that the designated use is unattainable for one of the reasons specified in Subsection (c) of Oregon's rule. If the Department preliminarily determines that grounds exist for granting a variance, it shall provide public notice of the proposed variance and provide an opportunity for public comment.

(A) The Department may condition the variance on the performance of such additional studies, monitoring, management practices, and other controls as may be deemed necessary. These terms and conditions will be incorporated into the applicant's NPDES permit or Department order.

(B) A variance may not exceed 3 years or the term of the NPDES permit, whichever is less. A variance may be renewed if the applicant reapplies and demonstrates that the use in question is still not attainable. Renewal of the variance may be denied if the applicant does not comply with the conditions of the original variance, or otherwise does not meet the requirements of this section.

(C) DEQ approval of a variance for a point source is not effective under the federal Clean Water Act until submitted to and approved by USEPA.

According to the BE (p. 180-181), EPA would enter into ESA section 7 consultation with NMFS prior to approving any individual request for a variance from water quality standards. We are unable to predict what the effects of a variance would be without knowing the details, and therefore do not attribute any adverse effects to this narrative criterion at this time. As with the potential use of the narrative criterion allowing for site-specific criteria, we will consider any effects of a variance on listed species or critical habitat in a separate consultation.

Basin-Specific Use Designations

Beneficial use designations define when and where beneficial uses (*e.g.*, salmon and steelhead spawning) occur. The EPA proposes to approve the fish use designations shown on the maps and tables in the Oregon Administrative Rules set out in OAR 340-041-0101 to OAR 340-041-0340 and listed below. Most of Oregon's basins have two maps to represent fish uses — one for uses that occur throughout the year, and a second for salmon and steelhead spawning use (spawning through fry emergence). Water quality criteria apply for the uses shown on the fish use designation maps below year-round, except when a more stringent spawning criterion applies. The spawning criteria apply to the reaches and date ranges shown on the salmon and steelhead spawning use designation maps. In many cases, more than one fish use occurs in the same water body. In this case, the use designation was based on the most sensitive species or life stage.

The DEQ worked with an interagency team with representatives from EPA, NMFS, the U.S. Fish and Wildlife Service, and the Oregon Department of Fish and Wildlife (ODFW) to designate fish uses. DEQ primarily relied on ODFW for information on fish distribution and life stage timing. The DEQ relied on the ODFW fish timing database (ODFW 2003) for fish distribution and timing data. The ODFW methodology for developing their database is described in the procedures manual for the 1:24K fish habitat distribution development project (ODFW 2002). The database was the product of a multi-year effort by ODFW to develop consistent and comprehensive fish distribution data for a number of salmonid fish species. This database includes all basins or sub-basins in Oregon that have anadromous fish. The distribution data represent known fish use based on documented observations, as well as the best professional judgment of local field biologists as to where use is likely to occur based on suitable habitat (*i.e.*, waters near areas of documented life stage presence on the same water body that have similar habitat features, such as flow volume, gradient, gravel size, and pool frequency, and no known obstructions or reasons why the use would not also be present in these waters).

ODFW compiled and reviewed fish distribution information from a variety of sources, including state and Federal fisheries agencies, Federal land management agencies, tribal entities, watershed councils, and other interested public or private organizations. The ODFW fish distribution data reflect areas of fish use based on information collected over the past five life cycles for a particular species, which ranges from 15 to 35 years. In addition to spatial fish distribution data that describe where a life stage use is known or likely to occur, the ODFW database also includes information describing when a life stage use is known or likely to occur based on locations near areas with documented life stage presence and suitable habitat. The DEQ also used unpublished data on juvenile salmonid fish abundance that was used for Ecotrust *et al.* (2000) and Dewberry (2003).

The databases used by DEQ reflect a conservative approach in that they are based on fish presence information spanning multiple years, and included waters where fish are likely to occur. This approach is appropriate because (1) salmonid fish use designations based solely on areas of documented presence would not sufficiently describe the actual waters of use due to the practical limitations of monitoring every stream mile, (2) routine fish monitoring sometimes indicates no fish presence when fish are actually present (*i.e.*, false negatives), and (3) fish distributions vary from year-to-year for any given water body (Dunham *et al.* 2001).

The beneficial use designations that EPA proposes to approve include the following:

1. **Salmon and steelhead spawning use on subbasin maps and tables set out in OAR 340-041-0101 to OAR 340-041-0340: Tables 101B, and 121B, and Figures 130B, 151B, 160B, 170B, 220B, 230B, 271B, 286B, 300B, 310B, 320B, and 340B.**

EPA proposes to approve the salmon and steelhead spawning through fry emergence use designation, which applies the 13°C criterion. The intent of this use is to protect the spatial extent of spawning, egg incubation, and fry emergence of salmon and steelhead, which is consistent with the Temperature Guidance (EPA 2003). The uses below occur in waters used for spawning of all species of salmon and steelhead covered in this opinion, with the exception of UCR spring-run Chinook salmon, SR sockeye salmon, and UCR steelhead. These three species would not be affected by approval of the subject criterion because their spawning and incubation habitat is located outside of the action area.

Salmon and Steelhead:

The interagency team considered identifying each different combination of species, locations and time periods where the ODFW database shows salmon or steelhead spawning through emergence occurs. However, this resulted in over 30 different spawning date ranges for just one basin. Because this approach seemed overly complicated and difficult to implement, the interagency team considered ways to simplify the method for designating spawning use time periods while still protecting this use. After reviewing the timing information for all salmon and steelhead, the interagency team agreed on the approach described below.

- In waters designated for salmon and trout rearing use during the summer months:
    - Spawning through emergence use applies from October 15 through May 15 in reaches with fall spawners (Chinook, coho or chum salmon), or a combination of fall and spring (steelhead) spawners.
    - Spawning through emergence use applies from January 1 to May 15 in reaches that have only steelhead spawning.

- In waters designated as core cold water habitats, spawning may begin earlier and/or emergence may end later. The above spawning through emergence dates apply unless they are extended as follows:
    - Spawning use for Chinook salmon begins 2 weeks after the earliest spawning date in the timing unit for that species according to the ODFW timing tables, but not later than October 15. If the initial spawning date is identified as peak use, there is no 2-week delay.
    - Emergence use for steelhead spawning reaches ends June 15.

- In waters designated as migration corridors, use the best available site-specific information to determine dates of spawning use. This occurs in only two locations.
    - In the Columbia River mainstem, chum salmon spawning use dates are based on site-specific information from ODFW.
    - In the Snake River mainstem below Hell's Canyon dam, fall Chinook salmon spawning use dates are based on site specific information assembled during the development of the temperature TMDL.

The rationale for the 2-week delay after the spawning start date for core cold water habitats is that the date shown in the ODFW timing tables applies to a timing unit, which in many cases includes several watersheds. The spawning criterion would apply throughout the designated reach the date this use begins, yet it is likely that the earliest spawning begins in cooler upstream tributaries. Also, the first 2 weeks of spawning was often identified in this effort as a period of lesser use (0 to 30%) of the life stage by ODFW, meaning fish are beginning to spawn at this time, but the majority of the populations (70 to 100%) spawn during the peak use period time.

The later emergence end date for steelhead in core cold waters was used because in these colder waters, steelhead spawning and emergence typically occurs later. Although steelhead fry may emerge even later than June 15 in some waters, those waters are typically a colder upstream (*i.e.*, high elevation) portion of where this use is designated. To attain the spawning criterion (*i.e.*, 13°C) on June 15 in the downstream extent of spawning reaches, temperatures would need to be colder in the upstream waters and therefore would likely not reach 13°C until later in the summer.

The reasons for using site-specific timing information for spawning through emergence in the migration corridors are that the number of spawning reaches in these larger mainstem rivers are limited, the reaches are shorter segments, each reach has spawning by only a single species, and there is more site-specific timing information available.

We helped develop the rules described above during the development of the Temperature Guidance and as part of the interagency team that developed the decision rules used by DEQ in developing the beneficial use designations. Our goal at that time was to avoid and minimize adverse effects on listed species of salmon and steelhead, as well as their critical habitats. Since that time, we have identified new information regarding CR chum salmon that pertains to the spawning use designations in the mainstem Columbia River. As explained earlier, in the Columbia River, only the 2-mile long reach from Beacon Rock to upstream of Ives Island (RM 141.5 to RM 143.5) is subject to the salmon and steelhead spawning criterion, which is designated from October 15 to March 31 (DEQ 2003a). This area includes one of the main spawning areas for CR chum salmon. However, CR chum salmon also spawn in other areas of the mainstem Columbia River such as the Woods Landing (RM 114) area on the Washington side of the river. Some spawning also occurs on the Oregon side of the river such as in the vicinity of Multnomah Falls (RM 137). In some years, relatively large numbers of adult CR chum salmon have been observed at some of these sites (*e.g.*, 161 fish at Woods Landing on November 16, 2012, and 126 fish at Multnomah Falls on December 5, 2011).[57] This compares to 74 fish at the Ives/Pierce Island complex near Bonneville Dam on November 13, 2012 and 226 fish at the Ives/Pierce Island complex on December 6, 2011.

As we explained when we analyzed the 13°C spawning and incubation criterion earlier in this opinion, chum salmon are likely to be exposed to optimal water temperatures under this criterion during peak incubation due to the temperature pattern of the river, regardless of where the beneficial use is designated. However, correcting the beneficial use designation to encompass the other areas where CR chum salmon spawn besides the Ives/Pierce Island complex would reduce or prevent possible future increases in mortality in incubating embryos and alevins due to discharges from any new point sources in these areas (which appear to be rural residential in character on the maps found on the Fish Passage Center website).

As we explained earlier when we analyzed the 13°C spawning and incubation criterion, CR chum salmon are likely to suffer only a minor rate of death and injury (on the order of 0.25%) of incubating fish due to approval of the criterion by EPA, which is not enough to affect any of the VSP variables at the population scale. Therefore we do not expect the beneficial use designation associated with this criterion to produce adverse effects on any of the VSP variables at the population scale for CR chum salmon. We also do not expect approval of this beneficial use to kill or injure any of the other listed salmon or steelhead, because we have not determined any

[57] Data from Fish Passage Center available at http://www.fpc.org/spawning/spawning_surveys.html (accessed May 5, 2015). Maps of spawning areas available at http://www.fpc.org/spawning/spawning_reddmaps.html (accessed May 6, 2015).

problems with any of the other beneficial use designations other than CR chum salmon. Therefore we do not expect adverse effects on any of the VSP variables that would be detectable at the population scale from EPA's proposed approval of the beneficial use designations.

2. **Core cold water habitat use on subbasin maps set out in OAR 340-041-101 to OAR 340-041-0340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A.**

The EPA proposes to approve the core cold water habitat use designation, which applies the 16°C criterion. The intent of this use is to provide optimal or near-optimal conditions for rearing of juvenile salmon and steelhead. In addition, these areas would provide colder holding waters for pre-spawning adults. These intentions are consistent with the recommendation for the subject uses in the EPA Temperature Guidance. The interagency team used the following indicators to identify where this use would apply: (1) waters where spring Chinook salmon spawn during the late summer (i.e, August 1 through September 15); (2) waters identified as "anchor habitats" in Ecotrust *et al.* (2000) and Dewberry (2003) for listed salmon or trout;[58] (3) waters upstream of the areas identified in (1) and (2), above, that also support salmon and steelhead rearing, or provide cold water to these areas; and (4) waters where water temperature data that meets DEQ's data quality requirements indicate that current stream temperature for the warmest week of the year are below 16°C (7DADM).

There are several reasons why the extent of waters meeting this criterion likely would be cooler than 16° C most of the year and even most of the summer: (1) if the criterion is met during the warmest week of the summer, then temperatures would be colder during the rest of the year ; (2) the criterion must be attained at the farthest point downstream where this use is designated; and (3) the criterion must be met in the warmest years [except for unusual warm conditions as per OAR 340-041-0028(12 (c)].

In our November 25, 2013 information request to EPA, we requested information about any new water temperature data since 2004 that could help rectify uncertainty about the extent of the designation of the beneficial use for the 16 in Oregon's South Coast Basin. In its February 13, 2014 response (Appendix 1), EPA explained that it analyzed temperature data since 2004 (for the season of May 1 to October 31st) for DEQ's South Coast and Rogue basins. The EPA analyzed both DEQ and USGS data; however, no USGS data have been collected for the South Coast Basin after 2003. All of the temperature data was collected from 2004 to 2013 (Table 4 in Appendix 1). After reviewing the available data, we do not see any additional stream reaches that are currently eligible for this beneficial use designation but are not designated as such.

Based on the prior paragraph and the reasons we list below, this beneficial use was properly applied by DEQ and is unlikely to lead to any deaths or injuries because:

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[58] Ecotrust collected data on densities of juvenile salmon and steelhead to identify areas of high rearing use or key habitat features (anchor habitats) for coho salmon, chinook salmon, and steelhead trout in certain Oregon coastal basins. This information was peer-reviewed. The DEQ designated stream segments as core cold-water habitat in the North Coast Basin (an upper portion of the Necanicum River, Ecola Creek and Plympton Creek) and in the Mid-Coast Basin (portions of the Siuslaw River) based on this data.

- There are multiple areas designated as core cold water habitat for each listed species of salmon and steelhead subject to this use.
- Most of the subbasins and watersheds without the core cold water habitat use designated consist of either relatively low-elevation, dry-climate streams, or contain relatively short streams lacking high-elevation reaches, or are in relatively dry and warm southwest Oregon, so the subject streams likely are warmer under natural conditions than streams in other areas supporting salmon and steelhead. There is no reason to designate waters at a temperature that could not be attained even under natural conditions.
- Oregon's rules at 340-041-0028 (11) require the protection of areas colder than the numeric criterion (for example, any areas designated under the next warmest beneficial use of 18°C).
- Oregon's rules at 340-041-0004 require an in-depth antidegradation review before DEQ permits any lowering of water quality in waters that meet the temperature criteria.
- In most, if not all, of the temperature-related TMDLs completed by DEQ to date, non-point heat sources in the subject river basins have been given zero allocations of heat, meaning that, in general (other than the 0.3°C allowance for human use for all sources in a basin considered together at the point of maximum impact), stream thermal potential would be achieved upon attainment of TMDL load allocations.

We expect the following effects due to EPA approval of this beneficial use designation:

- Chinook salmon **—** LCR, UWR, SR spring/summer-run, and SR fall-run: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.
- Coho salmon **—** LCR, OC and SONCC: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.
- Steelhead **—** LCR, UWR, MCR, and SRB: No mortalities or injuries of individual fish, and therefore no effect on any of the VSP variables.
- UCR Chinook salmon, CR chum salmon, SR sockeye salmon, UCR steelhead, eulachon and green sturgeon **—** This criterion is not designated where these species occur or in their migratory corridor, so they will not be affected by it at the individual or population scale.

3. Salmon and trout rearing and migration use on subbasin maps set out at OAR 340-041-0101 to OAR 340-041-0340: Figures 130A, 151A, 160A, 170A, 220A, 230A, 271A, 286A, 300A, 310A, 320A, and 340A.

Salmon and Steelhead:

EPA proposes to approve the salmon and trout juvenile rearing and migration use designation, which applies the 18°C criterion. The intent of this use is to protect migration habitat of adult and juvenile salmon and steelhead, and moderate-to-low density rearing habitat for salmon and steelhead, during the period of summer maximum temperatures. This intention is consistent with the recommendation for the subject uses in the Temperature Guidance (EPA 2003). The interagency team used the following indicators to identify where this use would apply: (1) waters that would provide rearing habitat for salmon or steelhead in July or August; (2) waters that would provide rearing habitat for rainbow or coastal cutthroat trout; and (3) all waters upstream of the waters identified in (1) and (2), above.

There are several reasons why the extent of waters meeting this criterion likely would be cooler than 18° most of the year and even most of the summer: (1) if the criterion is met during the warmest week of the summer, then temperatures would be colder during the rest of the year ; (2) the criterion must be attained at the farthest point downstream where this use is designated; and (3) the criterion must be met in the warmest years [except for unusual warm conditions as per OAR 340-041-0028(12 (c)].

In our November 25, 2013 information request to EPA, we requested information about water temperature patterns in streams meeting this beneficial use. In Appendix 1, EPA analyzed Oregon DEQ temperature data from 2000 to 2010 (from May 1 to October 31, and only sites with data spanning the months of July and August) for sites that are designated 18°C (salmonid rearing and migration criterion) or higher. Table 35 shows sites that had 7DADM temperatures of 17 to 19°C. All of the temperature data was collected continuously for at least 7 days, is of known quality (either A+ level data collected by DEQ that meets quality control limits, or A level data submitted by entities outside of DEQ that meets quality control limits), and was submitted to Oregon DEQ's Laboratory Storage and Retrieval database. For each location, the 7DADM (calculated based on all data available from May 1 to Oct. 31), the average temperature for the week that comprised the 7DADM, and the July/August average temperatures are displayed in Table 35.

Table 35. Oregon stream reaches designated 18°C or higher that have a 7DADM temperature between 17 and 19°C. Data from DEQ as described in supplemental information supplied by EPA to NMFS on February 13, 2014.

Subbasin	Site Name	7-Day averages date	7DAD Max. °C	1 Week Avg. °C	July/August Avg. °C
		Deschutes Basin			
Upper Deschutes	Deschutes River at Harper Bridge (Sunriver)	7/27/2003	17.9	17.2	16.7
Upper Deschutes	Deschutes River at Hwy 42 (Road 2114, South Century Drive)	7/18/2003	17.8	16.2	15.9
Upper Deschutes	Deschutes River at Steelhead Falls (Deschutes)	7/27/2000	18.3	16	15.4
		John Day Basin			
Upper John Day	North Fork Deer Creek, 260 m downstream of FSR 641 (Deer, SF John Day, John Day)	7/31/2000	17	13.1	11.2
		Mid Coast Basin			
Alsea	Big Creek; Alsea; Summer 03	7/17/2003	18	15.8	15.5
Alsea	Big Creek; Alsea; Summer 04	7/18/2004	18.3	15.7	15.6
Alsea	N Fk Yachats R; Alsea; Summer 03	7/17/2003	18.6	15.8	15.4
Alsea	N Fk Yachats R; Alsea; Summer 04	7/23/2004	19	17.2	16.2
Siltcoos	Five Mile Creek; Siltcoos; Summer 07	7/4/2007	18.4	16	16.3
Siltcoos	Five Mile Creek; Siltcoos; Summer 09	7/26/2009	18.9	16.6	15.7
Alsea	Big Creek; Alsea; Summer 05	7/14/2005	17.4	14.5	14.6
Alsea	N Fk Yachats R; Alsea; Summer 05	7/26/2005	17	14.8	14.6
		Mid-Columbia Hood Basin			
Mid-Columbia	Whiskey Creek at bridge near mouth	7/20/2002	18.2	16.4	15.2
		North Coast Lower-Columbia Basin			
Lower Columbia	Big Creek by Kappa Slough	7/22/2004	18.5	16	15
Lower Columbia	North Fork Klaskanine River upstream of fish hatchery	8/7/2001	18.8	15.1	14.8
Lower Columbia	Youngs River at Youngs River Loop Road	7/28/2000	18	16.3	15.1
Lower Columbia	Lewis and Clark River	7/22/2004	17.4	15.1	14.2
Lower Columbia	Youngs River at Youngs River Loop Road	8/7/2001	17.2	14.7	14.4
Necanicum	Necanicum R at Forest Lake RV Camp (Seaside)	8/6/2001	18	16.1	15.4
Clatskanie	Clatskanie River	7/27/2003	17.5	15.6	14.5
Clatskanie	Little Clatskanie River	7/24/2004	17.1	16	15.2
Clatskanie	Gnat Creek	7/22/2004	17.7	16	15.1
		Rogue Basin			

Subbasin	Site Name	7-Day averages date	7DAD Max. °C	1 Week Avg. °C	July/August Avg. °C
Applegate	Obrien Creek at River Mile 0.90	8/8/2001	17.1	14.3	13.3
Lower Rogue	Big Boulder Creek at confluence of Grave Creek	8/4/2000	18	17.1	15.3
Lower Rogue	Slate Creek at confluence Grave Creek	7/18/2000	18	15.2	14.3
Sandy Basin					
Sandy	Big Creek	7/22/2004	17.3	15.6	14.7
Snake River/Hells Canyon Basin					
Snake River/Hells Canyon	Tryon Creek	7/17/2003	17.2	13.4	12.7
South Coast Basin					
Coos	Larson Creek 2nd Bridge; Coos	7/20/2006	19	15.6	14.3
Coos	Sullivan Creek; Coos	7/21/2006	17.6	15.7	14.4
Umpqua Basin					
North Umpqua	North Umpqua upstream of Rock Creek	8/1/2000	19	18.1	16.3
North Umpqua	North Umpqua upstream of Steamboat Creek	8/7/2001	18	16.1	15.4
North Umpqua	North Umpqua upstream of Wright Creek	7/28/2000	18.5	16	15.1
South Umpqua	East Fork Shively Creek	7/31/2000	17.1	13.2	13.4
South Umpqua	East Fork Stouts Creek	7/24/2000	18.2	15.7	15.4
Umpqua	Wolf Creek at River Mile 3.5 (Umpqua)	8/7/2001	18.3	16.6	15.7
Umpqua	Wolf Creek at River Mile 3.5 (Umpqua)	8/4/2005	18.6	17	16.3
Willamette Basin					
Coast Fork Willamette	King Creek at River Mile 0.24	7/30/2000	17.9	16.3	14.8
Coast Fork Willamette	King Creek at River Mile 0.24	8/9/2001	18.1	16.2	14.9
Coast Fork Willamette	King Creek at River Mile 0.24	8/10/2004	19	16.7	16.3
Lower Willamette	Miller Creek	7/21/2006	18.6	16.5	15.2
Lower Willamette	Multnomah Channel tributary	7/18/2003	17.8	16	15.4
Middle Fork Willamette	Tributary to Goodman Creek, 1.0 mile upstream from footbridge (Goodman, Middle Fork Willamette)	8/3/2000	18.7	15.8	14.4
Tualatin	East Fork Dairy Creek	8/8/2001	17.6	14.8	13.6

The average difference between the 7DADM temperatures and the associated weekly average temperatures for the sites in Table 35 is 2.2°C, and the average difference between the 7DADMs and the July/August means is 3.0°C. These data demonstrate that a typical stream in Oregon that attains the 18°C 7DADM numeric criterion will have a weekly average temperature for the warmest week of the year and a July/August average temperature that are much (ca. 1 to 3°C) cooler than the criterion. The typical average temperatures are within the 10 to 16°C optimal range for juvenile growth under the conservative scenario of limited food (13 to 20°C is optimal with unlimited food) (citations as in Table 31).

The Temperature Guidance (EPA 2003) recognized that the mid-point between the mean and the maximum temperature should be considered when making comparisons to laboratory studies done at constant temperatures. The mid-point for a stream with a mean of 15°C and a maximum of 18°C would be 16.5°C, which is slightly above the conservative (limited food) optimal range for juvenile growth. However, because the mean of 15°C is within the optimal range for juvenile growth, any reductions in growth of juveniles are likely to be minimal. Also, some streams under this criterion will have parts of days during the warmest part of the summer where the temperature will be at or close to thresholds for elevated disease risk. However, considering the data from these streams and the factors discussed above, any adverse effects associated with the 18°C criterion are likely to be minimal and limited to those few streams with low diurnal variation and July/August average temperatures that exceed 16°C.

Based on the above information, we expect the following effects due to EPA approval of this beneficial use designation:

- Chinook salmon — LCR, UWR, SR spring/summer-run, and SR fall-run: A minor reduction in growth and increase in disease risk is likely to reduce the long-term survival of a small number of individuals of each species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables (because of limited exposure as described above).
- Coho salmon — LCR, OC and SONCC: A minor reduction in growth and increase in disease risk is likely to reduce the long-term survival of a small number of individuals of each species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables (because of limited exposure as described above).
- Steelhead — LCR, UWR, MCR, and SRB: A minor reduction in growth and increase in disease risk is likely to reduce the long-term survival of a small number of individuals of each species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables (because of limited exposure as described above).
- CR chum salmon — This criterion is designated in two streams in Oregon where this species occurs (Big Creek and Little Creek in Columbia County). The species does not rear during the summer maximum period when the criterion applies, nor are there currently any major points-source discharges that could expose fish to waters at this criterion. Therefore, we expect no mortalities or injuries of individual fish, nor any effect on any of the VSP variables.
- UCR Chinook salmon, SR sockeye salmon, and UCR steelhead — This criterion is not designated where these species occur or in their migratory corridor, so they will not be affected by it at the individual or population scale.

Eulachon:

We discussed effects of this beneficial use designation on eulachon earlier in the document when we analyzed effects of the 18°C rearing and migration criterion.

Green Sturgeon:

We discussed effects of this beneficial use designation on green sturgeon earlier in the document when we analyzed effects of the 18°C rearing and migration criterion.

4. Migration corridor use on subbasin maps and tables OAR 340-041-0101 to OAR 340-041-0340: Tables 101B, and 121B, and Figures 151A, 170A, and 340A.

The EPA proposes to approve the salmon and steelhead migration corridors use designation, which applies the 20°C criterion and its narrative provision regarding CWR. As we discussed above, the available information indicates that DEQ has not implemented the CWR criterion to date and has not provided sufficient interpretations of that criterion that would allow us to assess its potential effectiveness. Therefore, we analyze the 20°C criterion on its own, and do not assume that CWR would be available to ameliorate any adverse effects from that criterion.

The intent of this use is to protect migrating juveniles and adults from lethal temperatures and migration blockage due to thermal conditions. The interagency team applied this use to areas where the ODFW distribution and timing information indicated that there is migration habitat but no verifiable rearing use in July and August, or that a lower mainstem river is primarily a migration corridor during the period of summer maximum temperatures. Also, this use was applied only if there was evidence to suggest that temperatures would have reached 20°C under the natural thermal regime. Based on this approach, DEQ designated this use for the following reaches:

- Lower Willamette River (from the mouth to river mile 50),
- Lower John Day River (from the mouth to the confluence with the North Fork John Day River)
- Columbia River mainstem from the mouth to the Washington-Oregon border
- Snake River from the Washington-Oregon border to Hells Canyon Dam
- Lower Little Creek and Catherine Creek in the Grand Ronde River basin
- A short reach of the lower Coos River and two mid- to lower reaches of tributaries to the lower Coos River.

Salmon and Steelhead:

We analyze each of the designated reaches below.

<u>Lower Willamette River</u>: Based on temperatures at RM 12.8 in Portland, current daily maximum summer water temperatures in the Willamette River commonly are well over 20°C (Figure 36). In a scenario where the river was meeting the 20°C 7DADM criterion, assuming that the seasonal pattern of warming and cooling would be roughly the same as in recent years (Figures 37 through 39), waters in this river are most likely to be at or near (that is, within 1 to 2°C of) the 20°C criterion in July or August, so this is when listed species are most at risk of exposure to this temperature, should they be present.[59]

[59] Although we only show data for 2012 through 2014, we also examined USGS data at the same site for 2009 through 2011, and the pattern was similar.

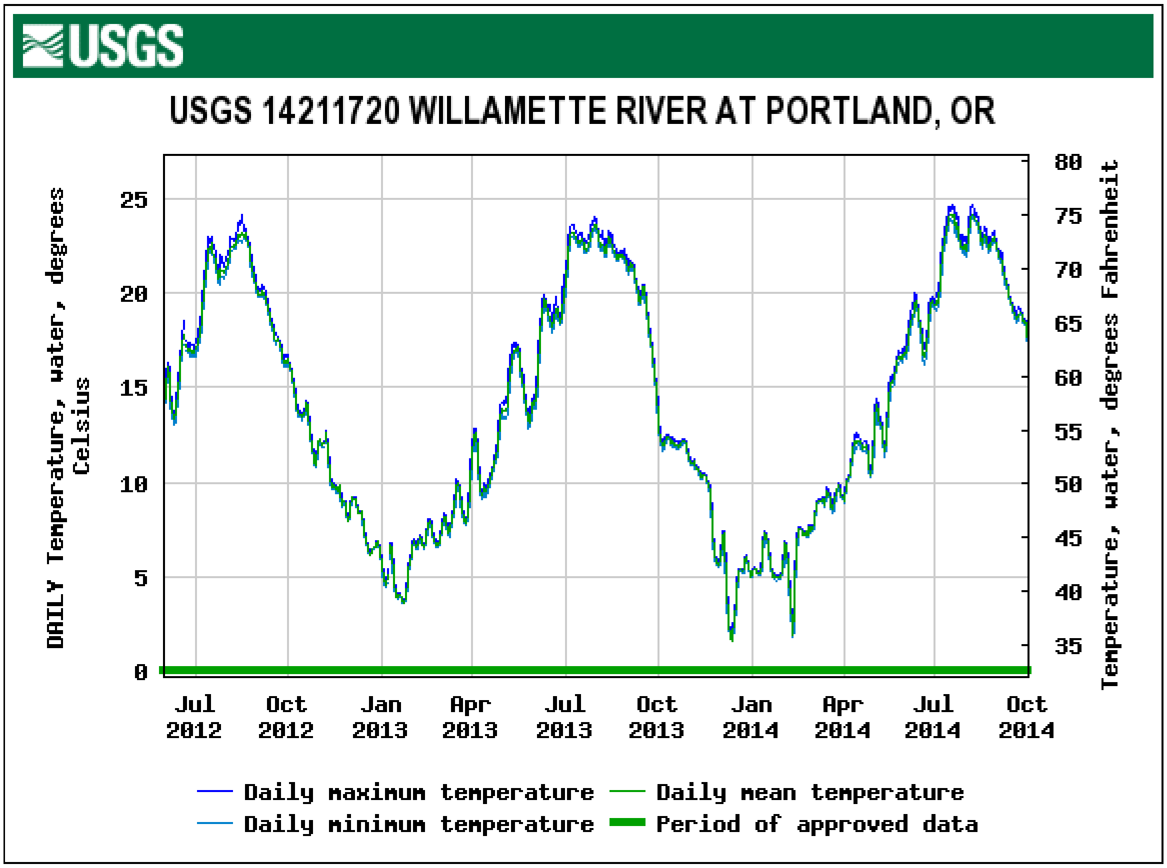

Figure 36. Daily water temperature for the Willamette River at Portland, June 2012 through September 2014. Location: Upstream side of Morrison Bridge, in Portland and at mile 12.8. Data from USGS at http://waterdata.usgs.gov/nwis/dv?cb_00010=on&format=gif_default&site_no=14211720&referred_module=sw&period=&begin_date=2012-06-01&end_date=2014-09-30 (accessed March 3, 2014).

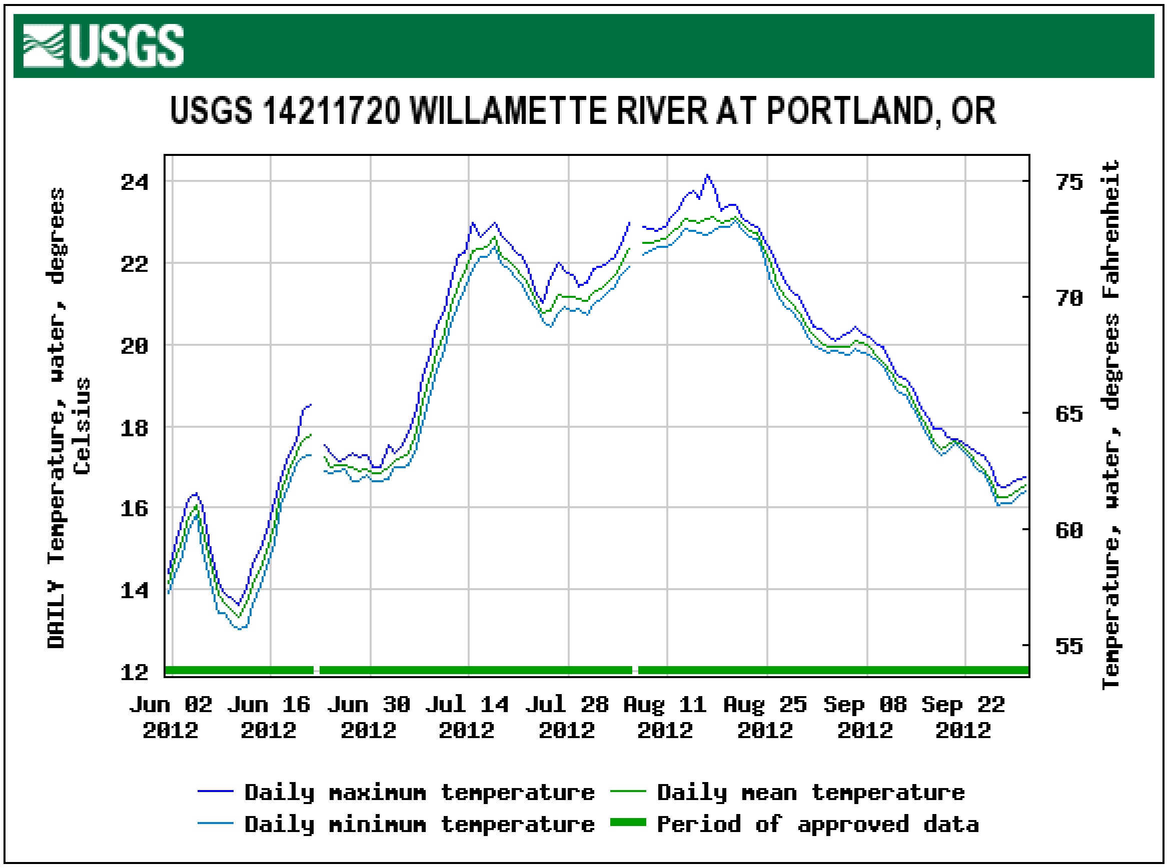

Figure 37. Daily water temperature for the Willamette River at Portland, June through September 2012. Location: Upstream side of Morrison Bridge, in Portland and at mile 12.8. Data from USGS at http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=14211720 (accessed March 3, 2014).

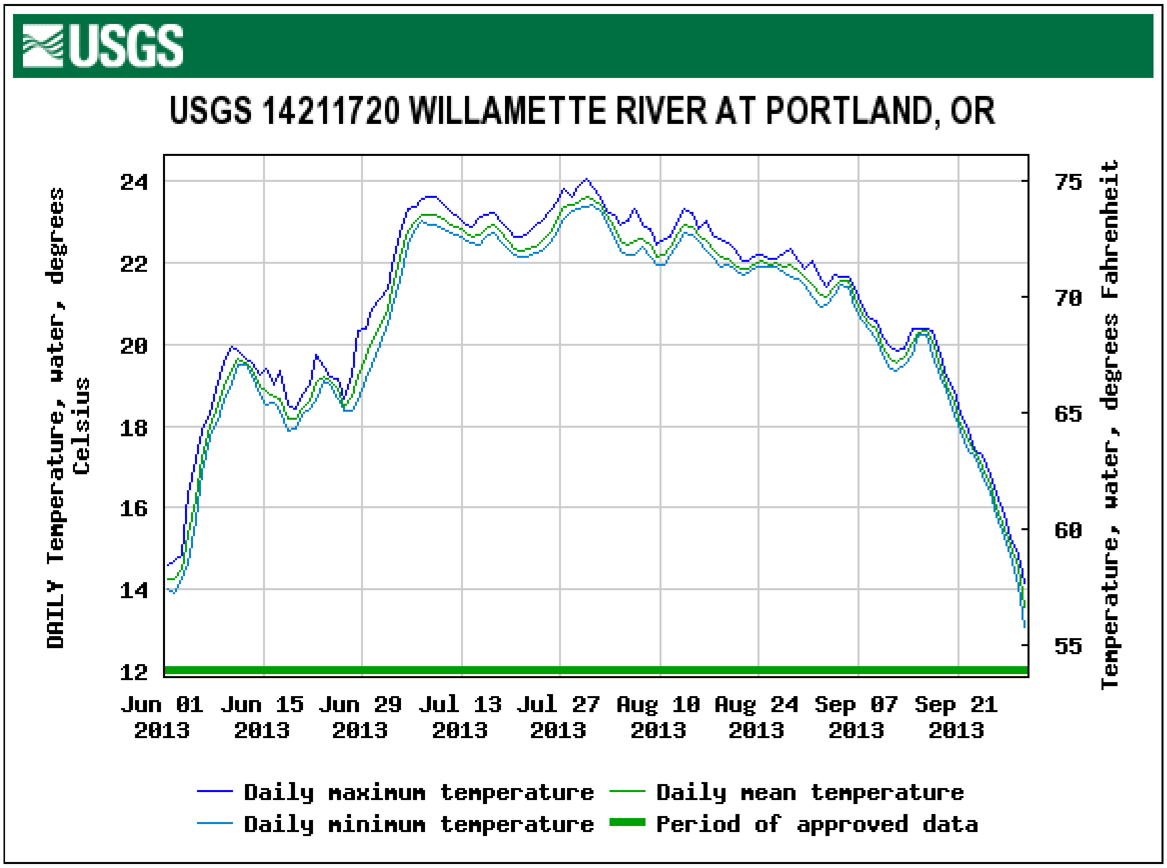

Figure 38. Daily water temperature for the Willamette River at Portland, June through September 2013. Location: Upstream side of Morrison Bridge, in Portland and at mile 12.8. Data from USGS at http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=14211720 (accessed March 3, 2014).

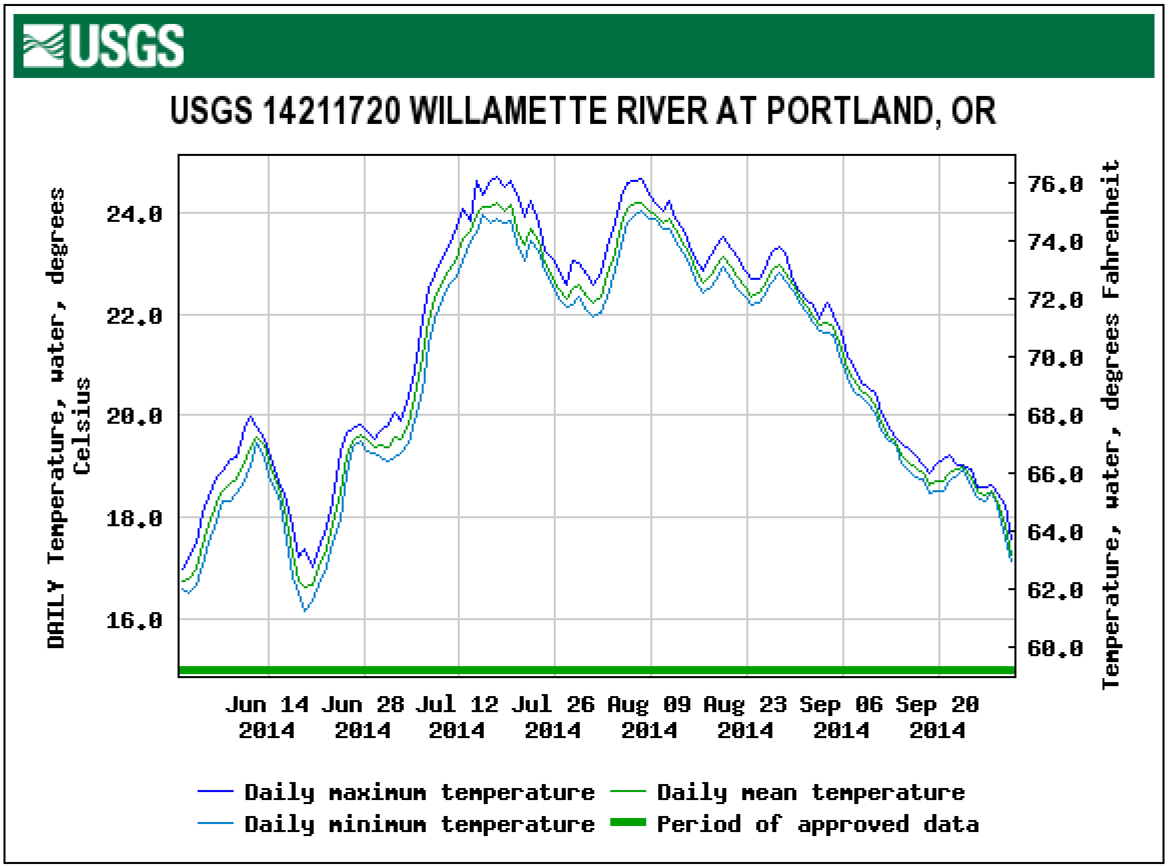

Figure 39. Daily water temperature for the Willamette River at Portland, June through September 2014. Location: Upstream side of Morrison Bridge, in Portland and at mile 12.8. Data from USGS at http://waterdata.usgs.gov/nwis/dv?referred_module=sw&site_no=14211720 (accessed March 3, 2014).

Up-river migration of adult UWR Chinook salmon adults in the reach from the mouth of the Willamette River to Willamette Falls is from mid-January through June, with peak migration from mid-March through May, and then lesser use according to ODFW (2003). Fish counts at Willamette Falls Dam from 2002 to 2012 showed that the 75th percentile of fish passage in 9 out of 12 years was before June 15, although fish were observed into July in 6 of 12 years (Figure 40; Jepson *et al.* 2013). In all years, the 90th percentile of fish passage occurred prior to July 1. From Willamette Falls upstream to Newburg (which is at RM 50, the upstream extent of the reach where the migration corridor applies), adults migrate from mid-January through August, with a peak from mid-March through June, and lesser use afterwards (ODFW 2003). The peak migration period above Willamette Falls is just outside of the July through August period when temperatures are likely to be at or near the migration corridor criterion in a scenario where the river met the criterion. It is possible that a portion of the run under more natural conditions that would continue to migrate in July has been truncated by the unnaturally warm temperatures now in the river, although we are not aware of historical run timing data that could corroborate this premise.

Existing high summer temperatures in the lower Willamette River (which are well above the migration corridor criterion) are high enough to increase physiological stress and disease rates, and to reduce gamete viability (McCullough 1999; McCullough *et al.* 2001; Marine 2002). These temperatures likely are responsible in part for high pre-spawn death rates of adult Chinook salmon in the Willamette River mainstem and tributaries (Schreck *et al.* 1994; Keefer *et al.* 2010, 2015; Naughton *et al.* 2012) and likely reduce the fitness of exposed individuals (Keefer *et al.* 2015).

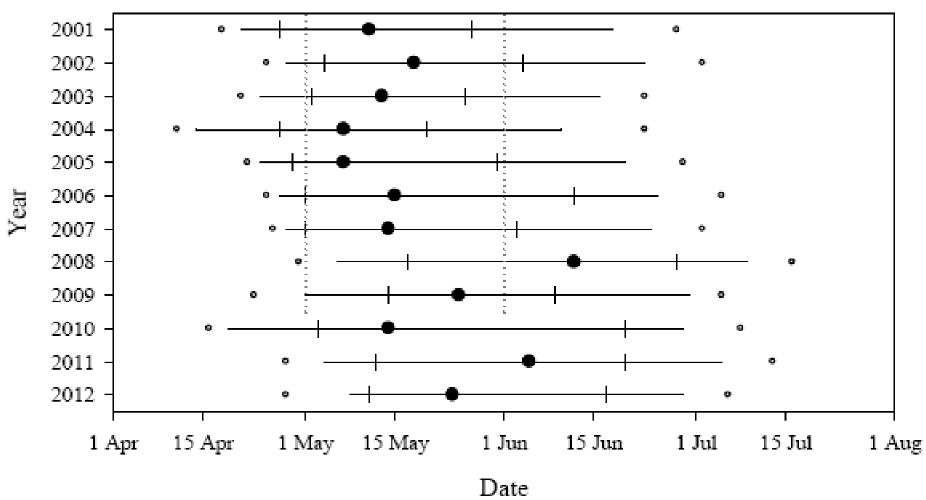

Figure 40. Annual upstream migration timing distributions for adult UWR Chinook salmon counted at Willamette Falls Dam, 2001 to 2012. Symbols show median (•), quartile (vertical lines), 10th and 90th percentiles (ends of horizontal lines), and 5th and 95th percentiles (.). Figure from Jepson *et al.* (2012).

Most juvenile UWR Chinook salmon rear in their natal tributaries for 1 year and emigrate through the lower Willamette River in winter through spring. From Newburg to Willamette Falls, ODFW (2003) lists juvenile migration as year-round, with a peak from October through mid-July, and lesser use the rest of the summer (ODFW 2003). Juvenile rearing is listed as year-round in this reach, with a peak from mid-February through September, and lesser use the rest of the fall and winter (ODFW 2003). From Willamette Falls to the mouth, ODFW (2003) lists downstream migration as occurring from mid-February through June, with a peak from mid-March through May, then lesser use (ODFW 2003). ODFW (2003) also lists juvenile rearing as year-round in this river reach, with a peak from mid-February through September. Friesen *et al.* (2005) found a downstream migration period from November through May, with a peak generally in April, but also stated that some juveniles are present in the Lower Willamette River year-round. In a study of juveniles tagged in Willamette River tributaries and in the mainstem Willamette River, Schroeder *et al.* (2005, 2007) found the highest number of juveniles migrating past Willamette Falls Dam in June, up to the time the detection facility at the dam closed in mid-June. This suggests that migration may have continued into the July to August timeframe when exposure to the migration corridor criterion is likely in a scenario where the river met the criterion. Water temperatures after July 15 were too warm for migration (Schroeder *et al.* 2007).

To summarize the above information for UWR Chinook salmon, during July and August when temperatures are likely to be at or near the migration corridor criterion, this species is likely to be exposed to the migration corridor criterion as follows:

- Adult UWR Chinook salmon are likely to be exposed during their upstream migration in the first half of July at non-peak abundance, and it is possible (but not confirmed) that larger numbers of fish would have migrated during July under more natural conditions.
- Reported peak and non-peak periods for downstream migration of juvenile UWR Chinook salmon vary by source. In the face of uncertain information about the proportion of juveniles that will be exposed, NMFS gives the benefit of the doubt to the listed species. On balance, out-migrating and rearing juvenile UWR Chinook salmon are likely to be exposed to the migration corridor criterion and beneficial use designation throughout July and August, including during part of their peak migration period.

LCR Chinook salmon and LCR coho salmon in the Clackamas River populations of these two ESUs also have to migrate through part of the area designated under the migration corridor criterion in the lower Willamette River. Adult LCR Chinook salmon in this population migrate upstream in the Clackamas River at a “lesser level of use” from August 1 to September 30, and at peak use from October 1 to November 15 (ODFW 2003), so a minority of fish are likely to be exposed to waters at or near the migration corridor criterion. These fish likely arrive in the lower Willamette River downstream of the Clackamas River several days before beginning their migration up the Clackamas River. Adult LCR coho salmon in the Clackamas River population upstream migration is listed as “presence” from August 1 through December 31 (ODFW 2003), so some fish from this population also are likely to be exposed to waters at or near the migration corridor criterion. As with LCR Chinook salmon, LCR coho salmon likely arrive in the lower Willamette River downstream of the Clackamas River several days before beginning their migration up the Clackamas River.

Juvenile LCR fall Chinook salmon in the Clackamas River population migrate downstream in the Clackamas River at peak level from February 15 to July 31, and at non-peak level from August 1 through September 15 (ODFW 2003). These fish are likely to be exposed to the migration corridor criterion in the lower Willamette River. Juvenile LCR coho salmon in the Clackamas River population migration is listed as "presence" from March 15 to July 15 (ODFW 2003), so some fish are likely to be exposed to the migration corridor criterion in the Willamette River. Also, coho salmon rearing is listed as "presence" year-round in the Willamette River below Willamette Falls (ODFW 2003).

Overall, a small proportion of adult UWR Chinook salmon in all populations, and a substantial portion of juvenile UWR Chinook salmon in all populations, are likely to be exposed to the migration corridor criterion temperature. A small proportion of adult LCR Chinook salmon and a substantial portion of juveniles in the Clackamas population also are likely to be exposed to the migration corridor criterion temperature. For LCR coho salmon, the timing data does not appear to be as specific as for Chinook salmon. Based on the typical life history of coho salmon (i.e., peak adult migration in the fall and peak juvenile migration in the spring), we expect minimal exposure to the migration corridor criterion for LCR coho salmon, and minimal adverse effects.

For UWR Chinook salmon, some of the fish exposed to this temperature are likely to suffer death, injury, increased disease incidence, impaired migration, reduced growth (juveniles only) or reduced gamete viability and fitness (adults only) due to approval of this criterion and its beneficial use designation. Water temperatures of 18 to 20°C that would prevail for much of the summer under the 20°C criterion also favor warm-water predators that would further increase deaths of juvenile UWR Chinook salmon (all populations) and LCR Chinook salmon (Clackamas population only). For UWR Chinook salmon and LCR Chinook salmon (Clackamas population only), the adverse effects likely will be severe enough to reduce abundance and productivity at the population scale.

UWR steelhead enter the Willamette River in January and February, and ascend to their spawning areas mostly from late March through April (Myers *et al.* 2006). According to ODFW (2003), up-river migration of adults in the reach from the mouth to Willamette Falls is from January through June, with peak migration from mid-January through April, and then lesser use. This pattern was mostly confirmed by fish counts at Willamette Falls Dam from 2002 to 2012, although the last fish were counted in May, not June (Figure 41; Jepson *et al.* 2013). From Willamette Falls upstream to Newburg (which is at RM 50, the upstream extent of the reach where the migration corridor applies), upstream migration is from January through May, with a peak from January through April, then lesser use (ODFW 2003). It is possible that part of the adult migration that under more natural conditions would continue at a diminishing rate into July but has been truncated by the unnaturally warm temperatures now in the river, although we are not aware of historical run timing data that could corroborate this premise.

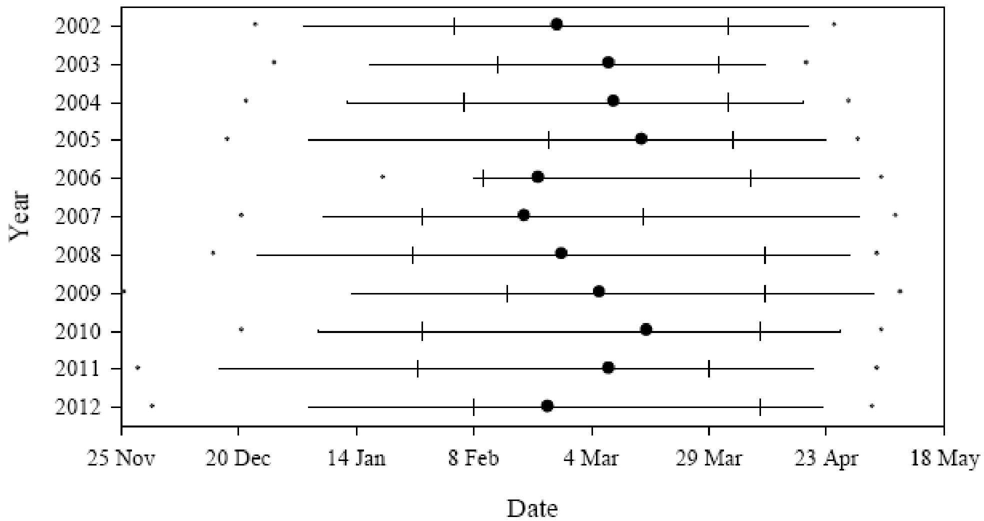

Figure 41. Annual upstream migration timing distributions for adult UWR steelhead counted at Willamette Falls Dam, 2002 to 2012. Symbols show median (•), quartile (vertical lines), 10th and 90th percentiles (ends of horizontal lines), and 5th and 95th percentiles (.). Figure from Jepson *et al.* (2013).

Downstream migration of juvenile UWR steelhead from Newburg to Willamette Falls is from February through November, with a peak from mid-February to mid-August, and then lesser use according to ODFW (2003). Juvenile rearing is listed as "presence" year round in this reach of the river by ODFW (2003). From Willamette Falls to the mouth, downstream migration is mid-February through November, with a peak from early March to mid-August, then lesser use, according to ODFW (2003). ODFW (2003) also lists "presence" for juvenile rearing year-round in this river reach. Sampling by Friesen *et al.* (2004) over 3 years found juvenile steelhead downstream of Willamette Falls only from November through July, with peak density in November (1 year) or May (2 years).

To summarize the above information for UWR steelhead, during July and August when temperatures are likely to be at or near the migration corridor criterion, UWR steelhead are likely to be exposed to the migration corridor criterion as follows:

- Adult UWR steelhead are unlikely to be exposed to this criterion, although it is possible (but not confirmed) that a portion of the run under more natural conditions that would continue to migrate in July has been truncated by the unnaturally warm temperatures now in the river.
- ODFW (2003) indicates that juvenile UWR steelhead are likely to be exposed to the migration corridor criterion and beneficial use designation at high densities from July1 through mid-August and at low densities the rest of the year, while Friesen *et al.* (2004) over 3 years found juvenile steelhead downstream of Willamette Falls only from November through July, with peak density in November (1 year) or May (2 years). In the face of uncertain information about the proportion of juveniles that will be exposed, NMFS gives the benefit of the doubt to the listed species. On balance, out-migrating and

rearing juvenile UWR steelhead salmon are likely to be exposed to the migration corridor criterion and beneficial use designation throughout July and August, including during part of their peak migration period.

Overall, a potentially substantial portion of juvenile UWR steelhead are likely to be exposed to the migration corridor criterion, and some of these fish are likely to suffer injury, death, reduced growth (juveniles only), impaired migration, or reduced gamete viability and fitness (adults only) due to adverse effects related to approval of the migration corridor criterion and the associated beneficial use designation. Water temperatures of 18 to 20°C that would prevail for much of the summer under the 20°C criterion also favor warm-water predators that would further increase deaths of juvenile UWR steelhead. These adverse effects are likely to occur in all of the MPGs of UWR steelhead each year that the criterion and beneficial use designation are in effect, which we assume will be indefinitely.[60] These adverse effects likely will be severe enough to reduce abundance and productivity at the population scale.

Peak upstream migration of LCR steelhead in the Clackamas River population is complete by the April, and non-peak is complete by the end of June (ODFW 2003), so they are unlikely to be exposed to temperatures at or near the migration corridor criterion, except perhaps in very small numbers at the tail of the migration period. Juveniles migrate out of the Clackamas River from mid-March through June (ODFW 2003), and therefore part of the group is likely to be exposed to temperatures at or near the migration corridor criterion in the Willamette River in July. Juveniles may rear in the lower Willamette River year-round, although we could not find population-specific information. When information is limited, we give the benefit of the doubt to the listed species, and thereby assume that a significant proportion of juvenile LCR steelhead in the Clackamas population will be exposed. Some of the exposed fish will suffer injury, death or reduced growth. These effects are likely to be severe enough to reduce abundance and productivity at the population scale.

Modeling by USGS of natural thermal potential (NTP) in the Willamette River suggests that even with restored riparian vegetation in the river basin and no point sources of heat in the river (blue line in Figure 42), temperatures in almost all of the lower 50 miles of the river likely would not meet the migration corridor criterion. For the modeling, NTP was defined as the water temperatures that would occur in the absence of point sources, with restored riparian vegetation, without Portland General Electric's cap and flashboards at Willamette Falls, and without the Eugene Water and Electric Board's hydroelectric diversions on the McKenzie River (Rounds 2007). However, water withdrawals for municipal, agricultural, and industrial uses were included in the NTP baseline conditions, as were the effects of upstream dams. Also, a more historical channel shape was not included in the definition of NTP.

[60] Section 303(c)(1) of the CWA and EPA's implementing regulations at 40 CFR 131.20 require that states and authorized tribes, from time to time, but at least once every 3 years, hold public hearings to review applicable WQS and, as appropriate, modify and adopt WQS. In each WQS review cycle, states and tribes, with input from the public, review their existing WQS to identify additions and/or revisions that are necessary or appropriate to ensure that their WQS meet the requirements of the CWA and the needs of the state or tribe. However, there does not appear to be any requirement to review any specific standard during a triennial review. Source: EPA's Clean Water Act Handbook (http://water.epa.gov/scitech/swguidance/standards/handbook/chapter06.cfm; accessed March 26, 2015).

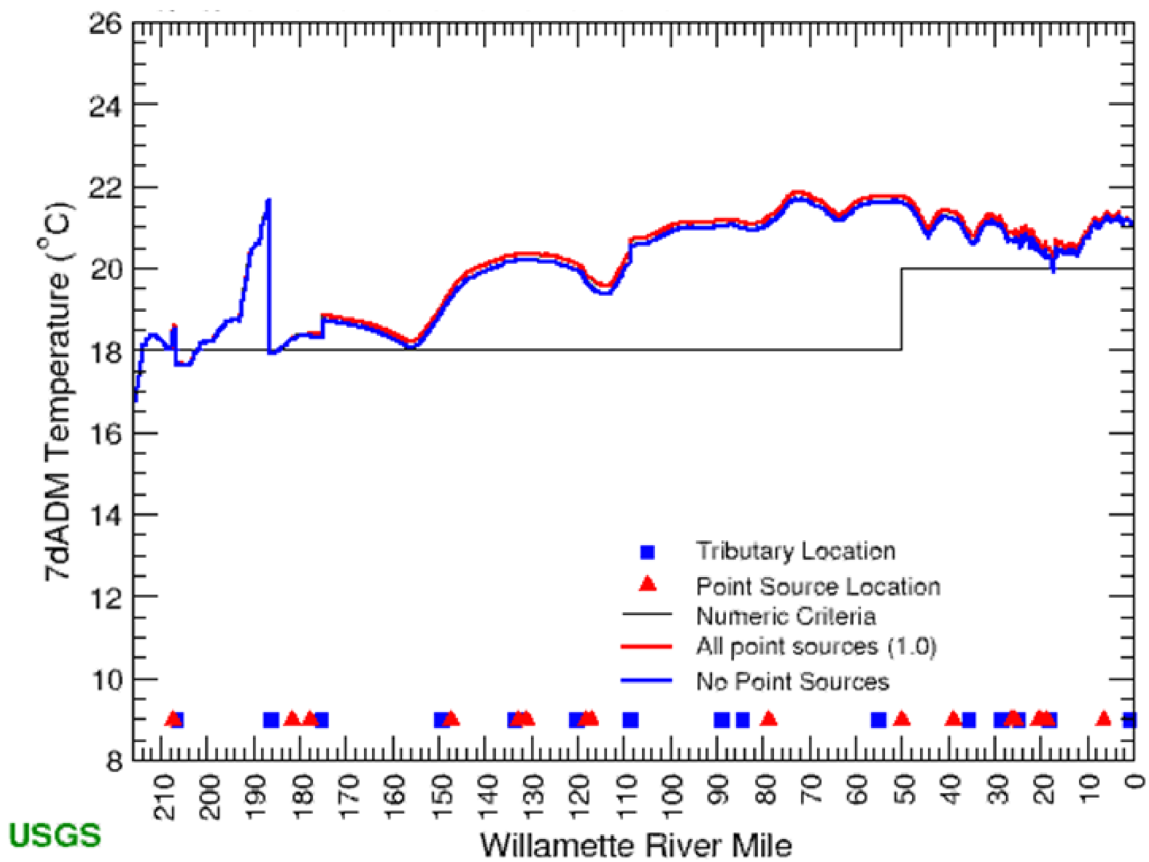

Figure 42. Modeled natural thermal potential of Willamette River with (red line) and without (blue line) point sources of thermal pollution, and with riparian vegetation restored. Source: USGS at http://or.water.usgs.gov/proj/will_temp/wla_vs_ntp.html (accessed March 3, 2015).

<u>Lower John Day River</u>: The migration corridor criterion is designated from the mouth of the John Day River upstream to the confluence with the North Fork John Day River. According to ODFW (2003), adult MCR steelhead migrate upstream in this river reach from January through mid-June, with peak use from January through March, then lesser use (ODFW 2003). Juveniles migrate downstream in this reach from January through June, with a peak from early April through early June, then lesser use in the second half of June (ODFW 2003). Juveniles are listed as having "presence" year-round in this reach (ODFW 2003).

The ODFW has been tagging and monitoring the migration of adult and juvenile MCR steelhead in the upper mainstem, Middle Fork and South Fork John Day River since 1998 (*e.g.*, Shultz et. al. 2006; Wilson *et al.* 2007, 2011). Out-migration of juvenile MCR steelhead commonly has peaked between late March and mid-May. In 2004, 2005, and 2010, the last fish was captured on June 24, July 6, and June 29, respectively (Shultz et. al. 2006; Wilson *et al.* 2007, 2011). This generally is consistent with the information in the run timing tables of ODFW (2003). The 2011 pattern for juvenile out-migration is shown in Figure 43.

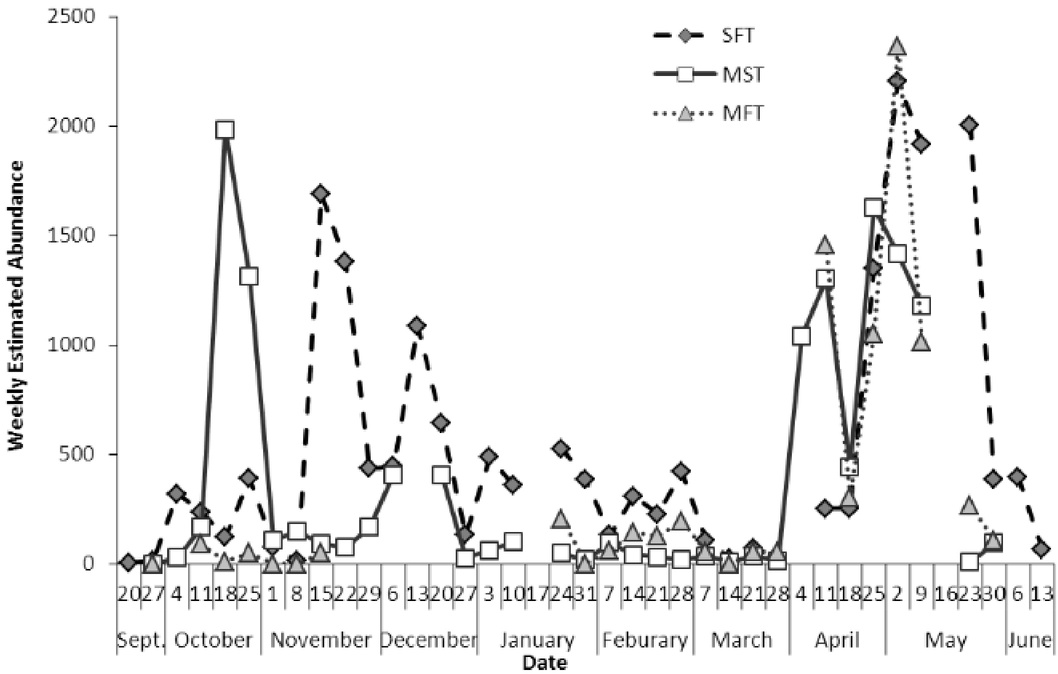

Figure 43. Estimated weekly number of juvenile MCR steelhead migrating past rotary screw traps operated in the John Day River basin during migratory year 2011. SFT = South Fork screw trap, MST = mainstem screw trap, and MFT = Middle Fork screw trap. Figure from DeHart et al. (2012).

The tags allowed the juveniles to be detected at downstream electronic monitoring stations. For fish tagged in 2004, detections of the tagged fish at the John Day Dam occurred between April 15 and June 23, with 50% detected by May 23. In 2005, detections at John Day Dam occurred between April 22 and May 25, with 50% detected by May 2. In 2011, detections at John Day Dam occurred between April 3 and June 23, with 50% detected by May 16.

Under current conditions, the lower John Day River is much warmer than the applicable temperature criterion, with temperatures above 30°C as a 7DADM during the summer in some years (Figure 44). The DEQ did not provide a figure in the John Day River TMDL indicating how the temperature changes in the Lower John day River over the year, but we can use information provided by DEQ for the Middle Fork John Day River in 2002 for an approximation (Figure 45). That figure shows that maximum temperatures in the Middle Fork occurred in early July. Because the 20°C criterion uses a 7DADM metric for compliance, temperatures are likely at or near 20°C for approximately 1 to 4 weeks during the warmest part of the summer between late June and mid-July. Adult MCR steelhead that migrate upstream may be exposed to 20°C waters under this beneficial use designation, but only during the latter non-peak period of their upstream migration. Some of these fish are likely to suffer death, reduction of reproductive success, or disease due to adverse effects at the criterion temperature of 20°C.

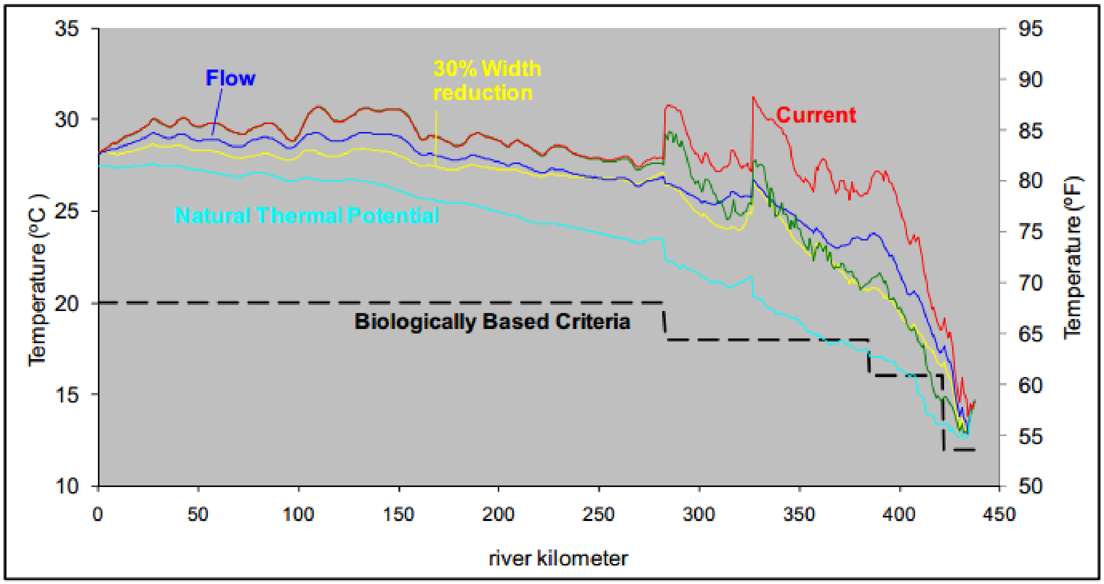

Figure 44. Predicted maximum 7DADM temperature profiles of the John Day River resulting from described scenarios during the model period 2004. Source: John Day River TMDL (DEQ 2010).

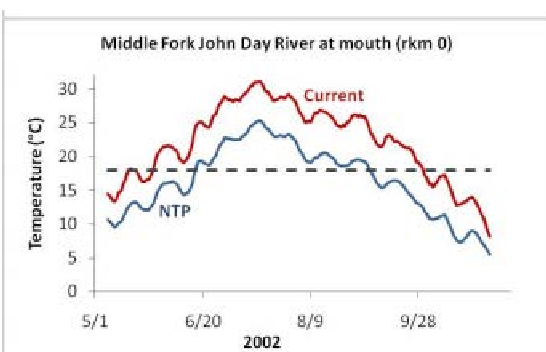

Figure 45. Current and modeled natural thermal potential temperatures in the Middle Fork John Day River in 2002. Source: John Day River TMDL (DEQ 2010).

Outmigrating juvenile MCR steelhead also likely will be exposed during the non-peak period of their downstream migration. Also, it is possible that the species has altered its migration timing due to the current overly warm temperature of the river. For juveniles, effects are likely to be exacerbated by exposure to the same criterion in the Columbia River after they have left the John Day River. Some juveniles rear year-round in this reach and would be exposed during the summer maximum period. Some of the exposed juveniles are likely to suffer death or disease at the criterion temperature of 20°C. Water temperatures of 18 to 20°C that would prevail for much of the summer under the 20°C criterion also favor warm-water predators that would further increase deaths of juvenile MCR steelhead.

There are no major point sources of pollution in the John Day River basin (Figure 46). All five populations of MCR steelhead in the John Day MPG are likely to be affected as described above, and effects on juveniles are likely to be significantly negative at the population scale. Even though we are identifying problems at or above 20°C (7DADM), we acknowledge that according to the temperature model used by DEQ in the John Day River TMDL (DEQ 2010), this reach likely remains warmer than 20°C as a 7DADM during the summer.

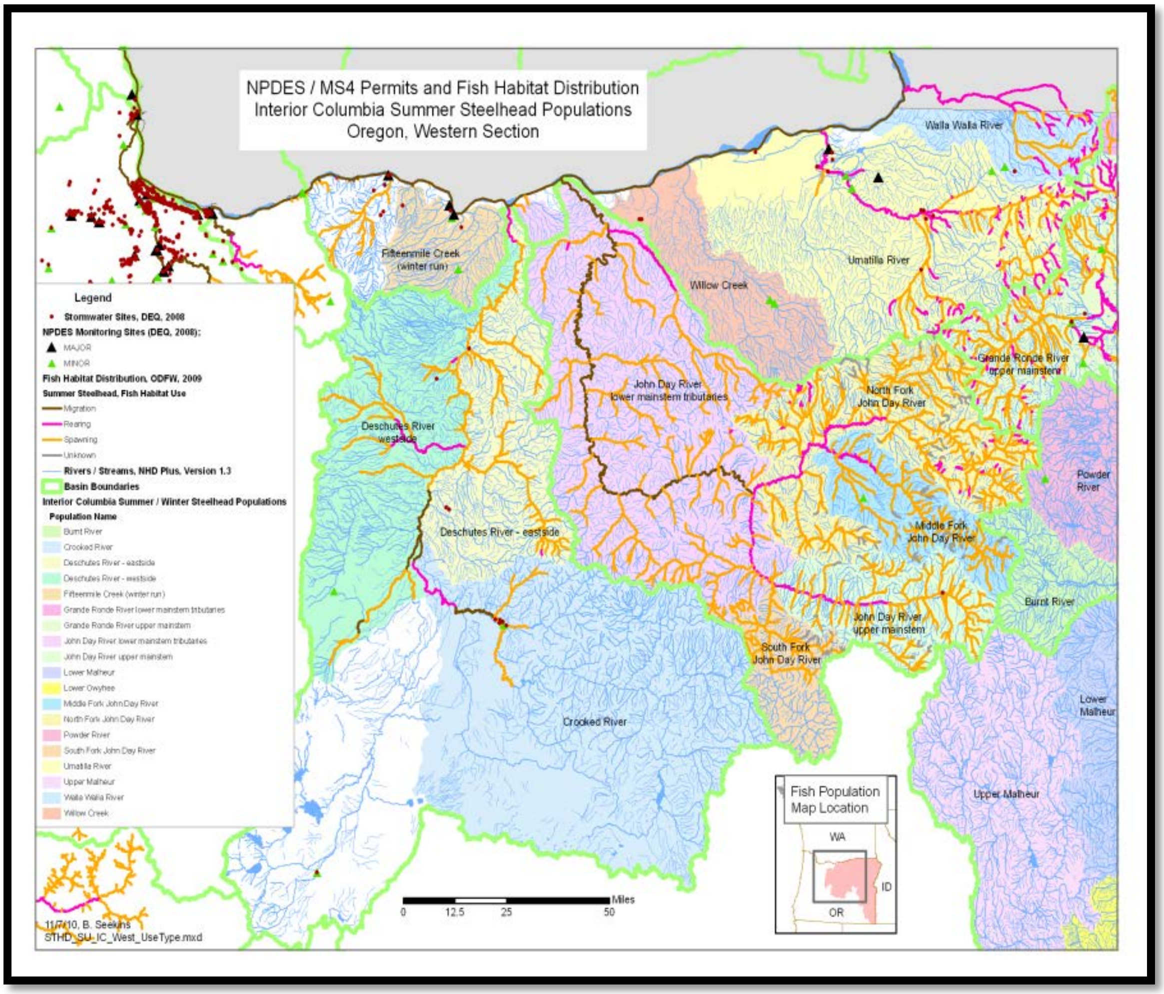

Figure 46. NPDES and stormwater discharges in the area occupied by MCR steelhead and other interior Columbia River basin steelhead.

Steelhead are probably the most temperature-sensitive anadromous salmonid fish during smoltification, which is a period of physiological transition that prepares a migrating juvenile fish for survival in salt water. That is why EPA (2003) recommended a separate designated use and criterion of 14°C for smoltification in its Temperature Guidance. The DEQ considered but declined to designate beneficial use of salmon and steelhead smoltification. The DEQ reasoned that Oregon's spawning criterion (13°C for spawning through fry emergence) and the associated use designations would protect steelhead smoltification. A possible exception was the John Day River, the only river (other than the lower Snake and Columbia rivers) in which a significant portion of the river likely supports smoltification. The lower mainstem John Day River is not designated for spawning through fry emergence, so the only beneficial use designated for this reach is the 20°C migration corridor use.

There were several reasons why the interagency team that worked on the beneficial use designations thought that existing designations would provide water at or near 14°C during smoltification of steelhead in the lower John Day River:

- The mouths of the tributaries in the lower reaches of the John Day River with spawning use designations would need to meet 13°C at their mouths through May 15, so they would be providing cold water that would help protect smoltification to the lower John Day River through much of the out-migration period.
- The mouth of the John Day River would need to meet 20°C during the warmest part of the summer, so it would be cooler during the spring out-migration period.
- Areas of the lower John Day River upstream of the mouth would need to be cooler than the mouth in order for the mouth to meet the 20°C criterion.
- The DEQ did not know the specific timing of smoltification during out-migration, but they thought that the juvenile steelhead likely would leave the river by May or June, and that steelhead likely would be exposed to waters below or slightly above 14°C during smoltification.

There is little data available for the lower John Day River during smoltification. We located data for part of 1 year (2002) near the mouth of the river (Figure 47). This figure demonstrates that for the single year for which data was available, during the second half of the period when peak outmigration — and presumably smoltification – occurs (*i.e.*, the month of May), the 7DADM temperature under current conditions (which are far warmer than the migration corridor criterion; Figure 44 above) is warmer than the 14°C criterion for smoltification recommended in EPA (2003). Figure 45 demonstrates that lowering summer maximum temperature in the lower John Day River likely also would lower temperatures during the peak spring outmigration of juveniles in April and May. However, it is difficult to predict based on the very limited data available for this analysis how much temperatures might fall in May if the river met the migration corridor criterion.

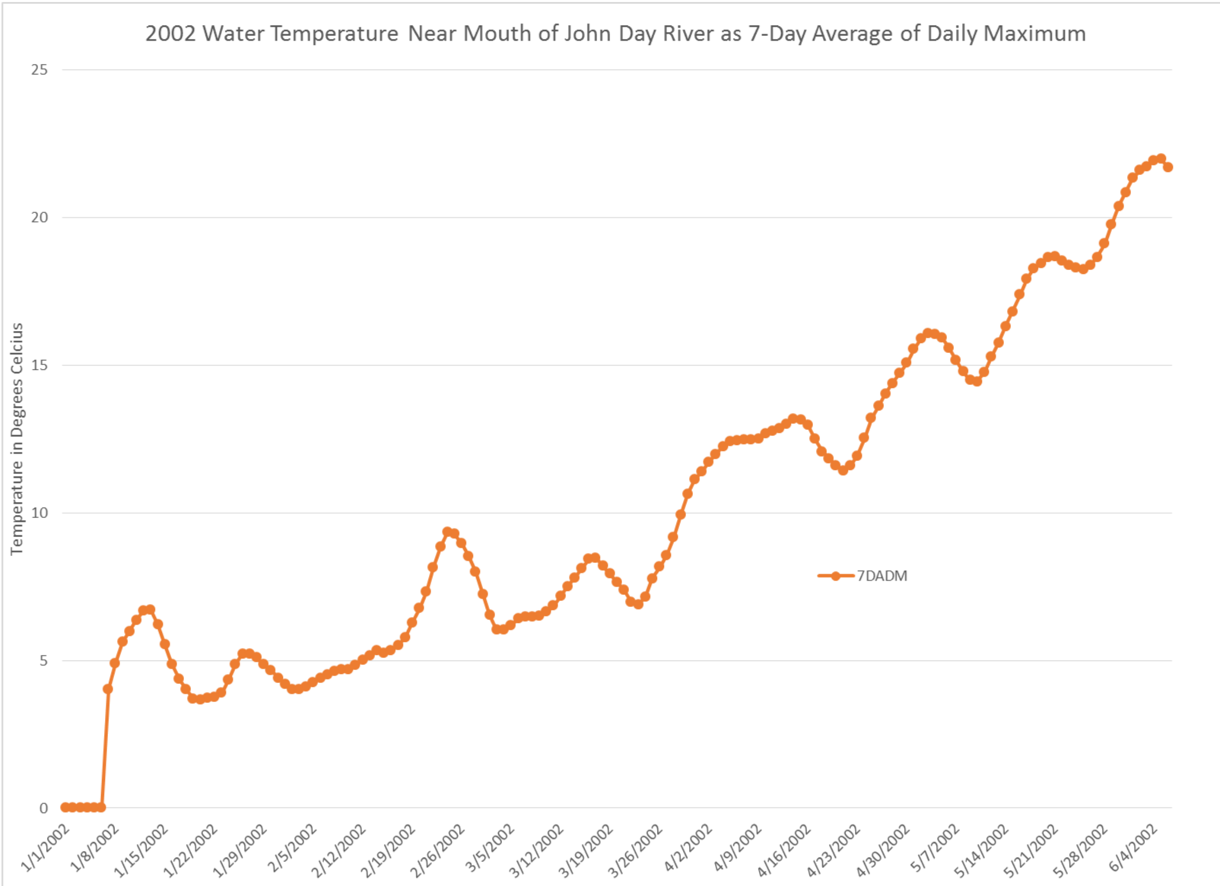

Figure 47. Winter and spring water temperatures as 7DADM near the mouth of the Lower John Day River in 2002. Source: Integrated Status and Effectiveness Monitoring Program, site JD_065, latitude 45.6194, longitude -120.467, available at https://www.webapps.nwfsc.noaa.gov/apex_stem/f?p=168:10:7842023832982 (accessed January 26, 2015).

Based on the migration timing information presented earlier, and the paucity of available temperature information for the Lower John Day River in spring and summer, we make the biologically conservative finding that not all of the above assumptions and rationale regarding protection of steelhead smoltification under the current beneficial use designation that we listed above seem completely valid.

The 20°C migration corridor use is likely to interfere with smoltification in a portion of outmigrating MCR juvenile steelhead, which is likely to reduce their long-term survival. All five populations of MCR steelhead in the John Day MPG are likely to be affected as described above, and effects on juveniles are likely to be significantly negative at the population scale.

Columbia River mainstem from the mouth to the Washington-Oregon border:
Listed steelhead, Chinook salmon, sockeye salmon, eulachon, and green sturgeon are most likely to be exposed to the effects of approving the waters at the 20°C migration corridor beneficial use designation. We previously considered the effects of approving the 20°C migration corridor criterion and the beneficial use designation together for eulachon and green sturgeon. Below we examine the likely effects of approving this beneficial use designation on listed salmon and steelhead.

Maximum summer water temperatures in the Columbia River in Oregon commonly occur in August, although maximum 7DADM temperature in Bonneville Dam forebay occurred on July 10 and 11 in 2015 (22.87 °C), and on September 18 in 2013 (22.42°C) (Figure 48). Temperatures close to the summer maximum sometimes begin in late July (*e.g.*, 2009), or persist into the third week of September (*e.g.*, 2011) (Figure 48). In a scenario where the river was meeting the 20°C criterion, we expect that the maximum temperature would still occur in July or August. If the scenario included removal of dams on the mainstem Columbia River, the maximum temperature could occur in mid-July (Figure 49).

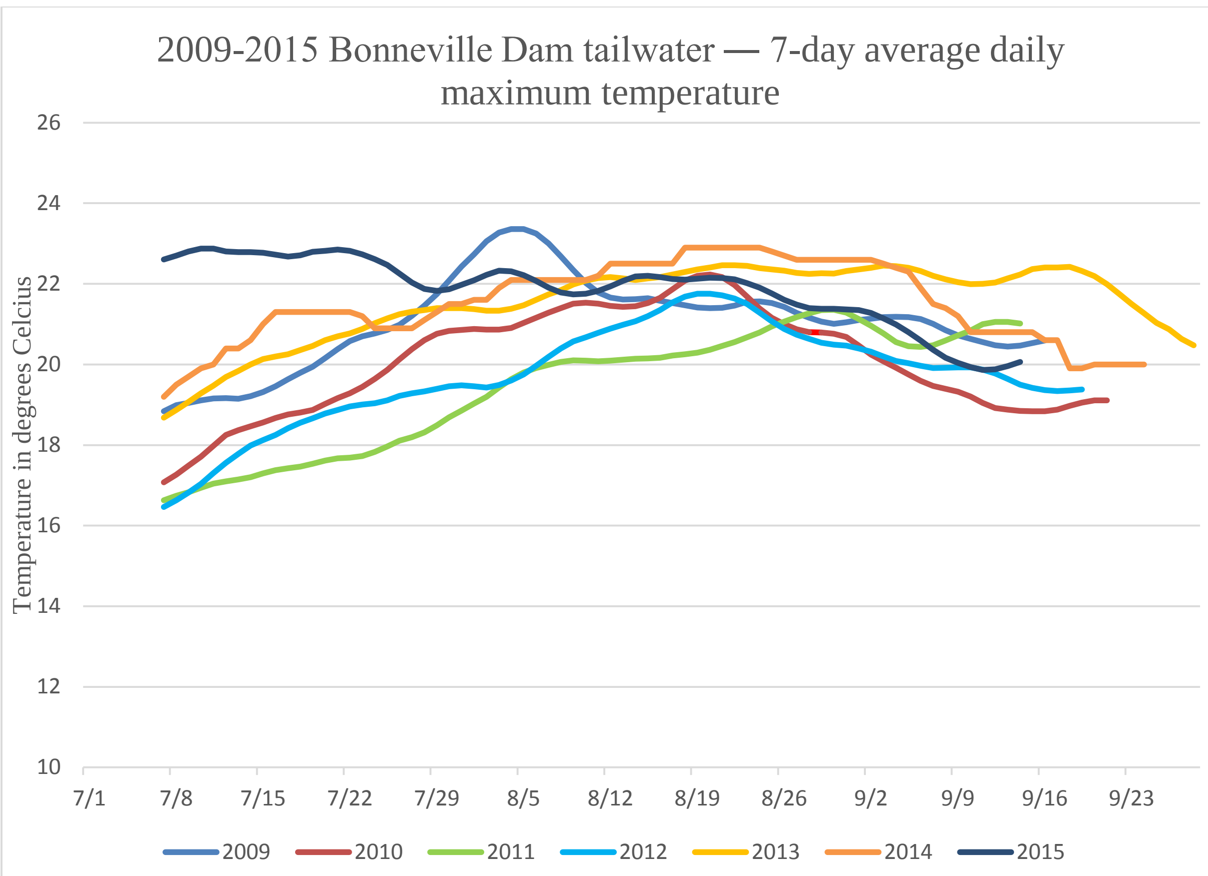

Figure 48. Year 2009 through 2013 7DADM water temperatures in Bonneville Dam tailrace. Source: Columbia River DART, http://www.cbr.washington.edu/dart/query/river_graph_text (accessed February 13, 2015).

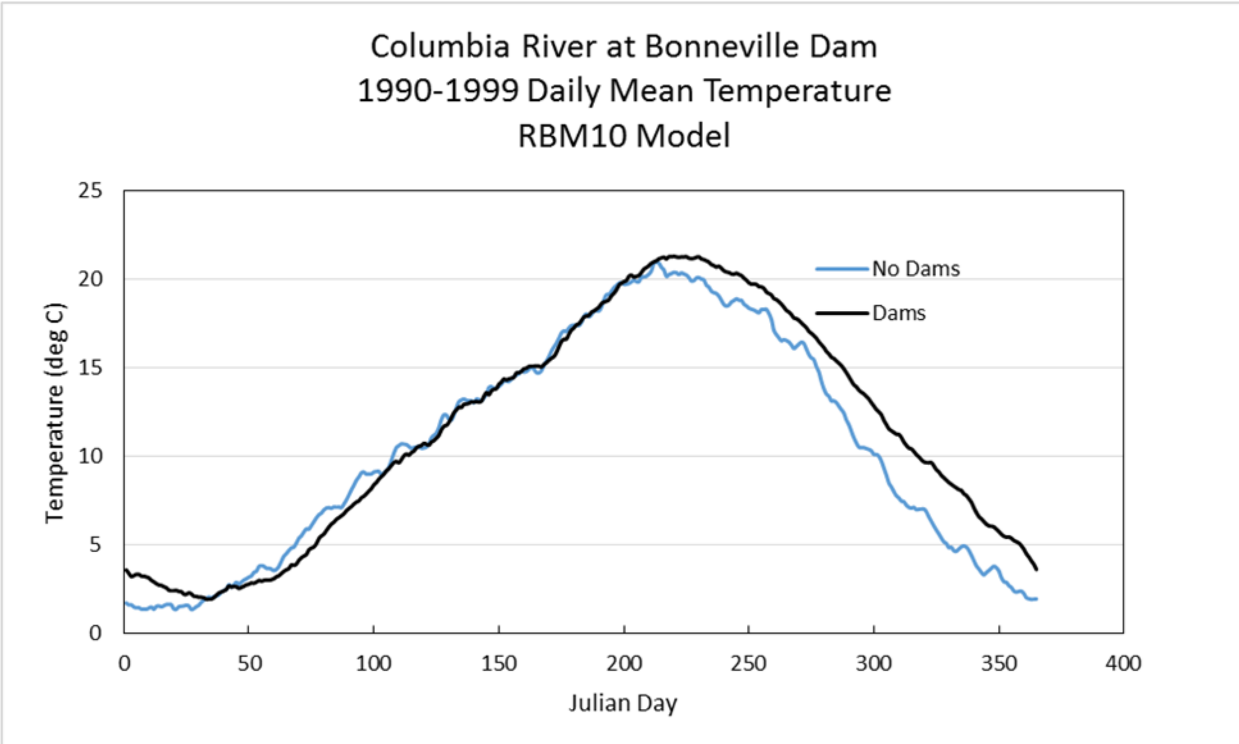

Figure 49. Daily mean temperatures at Bonneville Dam (RM 145) for 1990-1999 with and without mainstem Columbia River Dams. Julian day 200 is July 18 in non-leap years and July 19 in leap years.

Chinook Salmon – Adults

For the years 2009 through 2013, on average 100% of adult UCR spring-run Chinook salmon had migrated past Bonneville and McNary Dams by mid-July (Figure 50), based on data from fish with passive integrated transponder (PIT) tags.

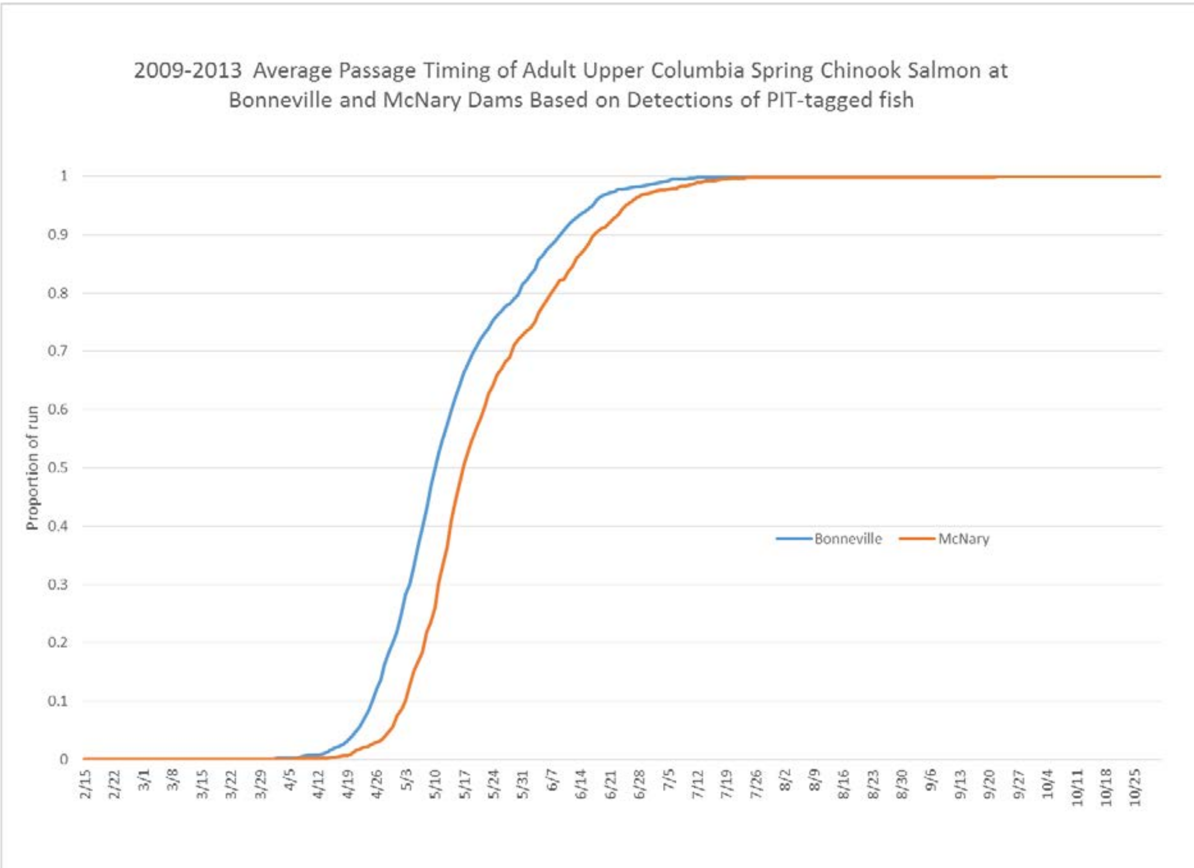

Figure 50. Average passage timing of PIT-tagged adult Upper Columbia spring Chinook salmon at Bonneville and McNary Dams during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

For the years 2009 through 2013, on average 100% of adult SR spring/summer Chinook salmon completed their migration past Bonneville and McNary Dams by mid-July (Figure 51).

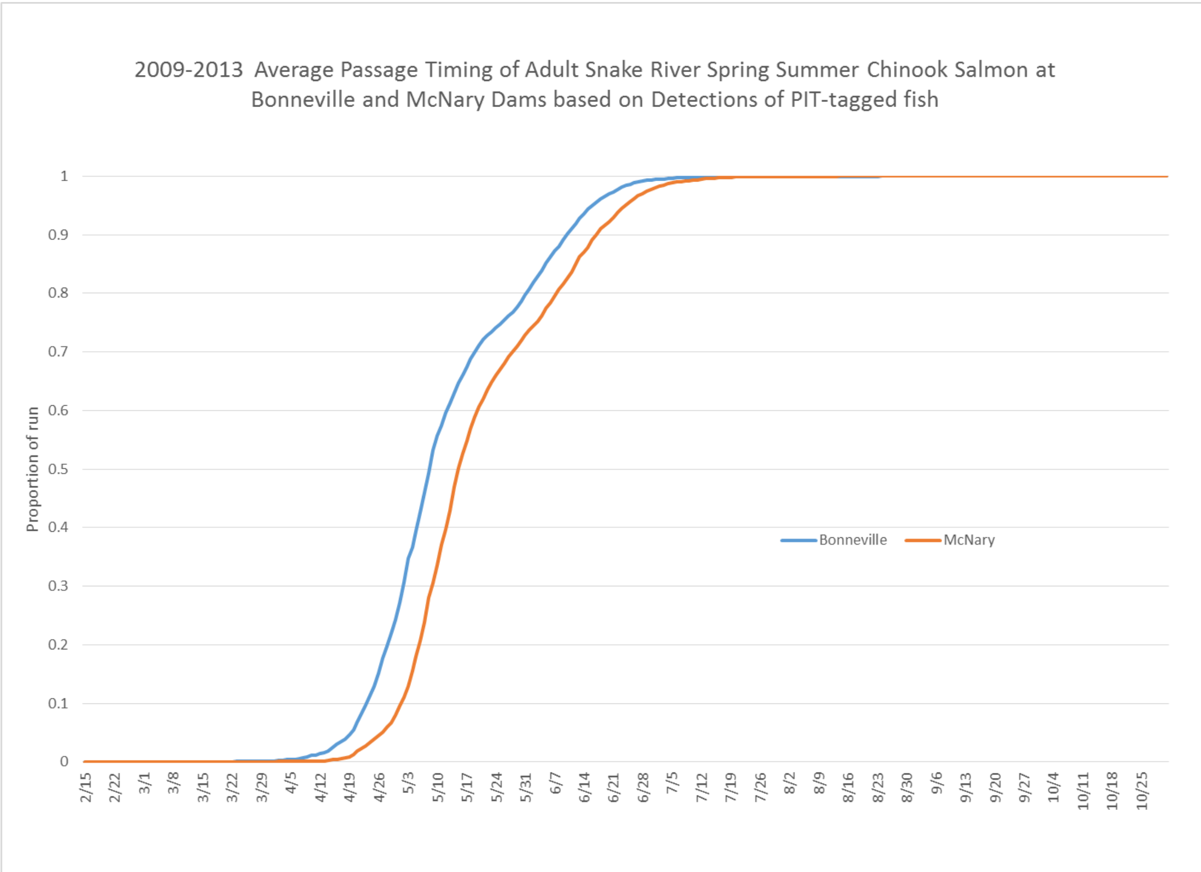

Figure 51. Average passage timing of PIT-tagged adult SR spring/summer Chinook salmon at McNary Dam during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

For LCR Chinook salmon in 2009 through 2013, on average 98.96% migrated past Bonneville Dam by July 15, and 99.16% migrated past the dam by August 1 (Figure 53). For LCR Chinook salmon, the only populations migrating past Bonneville Dam are Upper Gorge Fall Chinook, White Salmon River Fall Chinook, Hood River Fall Chinook, White Salmon River Spring Chinook, and Hood River Spring Chinook. Since these populations, which have the longest upstream migration for LCR Chinook salmon, are able to almost entirely pass Bonneville Dam by July 15, it is likely that other populations that enter tributaries downstream of Bonneville Dam also complete their upstream migrations by August 1, thereby avoiding exposure to temperatures associated with the beneficial use designation for the migration corridor criterion.

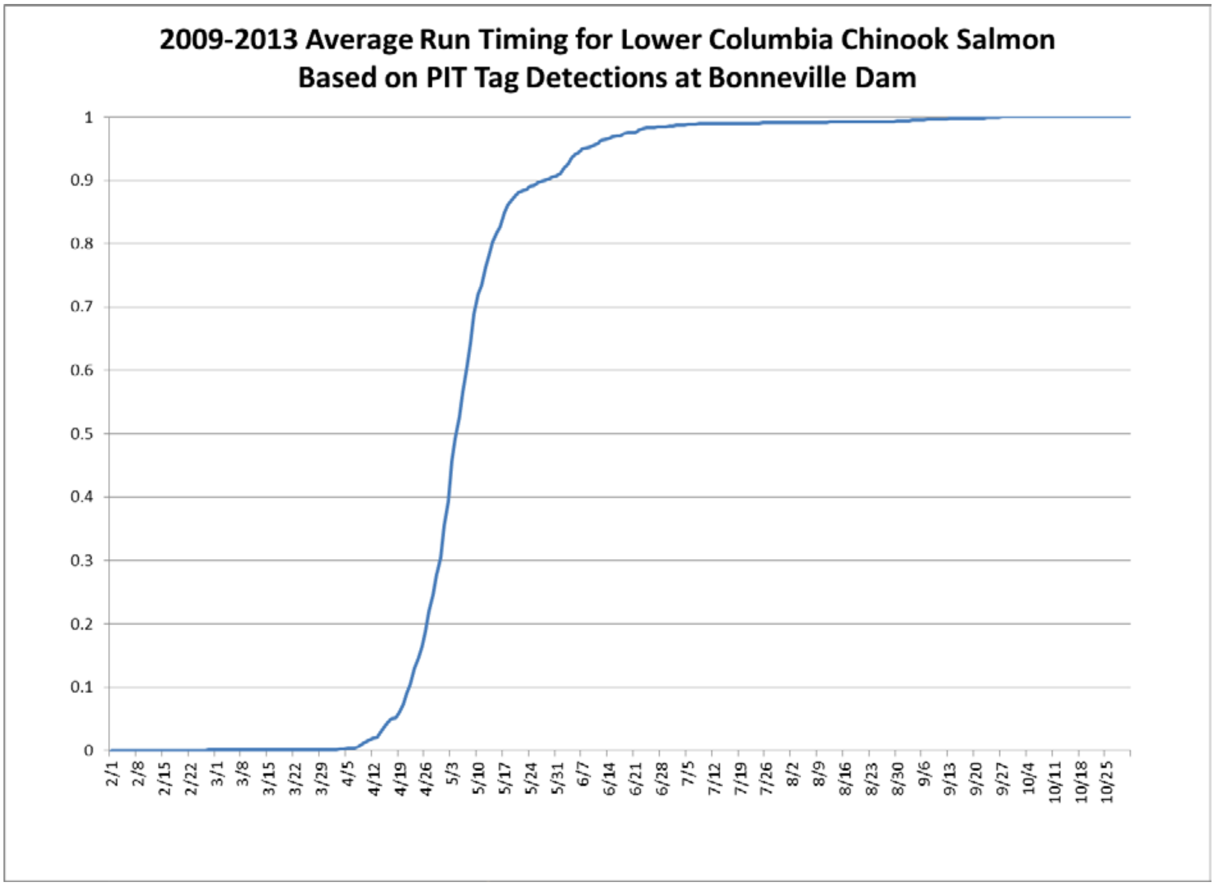

Figure 52. Average passage timing of PIT-tagged adult LCR Chinook salmon at Bonneville Dam during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

For SR fall-run Chinook salmon in 2009-2013, adults began migrating upstream past Bonneville Dam in mid- to late July (Figure 53). By September 15, almost 100% of adults had migrated past the dam. At McNary Dam, adult SR fall-run Chinook salmon began passing the dam in late July, and by September 15 (when temperatures usually have fallen below the summer maximum; Figure 53), approximately 85% of adults had passed the dam (Figure 53).

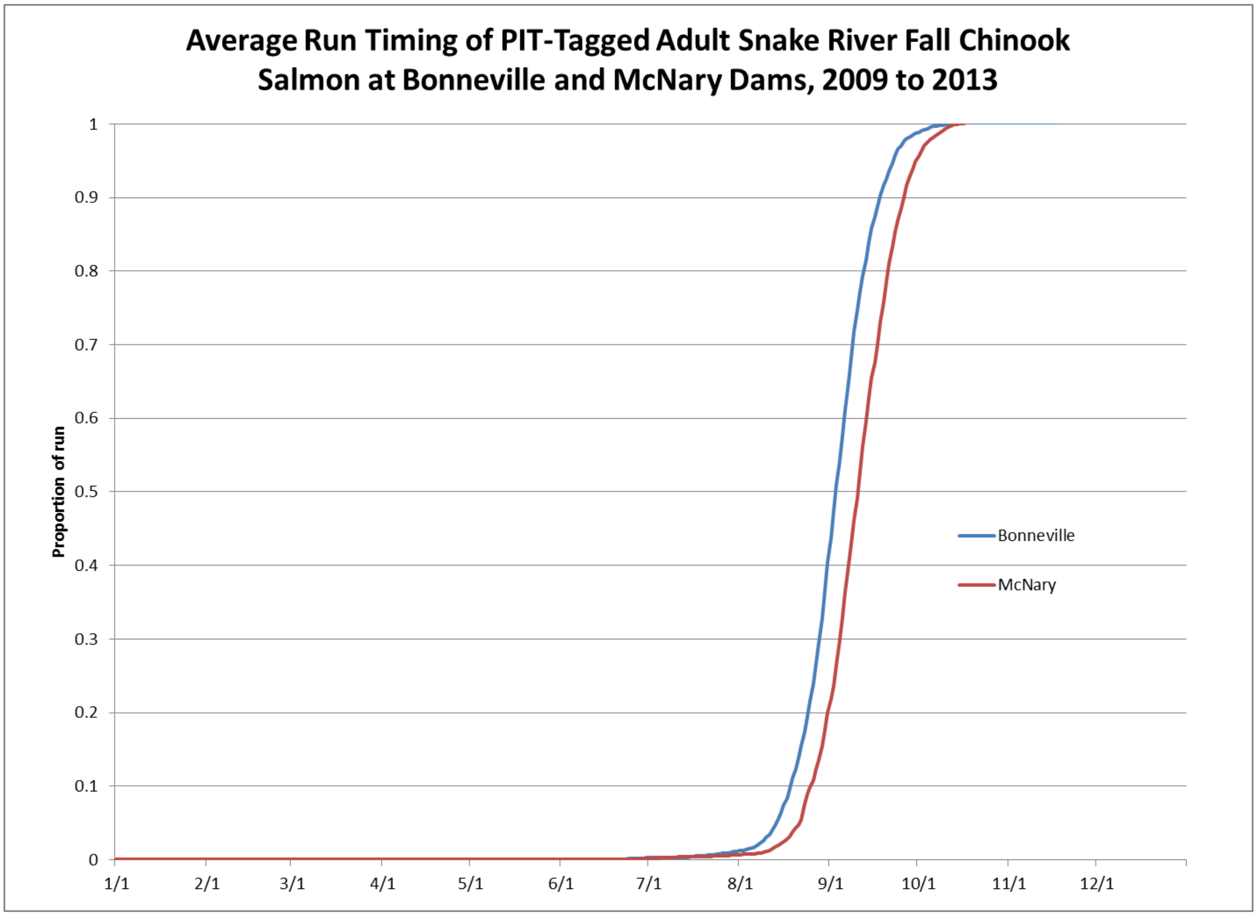

Figure 53. Average passage timing of PIT-tagged adult SR fall-run Chinook salmon at Bonneville and McNary Dams during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

Based on the above information, on average, no adult UCR spring-run and SR spring/summer Chinook salmon, and <1% of adult LCR Chinook salmon, are likely to be exposed to waters at or near the 20°C migration corridor criterion in the Columbia River, except potentially in mixing zones of point-source discharges of heated water. We listed the sources of these discharges in the discussion of the effects of approving the migration corridor criterion on eulachon. We previously explained how the narrative criterion pertaining to thermal plume limitations will protect all listed species of salmon and steelhead from adverse effects at the population scale.

The Oregon water quality standards apply for approximately 16.5 miles upstream of McNary Dam, after which the river turns north into Washington state. Based on taking only approximately 1 week to pass the 146 miles from Bonneville Dam to McNary Dam, both UCR spring-run and SR spring/summer-run Chinook salmon likely migrate through this 16.5-mile reach by the end of July, avoiding exposure to the migration corridor criterion temperature in this reach. UCR Chinook salmon do not enter the Snake River in Oregon, but SR spring/summer Chinook salmon do enter that reach, and therein may receive additional exposure to the 20°C migration corridor criterion temperature (see discussion later in this opinion).

For LCR Chinook salmon, < 1% of migrating adults in each population are likely to be exposed to the migration corridor criterion temperature. Because this is such a small proportion of each population, adverse effects at the population scale for LCR Chinook salmon from approval of the beneficial use designation for the 20°C migration corridor criterion are unlikely.

For SR fall-run Chinook salmon, almost all adult SR fall-run Chinook salmon will be exposed to this criterion's temperature during their spawning migration, considering exposure from the mouth of the Columbia River to Bonneville Dam. At least 85% of fish likely will be exposed between Bonneville Dam and McNary Dam, and the other 15% of the fish that complete passage through this reach after September 15could be exposed to the criterion during their migration from the mouth of the Columbia River to McNary Dam.

The relationships between water temperatures and migration rates, temporary tributary use, and run timing of adult fall Chinook salmon[61] were studied in the lower Columbia River by Goniea *et al.* (2006). They collected movement data between Bonneville Dam and John Day Dam from 2,121 upriver fall Chinook salmon that were radio-tagged over 6 years (1998, and 2000–2004). Weekly median migration rates (for distance traveled per day) through the lower Columbia River between Bonneville Dam and John Day Dam slowed by approximately 50% when water temperatures were above about 20°C as a daily mean. Slowed migration was strongly associated with temporary use of tributaries, which averaged 2 to 7°C cooler than the mainstem river. Overall, 18% of all radio-tagged salmon entered lower Columbia River tributaries, and 9% used tributaries for more than 12 hours. The proportions of salmon that used tributaries increased exponentially with increasing mean weekly Columbia River water temperature, from mostly <5% when temperatures were below 20°C to about 40% when temperatures neared 22°C.

There is also PIT tag data for 2013 to 2015 showing the following percentages of SR fall Chinook salmon that passed Bonneville Dam entered the Deschutes River: for 2015, 0.2%; for 2014, 0.8% and for 2013, 6.4% (mean across 3 years 3.5%).[62] The relatively high use in 2013 may have been because water temperature in the Columbia River peaked relatively late in the summer and remained near the summer maximum until mid-September, overlapping with the peak migration period for this ESU. The type of PIT tag detector used in the Deschutes River

[61] These fish would include ESA-listed SR fall-run Chinook salmon, as well as non-listed fall Chinook salmon from the Hanford reach of the Columbia River.
[62] Data from Columbia River DART program, available at: http://www.cbr.washington.edu/dart/query/esu_graph_text (accessed September 18, 2015).

probably underestimates the number of fish passing up-river by as much as 15 to 20%.[63] With an underestimate of 20%, the mean use of the Deschutes River by SR fall Chinook salmon for 2013 to 2015 would be 4.2% of the fish that passed Bonneville Dam.

Based on the work of Goniea *et al.* (2006) for adult fall Chinook salmon, 20°C as a daily mean likely represents a threshold above which some SRB fall Chinook salmon are likely to seek refuge in cool-water tributaries, delaying their migration. Migrating adult steelhead in the Columbia River that used CWR had higher loss rates due to unknown causes than fish that did not use the tributaries, and relatively high harvest rates in refugia streams (Keefer *et al.* 2009). Harvest in the mainstem river was higher for fish not recorded in CWR, although many fish harvested in the mainstem were reported captured near tributary mouths where they may have been using cool-water tributary plumes (Keefer *et al.* 2009). Although Goniea *et al.* (2006) did not examine the fate of fish that used CWR, we presume they are subject to less fishing pressure than steelhead that use CWR, because they migrate upriver more rapidly and spend less time in the CWR — on the order of hours to days for fall Chinook salmon compared to days to weeks for steelhead (Keefer et al. 2009). Also, based on high rates of adult survival from Bonneville Dam to Lower Granite Dam, which have been meeting or exceeding goals in the 2008 biological opinion on operation of the FCRPS from 2008 through 2014 (the last year with complete data, Figure 54), there does not appear to be a problem with mortality due to unknown reasons in CWR between Bonneville Dam and John Day Dam as there is for steelhead.

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[63] Personal communication with Ritchie Graves, chief of Columbia Hydropower Branch, NMFS, on September 22, 2015.

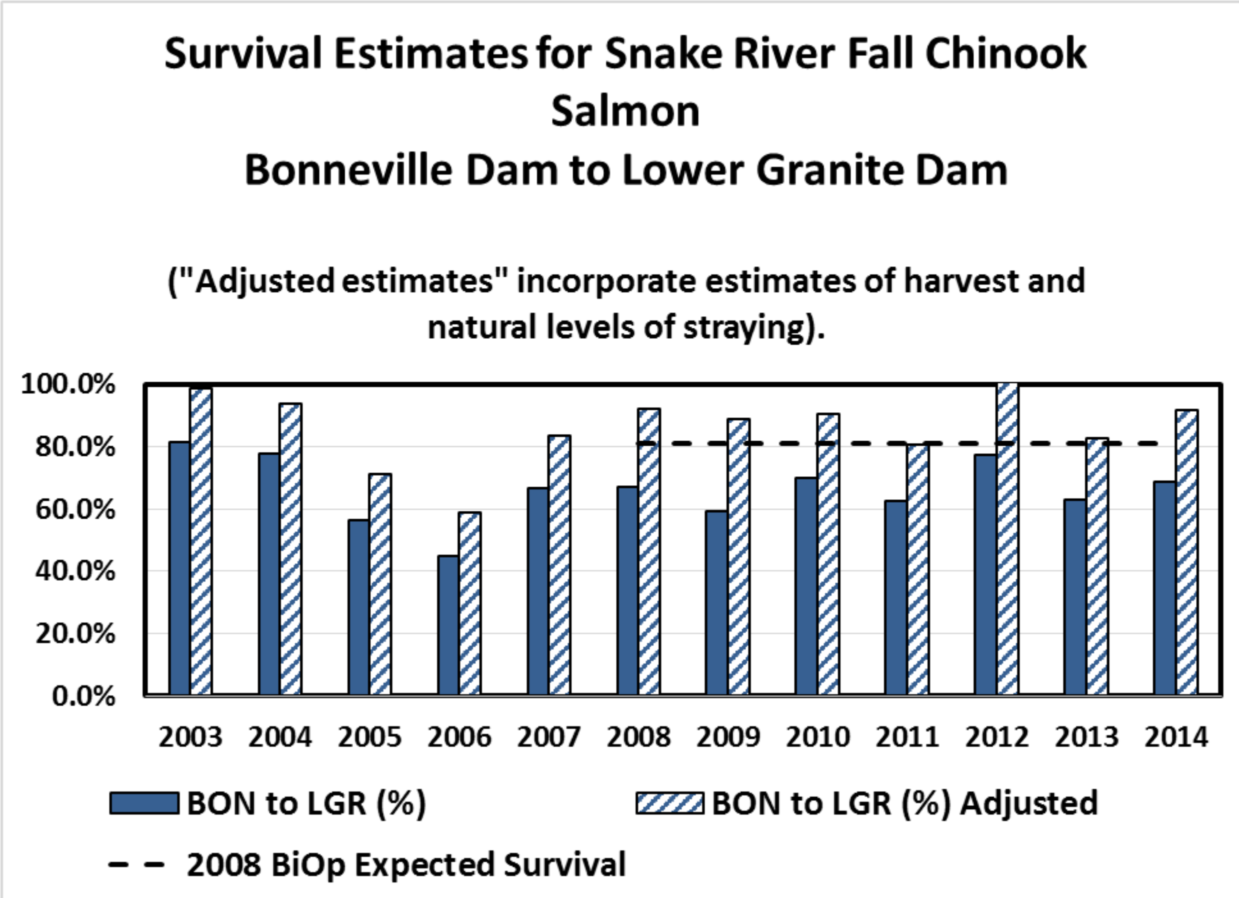

Figure 54. Survival rates of PIT-tagged adult SR fall-run Chinook salmon from Bonneville Dam to Lower Granite Dam, 2003 through 2014. Source: Unpublished data maintained by Blane Bellerud, Columbia Hydropower Branch, NMFS.

The only listed species sampled by Goniea *et al.* (2006) was SR fall-run Chinook salmon. Goniea et al. (2006) noted the need to protect thermal conditions in coolwater tributaries in the face of predicted increases in global temperature, and noted the risk of fishing pressure in these waterways.

The apparent threshold for adverse effects on migration of adult Chinook salmon is 20°C as a daily mean (average) (Goniea *et al.* 2006). A key question for evaluating the beneficial use designation for the migration corridor criterion is whether attaining 20°C as a 7DADM would ensure that temperatures do not exceed 20°C as a daily average. To examine this assumption, we looked at annual patterns of average water temperature at Bonneville Dam forebay and McNary Dam tailrace for the period of 2009 through 2013 (Figures 55 and 56).

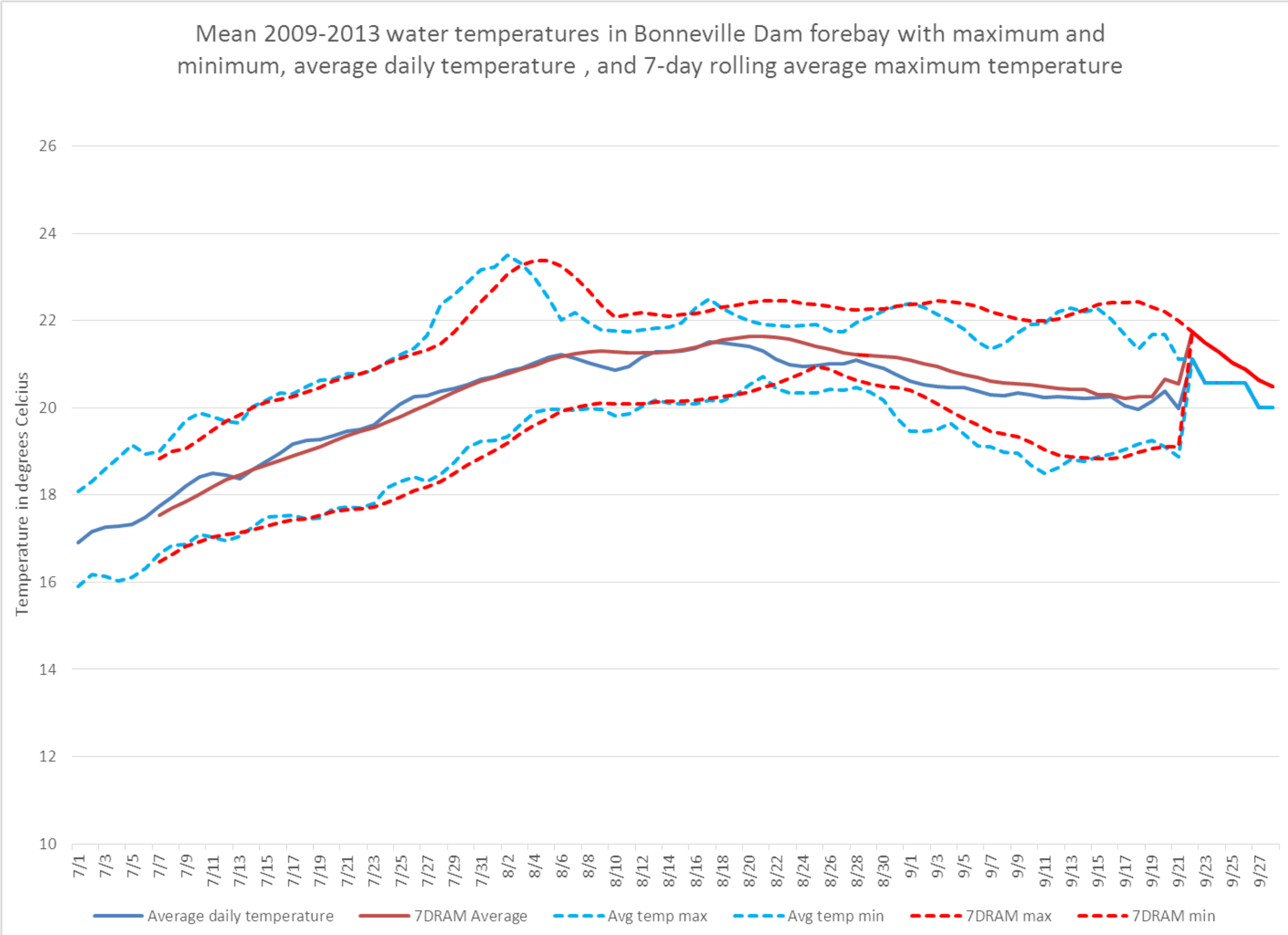

Figure 55. Water temperatures from 2009 to 2013 in Bonneville Dam forebay including 5-year average of daily average temperature (solid blue), 5-year average of 7-day running average daily maximum temperature (solid red), 5-year maximum of daily average temperature (upper dashed blue), 5-year minimum of daily average temperature (lower dashed blue), 5-year maximum of 7-day running average daily maximum temperature (upper dashed red), and 5-year minimum of 7-day running average daily maximum temperature (lower dashed red). Five-year maximum and minimum temperatures (dashed lines) shown only to illustrate complete range of temperatures. Source: Columbia River DART, http://www.cbr.washington.edu/dart/query/river_graph_text (accessed February 13, 2015).

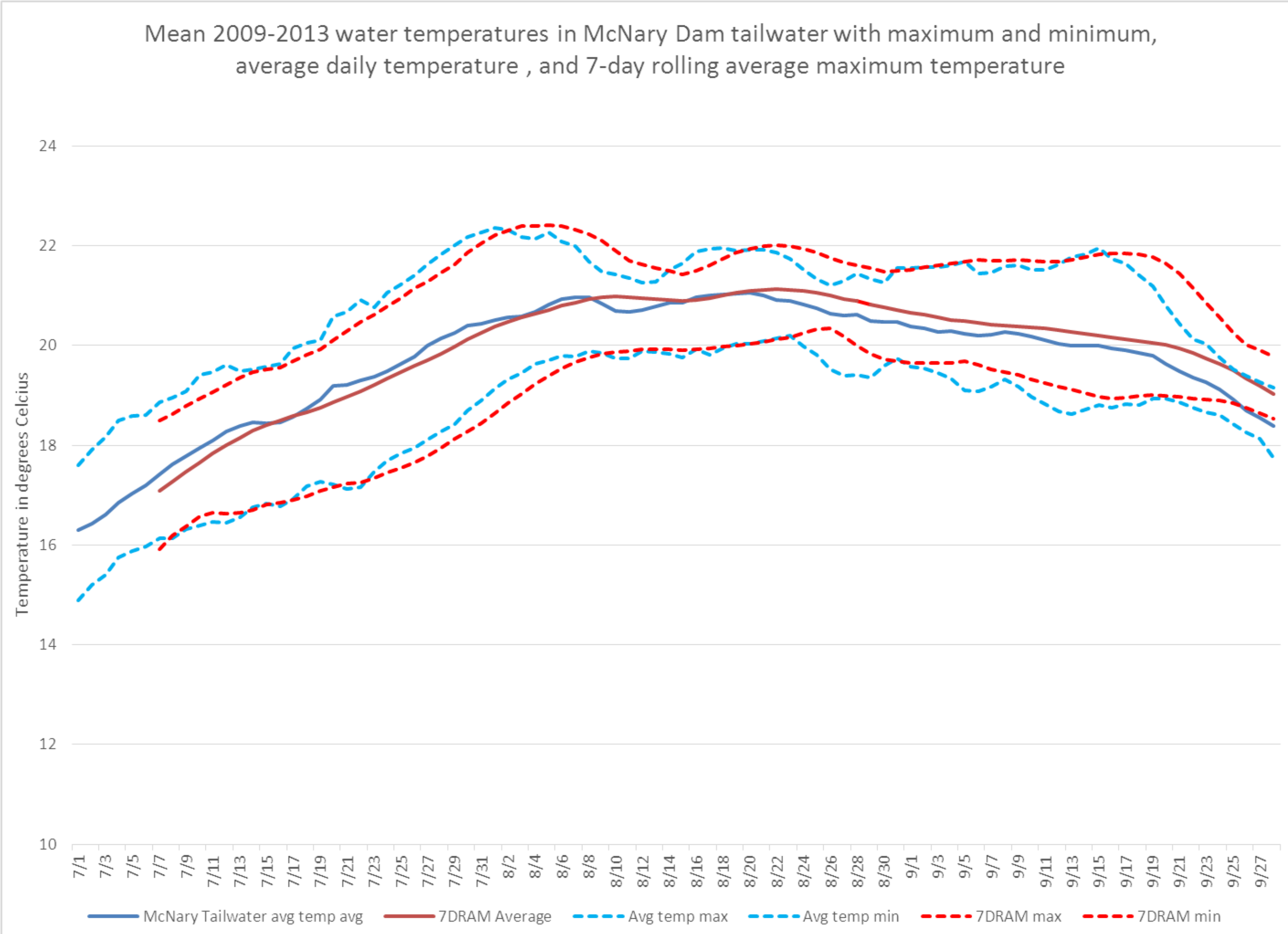

Figure 56. Water temperatures from 2009 to 2013 in McNary Dam tailrace including 5-year average of daily average temperature (solid blue), 5-year average of 7-day running average daily maximum temperature (solid red), 5-year maximum of daily average temperature (upper dashed blue), 5-year minimum of daily average temperature (lower dashed blue), 5-year maximum of 7-day running average daily maximum temperature (upper dashed red), and 5-year minimum of 7-day running average daily maximum temperature (lower dashed red). Five-year maximum and minimum temperatures (dashed lines) shown only to illustrate complete range of temperatures. Source: Columbia River DART, http://www.cbr.washington.edu/dart/query/river_graph_text (accessed February 13, 2015).

The data from Bonneville and McNary Dams represent the best available temperature data for the portion of the Columbia River subject to the migration corridor criterion. The data demonstrate that as the river warms in the early summer, it is common for the average daily temperature to be slightly (*i.e.*, <1°C) warmer than the 7DADM temperature, because the 7DADM temperature lags slightly due to being calculated based on the prior week when temperatures may have been cooler than the average temperature for a given day at the end of a given week. Sometimes the average daily temperature is the same as or slightly (*i.e.*, <1°C) cooler than the 7DADM temperature, particularly after mid-August, which is when most of the SR fall Chinook salmon migrate upstream on average (Figure 53). Overall, it appears that average daily temperatures in a river attaining 20°C as a 7DADM generally would not be over the adverse effects threshold of 20°C during the peak migration period for adult SR fall Chinook salmon.

As for the other potential adverse effects at 20°C for salmon and steelhead that were listed earlier, the ones that are well documented as occurring in the Columbia and Snake Rivers are (1) increased predation on juveniles due to increased abundance of non-native, warm-water species, and (2) increased disease virulence and reduced disease resistance. Increased predation is a problem that likely could be reduced by lower in-river temperatures with regard to the species with the highest temperature preferences (*e.g.*, largemouth bass, *Micropterus salmoides* and channel catfish (*Ictalurus punctatus*). Non-native predators benefit from changes to the river brought about by certain aspects of the construction and operation of the FCRPS that include temperature but are not limited to it, and it will be difficult, if not impossible, to entirely remove this pressure on native species solely by manipulating the temperature criteria and beneficial use designations.

There are a variety of fish diseases in the Columbia River basin that increase in infectivity and virulence with increasing water temperature (Table 36), and risks are high at a water temperature of 20°C (Poole et al. 2001a). These diseases likely increase rates of morbidity and mortality in migrating adult Chinook salmon, although we are not aware of data that would allow us to quantify this effect. The use of CWR by some Chinook salmon during periods of peak water temperatures may be an evolutionary strategy to reduce morbidity and mortality from diseases.

Table 36. Fish diseases in the Columbia River basin that demonstrate increases in infectivity and virulence with increasing water temperature. (Sources: McCullough 1999; Poole *et al*. 2001a; Washington Department of Ecology 2002).

Organism	Disease Name	Temperature Effects	Susceptible Species	Severity of Effects
Bacteria				
Flexibacter columnaris	Columnaris	Outbreaks strongly associated with water temperatures >15 ^{o} C.	All fishes	Has been observed to cause high levels of mortality among wild and hatchery populations.
Renibacterium salmoninarum	Bacterial Kidney Disease	Increased temperatures reduce infectivity, but increase the severity of infections (time until death) in laboratory trials.	All salmonid fishes, especially Chinook and sockeye salmon	Often causes high levels of mortality in hatcheries. High prevalence in some wild fish populations.
Aeromonas salmonicida	Furunculosis	Epizootics strongly correlated with temperature	All fishes	Has been observed to cause high levels of mortality in the wild and hatcheries
Myxobacter sp.	Bacterial Gill Disease	Outbreaks strongly correlated with water temperature and poor water quality	All fishes	
Parasites				
Ceratomyxa Shasta	Ceratomyxosis	Increased temperatures reduced time from exposure to death in laboratory studies.	All salmonid fishes, especially Chinook salmon	Has been observed to cause high levels of mortality in the wild and in hatcheries.
Icthyopthirius multifilis	Ich	Outbreaks strongly associated with water temperatures >15 ^{o} C	All fishes	Has been observed to cause high levels of mortality in the wild and in hatcheries

Chinook Salmon – Juveniles

Based on passage of juvenile UCR spring-run and SR spring/summer Chinook salmon in 2009 through 2013, on average all juveniles complete their downstream migration past McNary and Bonneville Dams by mid-July (Figure 57). Based on the rapid (approximately 1 week) passage through the 146 miles between McNary Dam and Bonneville Dam, these juveniles likely complete the final 46 miles of their migration to the mouth of the Columbia River by August 1, thereby avoiding exposure to the migration corridor criterion in most years. In an unusual year like 2015, when the maximum 7DADM temperature the Bonneville Dam forebay occurred on

July 10 and 11, the tail end of the run may be exposed to the migration corridor criterion, but it would be only a few fish (Figure 57).

Based in passage of juvenile SR fall-run Chinook salmon in 2009 through 2013 , on average 84.7% of juveniles complete their downstream migration past McNary Dam by July 15, and 78.1% completed their migration past Bonneville Dam by July 15 (Figure 57). Based on the roughly 1-week passage time between McNary Dam and Bonneville Dam, these fish likely complete the final 46 miles of their migration to the mouth of the Columbia River by August 1, thereby avoiding exposure to the migration corridor criterion in most years.by August 1 and thereby avoid exposure to the migration corridor criterion temperature in most years. However, approximately 22% of juvenile SR fall-run Chinook salmon will be exposed to this temperature in a typical year, and a higher percentage will be exposed in an unusual year when the water temperature peaks in early July, as it did in 2015. Survival estimates for out-migration from Bonneville Dam to the mouth of the Columbia River range from about 70 to 90% in June, and decline to 20 to 60% in mid-July (McComas *et al.* 2008). By mid-July the average 7DADM temperature at Bonneville Dam under current conditions is approaching 20°C (Figure 30), although we do not know how much of the summer decline in out-migration is due to water temperature and how much is due to other factors.

Although we do not have specific migration timing information for juvenile LCR Chinook salmon, based on life history information we expect a portion of outmigrating juveniles in the Gorge Fall stratum (*i.e.*, Upper Gorge, White Salmon, and Hood populations) will be exposed to the migration corridor criterion during non-peak migration.

Deaths of juvenile salmon from an array of diseases have been observed at many fish collection and handling systems in the FCRPS migratory corridor. *Columnaris* and bacterial kidney disease are two commonly observed at FCRPS juvenile collection systems. While we know that juvenile passage survival is lower under high-temperature conditions, it is often difficult to discern if the cause of death is thermal stress, increased predation, increased susceptibility to disease, or a combination of these factors.

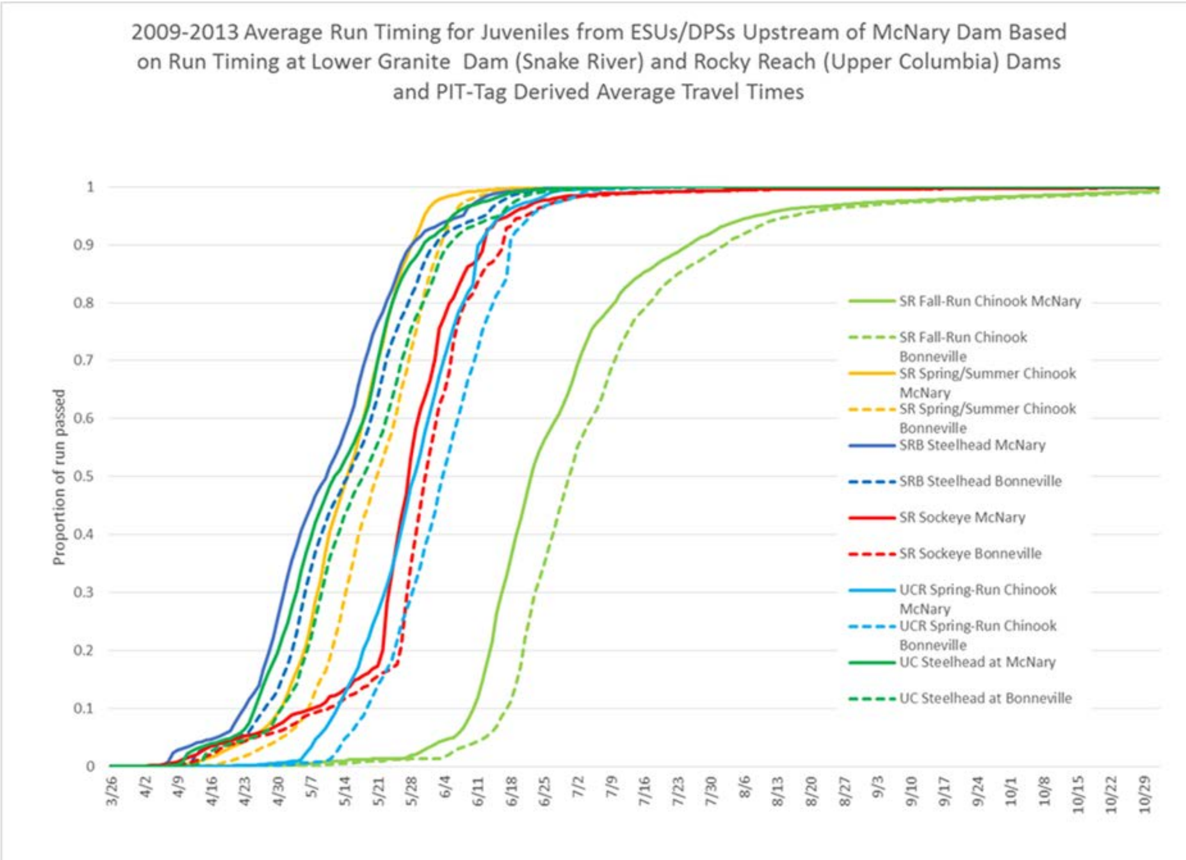

Figure 57. Average passage timing during 2009 through 2013 at McNary and Bonneville Dams for juveniles of Snake River and Upper Columbia River species based on passage timing at Lower Granite Dam (Snake River) and Rocky Reach Dam (Upper Columbia), and PIT-tag derived travel times.

Steelhead – Adults

For steelhead in 2009 through 2013, adults began migrating upstream past Bonneville Dam in early to mid-June (Figure 58). By August 1, when fish are likely to begin experiencing waters at or near the maximum temperature allowed under the 20°C criterion and beneficial use designation, the following approximate proportions had migrated past the dam:

- UCR steelhead: 55%
- MCR steelhead: 60%
- SRB steelhead: 30%
- LCR steelhead: 30%[64]

[64] Most populations of LCR steelhead do not pass Bonneville Dam; only the Upper Gorge Winter, Upper Gorge Summer, Hood Winter and Hood Summer populations migrate this far upstream.

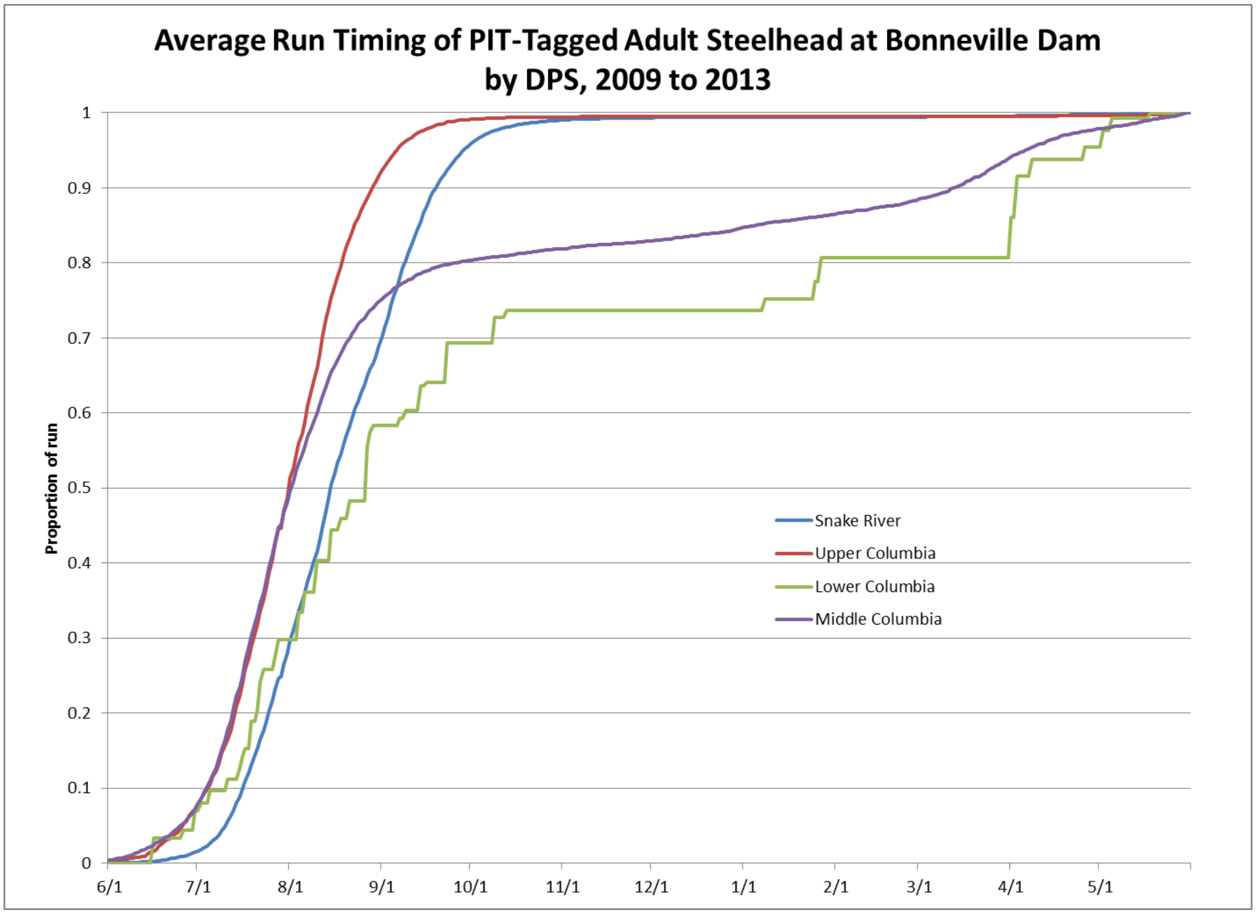

Figure 58. Average passage timing of PIT-tagged adult steelhead by DPS at Bonneville Dam during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

For steelhead in 2009 through 2013, adults began migrating past McNary Dam in mid- to late June (Figure 59). By August 1, when fish are likely to begin experiencing waters at or near the maximum temperature allowed under the 20°C criterion and beneficial use designation, the following approximate proportions had migrated past the dam:

- UCR steelhead: 40%
- MCR steelhead: 35%[65]
- SRB steelhead: 10%

LCR steelhead do not migrate past McNary Dam.

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[65] Some populations of MCR steelhead pass Bonneville Dam but do not migrate as far upstream as McNary Dam.

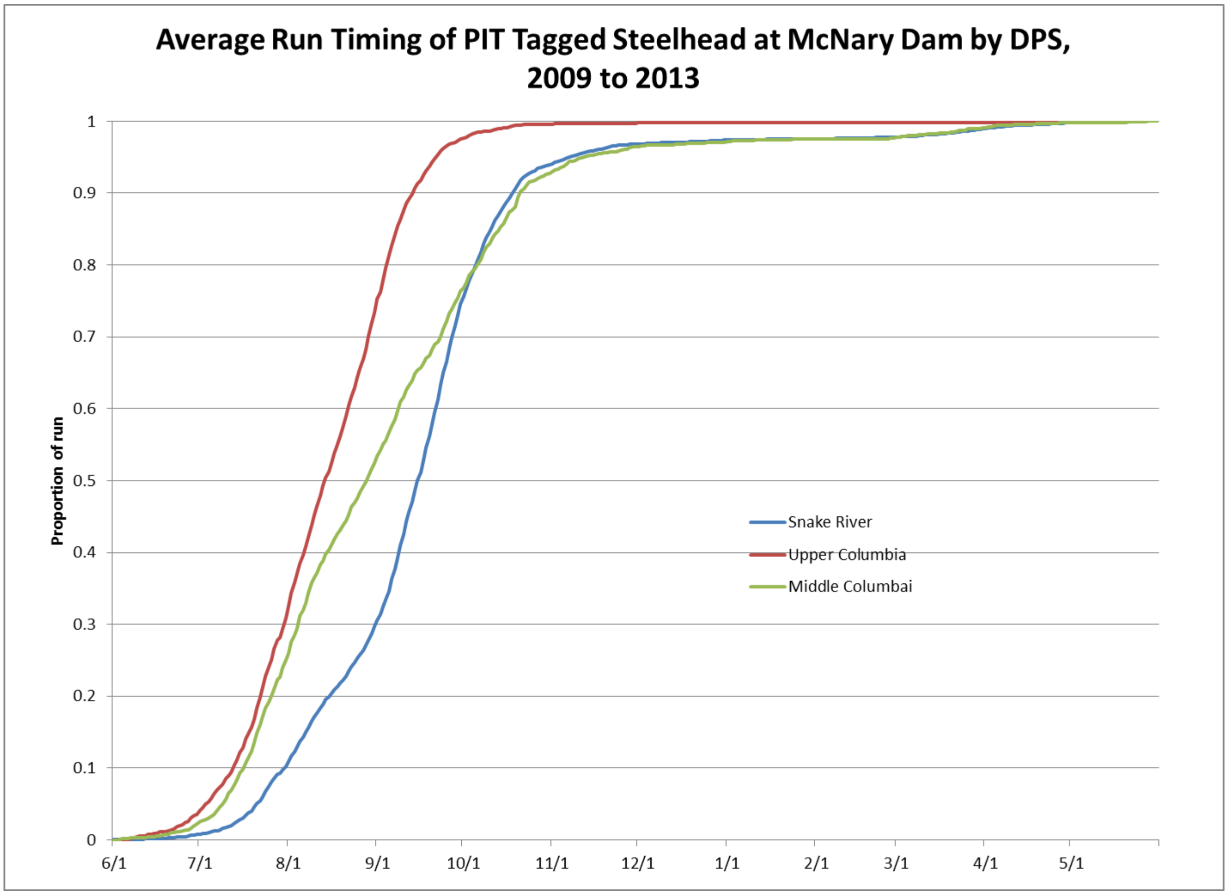

Figure 59. Average passage timing of PIT-tagged adult steelhead by DPS at McNary Dam during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed December 11, 2014).

Based on the above information, adult steelhead will be exposed to the 20°C criterion in the Columbia River at various intensities depending on their migration timing. For UCR steelhead, approximately 50% of the annual run will be exposed in a typical year between the mouth of the Columbia River and McNary Dam, as approximately 50% will be upstream of McNary Dam by August 1, although some of those fish will be exposed briefly in the 16.5-mile upstream portion of the Columbia River subject to the Oregon water quality standard. For MCR steelhead, it is difficult to give an accurate estimate of the proportion of the DPS that is exposed, as some populations do not migrate upstream of McNary Dam. We do know that 60% of the run commonly migrates past Bonneville Dam by August 1, so at least 40% of the run will be exposed after August 1 in its migration from the mouth of the river to at least as far as Bonneville Dam. We also know that the upper boundary of the run that would be exposed in a typical year would be 72% (or a slightly higher percentage), since 28% of the run has migrated past McNary (but not completely out of Oregon's portion of the Columbia River) by August 1. We do not know the percentage of the run that passes Bonneville Dam before August 1 that has left the Columbia River somewhere between the two dams by August 1, reducing their exposure. For SRB steelhead, approximately 90% of the run will be exposed. For all adult steelhead, exposure to the migration corridor criterion would be greater in a year with an early peak in summer water temperature, such as 2015, when the maximum 7DADM temperature occurred on July 10 and 11.

UCR steelhead do not enter the Snake River in Oregon, but SRB steelhead do enter that reach, and therein could be exposed to the 20°C migration corridor criterion (see discussion later in this opinion).

In a study concurrent with that of Goniea *et al.* (2006), High *et al.* (2006) and Keefer *et al.* (2009) monitored how water temperatures affect migration rates and temporary tributary use for adult summer steelhead[66] in the same river reach. They collected radio telemetry data for the movement patterns of 2,900 radio-tagged steelhead between Bonneville Dam and John Day Dam over 3 years (1996, 1997, and 2000). An average of 61% of the steelhead destined for upstream areas temporarily staged in one or more cool tributaries in the lower Columbia River for durations from <1 hour to 237 days. The use of cool tributaries was most directly related to mainstem Columbia River temperature, followed by the temperature differential between the mainstem and tributaries (High *et al.* 2006). Steelhead use of cool-water tributaries as thermal refugia rapidly increased when the Columbia River reached a temperature threshold of about 19°C as daily mean (Keefer *et al.* 2009).

Steelhead that temporarily staged in tributary rivers migrated through the lower Columbia River significantly more slowly than steelhead that did not use tributaries. When temperatures at Bonneville Dam were <19°C (daily mean), fish passed from that dam to The Dalles Dam in a median of 3 days, with 10% recorded in cool-water tributaries. At reservoir entry temperatures of 19 to 21°C (daily mean), the median passage time was 6 days, and 49% used tributaries. Above 21°C as a daily mean, the median time was 25 days, and 71% used tributaries (Keefer *et al.* 2009).

The Little White Salmon River (in Washington) and the Deschutes River (in Oregon) accounted for 78% to 83% of all tributary usage, and approximately 25 to 30% of the tagged steelhead that migrated upstream of the Dalles Dam were observed in one of these two tributaries. The percentage of tagged steelhead using the Deschutes River ranged from 15 to 16%, and the percentage of tagged fish using any of the monitored Oregon tributaries (*i.e.*, Deschutes River, Herman Creek, or Eagle Creek) ranged from 15 to 19%. Telemetry data from tributary and confluence antennas indicated that steelhead with passage times >3 days spent most of the additional migration time inside refugia tributaries or areas where cool tributary water mixed with the mainstem near confluences (High *et. al*. 2006).

On average, the steelhead populations that migrated earliest (Tucannon, Hanford Reach, and Lyon's Ferry[67]) and latest (Clearwater[68]) encountered the lowest mean daily temperatures in the Bonneville reservoir, were least likely to use refugia, and passed through the Bonneville to John

[66] These fish would include ESA-ESA-listed MCR steelhead, SRB steelhead, and UCR steelhead.

[67] Fish from the Tucannon River population are in the Lower Snake River MPG of ESA-ESA-listed SRB steelhead. The Hanford Reach and Lyon's Ferry stocks of steelhead are not ESA-listed under the ESA.

[68] Fish from the Clearwater River basin are in the Clearwater River MPG of ESA-ESA-listed SRB steelhead.

Day reach fastest. The populations that migrated during the warmest conditions (Grande Ronde, Imnaha, John Day, and Umatilla[69]) had the longest passage times and highest rates of refugia use (Keefer *et al.* 2009).

Success in homing to natal streams, measured in 2001 to 2003, was 8.1% lower for all wild and hatchery fish that used thermal refugia, and 4.5% lower for wild steelhead (68.5% versus 73.0%). As for the cause of the reduced homing success, fish that used thermal refugia had higher loss rates due to unknown causes than fish that did not use the tributaries, and relatively high harvest rates in refugia streams. Harvest in the mainstem river was higher for fish not recorded in refugia, although many fish harvested in the mainstem were reported captured near tributary mouths where they may have been using cool-water tributary plumes. Keefer *et al.* (2009) did not observe any delayed adverse effects in steelhead based on whether or not they used cool-water refugia, noting that "There was little evidence that steelhead survival upstream from The Dalles and (or) John Day dams was affected by thermoregulatory behavior in reservoir reaches downstream from these sites." This suggests either that other adverse effects of warm temperatures on survival of migrating adults were equal between fish that used cool-water refugia and those that did not, or that increased losses due to fishing in the areas influenced by cool-water refugia were the only adverse effect of warm temperatures. Keefer *et al.* (2009) did not examine how the use of cool-water tributaries and the delay of migration affected spawning success or survival of offspring.

Based on the work of Keefer *et al.* (2009) and High et al. (2006), 19°C as a daily mean likely represents a threshold above which more than half of adult summer steelhead in the MCR, SRB and UCR DPSs are likely to seek refuge in cool-water tributaries, delaying their migration. Therefore, a key question for evaluating the beneficial use designation for the migration corridor criterion is whether attaining 20°C as a 7DADM would ensure that temperatures do not exceed 19°C as a daily average. We explained earlier that, based on seasonal patterns of heating and cooling at Bonneville and McNary Dams (Figures 55 and 56), it does not appear that attaining 20°C as a 7DADM would ensure that daily mean (average) temperatures would stay below 20°C. Therefore, it also is unlikely that attaining 20°C as a 7DADM would ensure that daily mean (average) temperatures would stay below the adverse effects threshold for adult steelhead of 19°C.

There is also PIT tag data for 2013 to 2015 showing the following percentages of SRB steelhead that passed Bonneville Dam entered the Deschutes River: for 2015, 7.50%; for 2014, 8.13%; and for 2013, 13.27% (mean across 3 years 9.41%).[70] The type of PIT tag detector used in the Deschutes River probably underestimates the number of fish passing up-river by as much as 15 to 20%.[71] With an underestimate of 20%, the mean use of CWR by SRB steelhead for 2013 to 2015 would be 11.29% of the fish that passed Bonneville Dam. These percentages for SRB

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[69] Fish from the Grande Ronde and Imnaha river populations are in MPGs of the same names within ESA-ESA-listed SRB steelhead. The John Day populations are in the John Day MPG, and the Umatilla population is in the Walla Walla and Umatilla MPG.

[70] Data from Columbia River DART program, available at: http://www.cbr.washington.edu/dart/query/esu_graph_text (accessed September 18, 2015).

[71] Personal communication with Ritchie Graves, chief of Columbia Hydropower Branch, NMFS, on September 22, 2015.

steelhead are not directly comparable to percentages of steelhead using CWR described in High *et al.* (2006) and Keefer *et al.* (2009) due to different detection methodologies and because the two earlier authors were not able to separate fish from the MCR, SRB and UCR DPSs; however, they do confirm that significant numbers of SRB steelhead used the Deschutes River as a CWR in recent years.

Increase in fishing pressure on steelhead that use refugia has reduced the number of fish reaching spawning streams by approximately 4.5%, so we assume that this increase in mortality will continue unless fishery managers for the Columbia River reduce fishing pressure. The summer steelhead MPGs most likely to suffer increased deaths in this manner are those that migrate primarily during the warmer months, which include the Upper Grande Ronde and Imnaha MPGs within SRB steelhead, and the John Day and Umatilla/Walla Walla MPGs within MCR steelhead. Also, since only approximately 40% of adult UCR steelhead have passed McNary Dam by August 1, we presume that approximately 60% of the fish in this DPS will be exposed to waters at or near the maximum temperature allowed under the 20°C criterion and beneficial use designation, and will experience the same adverse effects.

High *et al.* (2006) noted “the need for the conservation of lower Columbia River tributary habitat to ensure the availability of coolwater refugia to listed runs of upriver adult steelhead migrants. The need may be more urgent in the future, as average air temperatures are expected to continue to increase in light of predicted regional climate change.” High et al. (2006) also noted that “Agencies responsible for setting fishing regulations should be mindful that decisions affecting harvest in downstream tributary areas may potentially affect listed upriver stocks. In warmer years, such effects are potentially greater.” Keefer *et al.* (2009) noted that “In the Columbia River system, where many important refugia have already been identified, managers must now balance demands for fisheries with more conservative restrictions in refugia sites to protect populations listed under the Endangered Species Act.”

There are a variety of fish diseases in the Columbia River basin that increase in infectivity and virulence with increasing water temperature (Table 36), and risks are high at a water temperature of 20°C (Poole et al. 2001a). These diseases likely increase rates of morbidity and mortality in migrating adult steelhead, although we have not seen data that would allow us to quantify this effect. The use of CWR by some steelhead during periods of peak water temperatures may be one evolutionary strategy to reduce morbidity and mortality from diseases, although data are lacking to confirm this.

Steelhead — Juveniles

Based on passage of juvenile UCR and SRB steelhead in 2009 through 2013, on average all juveniles complete their downstream migration past McNary and Bonneville Dams by mid-July (Figure 60). Based on the rapid (approximately 1 week) passage through the 146 miles between McNary Dam and Bonneville Dam, these juveniles most likely complete the final 46 miles of their migration to the mouth of the Columbia River by late July, thereby avoiding exposure to the migration corridor criterion temperature in a typical year. However, exposure to the migration corridor criterion of 20°C would be greater in a year with an early peak in summer water temperature, such as 2015, when the maximum 7DADM temperature occurred on July 10 and 11.

For MCR steelhead, over 99% of juveniles from all populations pass Bonneville Dam by the end of June, and over 99% of the Yakima, Walla Walla and Umatilla populations pass McNary Dam by the same date. Therefore, these populations likely would avoid exposure to the migration corridor criterion. The John Day population completed about 82% of its migration by early June, and the remainder migrated in the fall.

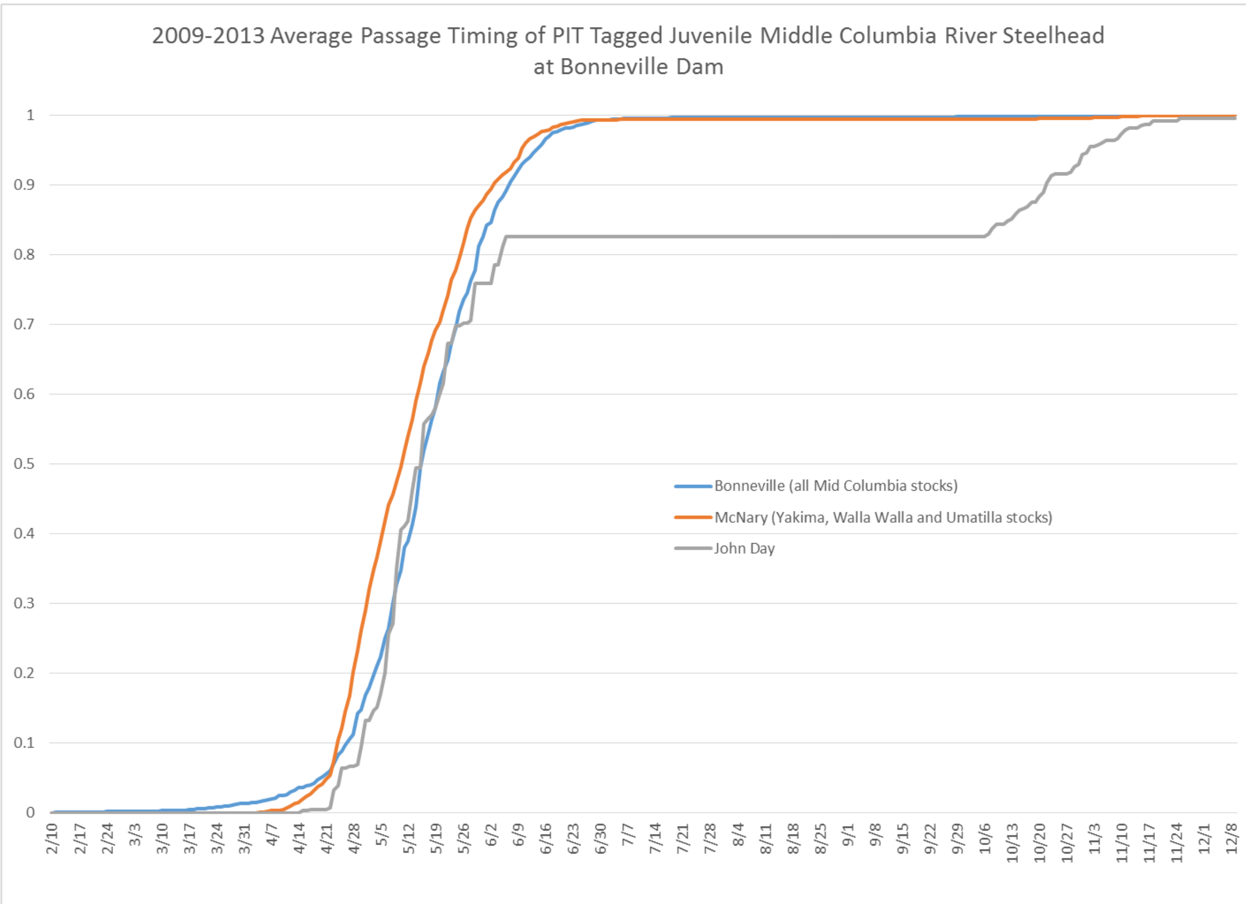

Figure 60. Average passage timing of PIT-tagged juvenile MCR steelhead at Bonneville and McNary Dams during 2009 through 2013.

Sockeye Salmon – Adults

Adult SR sockeye salmon generally migrate through the Oregon portion of the Columbia from mid-June to mid-July, when daily mean temperatures are mostly 15 to 19°C (Quinn *et al.* 2007), with little evidence of refugia use. By late July, SR sockeye salmon have passed both Bonneville and McNary Dams (Figure 61). However, exposure to the migration corridor criterion of 20°C would be greater in a year with an early peak in summer water temperature, such as 2015, when the maximum 7DADM temperature occurred on July 10 and 11.

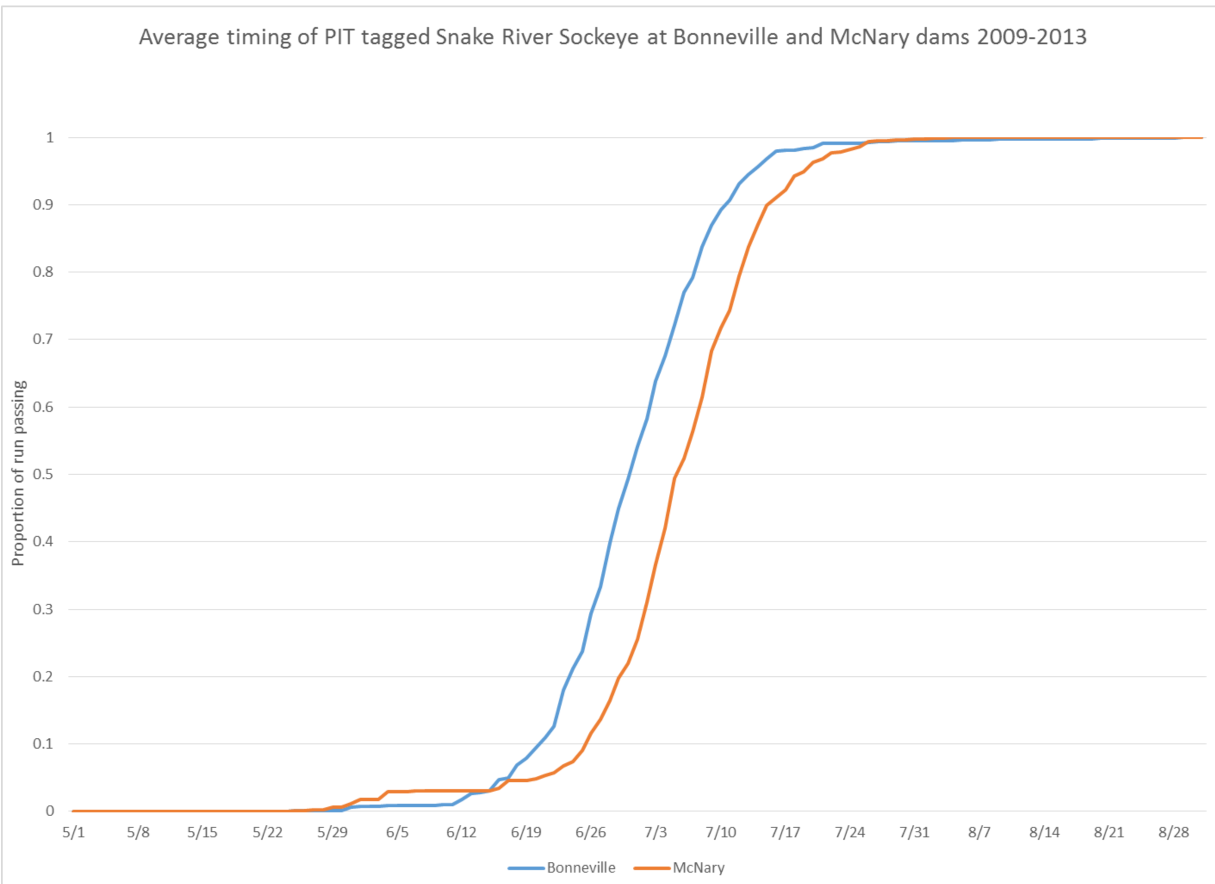

Figure 61. Average passage timing of PIT-tagged adult sockeye salmon at McNary Dam during 2009 through 2013. Source: Columbia River DART program. Available at http://www.cbr.washington.edu/dart/query/adult_daily (accessed February 23, 2015).

There is also PIT tag data for 2013 to 2015 showing the following percentages of SR sockeye salmon that passed Bonneville Dam entered the Deschutes River: for 2015, 6.18%; for 2014, 1.69%; and for 2013, 0.96% (mean across 3 years 4.01%).[72] The type of PIT tag detector used in the Deschutes River probably underestimates the number of fish passing up-river by as much as 15 to 20%.[73] With an underestimate of 20%, the mean use of CWR by SR sockeye salmon for 2013 to 2015 would be 4.82% of the fish that passed Bonneville Dam. Overall, a smaller percentage of SR sockeye than SRB steelhead appears to using the Deschutes River as a CWR.

Crozier *et al.* (2014) analyzed existing data from 920 adult SR sockeye salmon marked with passive integrated transponder tags and detected at Bonneville Dam from 2008 through 2013. The goal of their analysis was to identify the river conditions most unfavorable for migration success in reaches from Bonneville Dam to the Sawtooth Valley in Idaho, and to explore potential triggers for barge transportation of the fish.

The probability of an individual sockeye salmon surviving the migration during 2010 to 2013 from Ice Harbor Dam (located on the Snake River just upstream of the confluence of the Columbia River) to the Sawtooth Valley in Idaho was strongly correlated with temperature, with survival dropping below 50% when water temperature exceeded 18°C as a daily mean (Figure 62). The strongest predictors of survival from Lower Granite Dam (the last dam on the Snake River in Washington state moving upstream) to the Sawtooth Valley in the two models developed by Crozier *et al.* (2014) was temperature experienced at Ice Harbor Dam (which is the first dam on the Snake River upstream of the Columbia River), and cumulative thermal exposure from Bonneville Dam to Lower Granite Dam (which is three dams upstream of Ice Harbor Dam on the Snake River). Uncertainty was high for effects of cumulative exposure. Based on this information, approving the beneficial use designation for the migration corridor criterion of 20°C in the Columbia River likely would increase cumulative thermal exposure and mortality of adult SR sockeye salmon during upstream migration. However, as stated earlier, there is considerable uncertainty about the contribution of cumulative exposure in the Columbia River to this effect.

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[72] Data from Columbia River DART program, available at: http://www.cbr.washington.edu/dart/query/esu_graph_text (accessed September 18, 2015).

[73] Personal communication with Ritchie Graves, chief of Columbia Hydropower Branch, NMFS, on September 22, 2015.

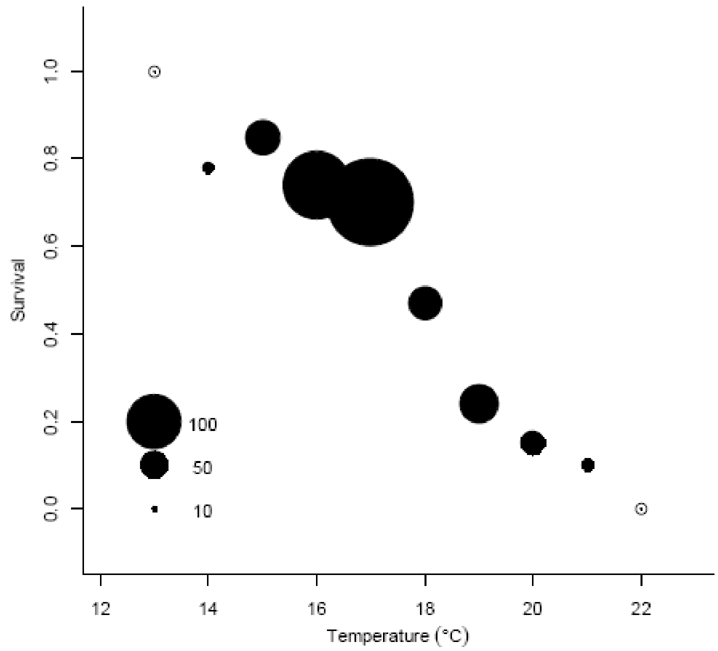

Figure 62. Observed survival of SR sockeye salmon during 2010 to 2013 from Ice Harbor Dam to the Sawtooth Valley as a function of the temperature experienced at Ice Harbor Dam as a daily mean. Circle size is proportional to the number of fish within each 1°C temperature bin. Hollow circles indicate a single fish. Figure from Crozier *et al.* (2014).

There are a variety of fish diseases in the Columbia River basin that increase in infectivity and virulence with increasing water temperature (Table 36), and risks are high at a water temperature of 20°C (Poole et al. 2001a). These diseases likely increase rates of morbidity and mortality in migrating adult sockeye salmon, although we have not seen data that would allow us to quantify this effect. The use of CWR by some sockeye salmon during periods of peak water temperatures may be one evolutionary strategy to reduce morbidity and mortality from diseases, although data are lacking to confirm this.

SR Sockeye Salmon - Juveniles

Based on passage of juvenile SR sockeye salmon in 2009 through 2013, on average 99.0% of juveniles complete their downstream migration past McNary Dam by July 15, and 98.9% complete their migration past Bonneville Dam by July 15 (Figure 57). Based on the rapid (approximately 1 week) passage through the 146 miles between McNary Dam and Bonneville Dam, these juveniles most likely completed the final 46 miles of their migration to the mouth of the Columbia River by late July, thereby avoiding exposure to the migration corridor criterion temperature in a typical year. Approximately 1% of juveniles would be exposed to the migration corridor criterion temperature, but this is such a small proportion that it likely would not add significantly to the population-scale effects related to adult migration. In an unusual year like

2015, when the maximum 7DADM temperature the Bonneville Dam forebay occurred on July 10 and 11, the tail end of the run may be exposed to the migration corridor criterion, but it would be only a few fish (Figure 57).

Snake River from the Washington-Oregon border to Hells Canyon Dam: SR fall-run Chinook salmon and Snake River sockeye salmon will receive additional exposure to the migration corridor criterion temperature in this river reach should EPA approve the migration corridor beneficial use designation. This is likely to increase disease incidence, and could reduce spawning success due to thermal stress on gametes, although we did not have data that would allow us to quantify these effects.

Summary for Columbia and Snake Rivers: Significant portions of adult SR fall-run Chinook salmon will be exposed to the 20°C migration corridor criterion during their migration. Thus some deaths due to migration delay, increased fishing pressure and predation, and disease issues are likely under the migration corridor beneficial use designation. However, as documented above, adults in this ESU migrate up-river relatively rapidly, do not use CWR at high rates or remain in them for long, and do not appear to experience biologically significant losses during upstream migration due to fishing pressure in CWR or other reasons. Also, abundance of fish in this ESU is up considerably over the last 10 to 15 years (Figure 62). Less than a quarter of out-migrating juveniles also are likely to be exposed to this criterion in a typical year. Although we expect some deaths and injuries due to increased predation and disease issues would occur in late-migrating juveniles in a river meeting the 20°C migration corridor criterion, it is unlikely that enough fish would be exposed or affected to cause effects on any of the VSP variables at the scale of the population.

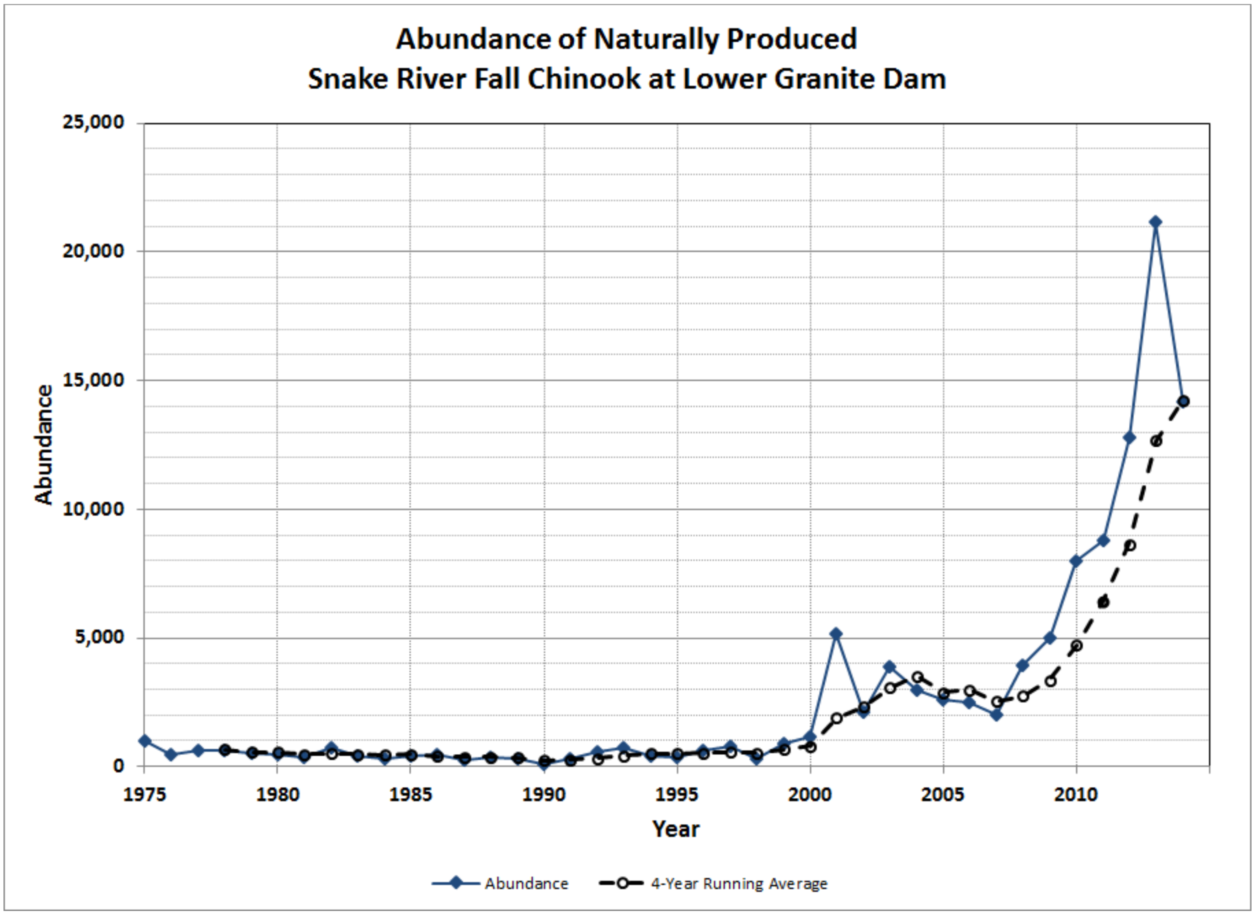

Figure 62. Abundance of naturally produced SR fall-run Chinook salmon at Lower Granite Dam from 1975 to 2014.

For LCR Chinook salmon, < 1% of migrating adults in each population are likely to be exposed to the migration corridor criterion temperature. Some of these few exposed fish are likely to suffer deaths due to migration delay, increased fishing pressure and predation, and disease issues under the migration corridor beneficial use designation. A small number of juveniles in the Upper Gorge, White Salmon, and Hood populations (Gorge Fall stratum) are likely to be exposed during non-peak migration, but data to quantify this are not available. Some of these few exposed juveniles are likely to suffer deaths and injuries due to increased predation and disease issues under the migration corridor beneficial use designation. However, because of the small numbers of adult and juvenile fish likely to be affected, population-scale reductions in any of the VSP variables for LCR Chinook salmon from approval of the beneficial use designation for the migration corridor criterion are unlikely.

Significant portions of adult SRB, MCR and UCR steelhead will be exposed to the migration corridor criterion during their migrations. The populations likely to be affected most severely for SRB and MCR steelhead are the ones that migrate during the warmest conditions (i.e, Upper

Grande Ronde, Imnaha, John Day, and Umatilla[74]). Increases in deaths and disease rates, impairment of migration behaviors, and reduction of spawning success are likely under the migration corridor beneficial use designation. These issues are likely to cause population-scale reductions in the VSP variables abundance and productivity for SRB, MCR, and UCR steelhead should EPA approve the migration corridor beneficial use designation.

For Snake River sockeye adults, direct mortality and elevated disease rates are likely to contribute to population-scale reductions in the VSP variables abundance and productivity for this species should EPA approve the migration corridor beneficial use designation.

The disease rates and effects noted above should be considered in the context of current 7DADM temperatures in much of the Columbia and Snake Rivers subject to the migration corridor criterion and beneficial use designation currently being well over the 7DADM criterion of 20°C criterion. Although we have not seen any models or projections that would allow us to quantify how disease dynamics would change in a scenario where both the Snake and Columbia rivers met the migration corridor criterion, we are confident that disease rates, virulence and effects on populations of fish would be lower in such a scenario.

All of the effects described in this section should be considered in light of available modeling information suggesting that even in a scenario where dams were removed, the Columbia River, which is a large, mostly unshaded river that travels over 100 miles through a warm desert, the annual maximum 7DADM temperature likely was cooler than today but not cooler than 20°C historically (Figure 29 above). The Snake River also is a large, mostly unshaded river traveling through a desert that historically likely was cooler than today but did not have an annual maximum 7DADM temperature cooler than 20°C. Before European development, however, the rivers likely had a greater diversity of thermal habitats (*e.g.*, CWR) due to more functional floodplains and other features that have been lost due to the construction of dams, highways, railroads and other human-induced changes (Poole and Berman 2001, Poole et al. 2001a).

A number of species have juveniles that out-migrate primarily in the spring, and are likely to be exposed to the migration corridor criterion during non-peak migration. These include:

- UCR spring-run Chinook salmon
- SR spring/summer Chinook salmon
- SRB steelhead
- LCR Chinook salmon
- LCR coho salmon
- CR chum salmon
- LCR steelhead
- UCR steelhead

[74] Fish from the Grande Ronde and Imnaha river populations are in MPGs of the same names within ESA-listed SRB steelhead. The John Day populations are in the John Day MPG, and the Umatilla population is in the Walla Walla and Umatilla MPG.

The species listed immediately above out-migrate primarily in spring and are likely to have a small number of deaths and injuries in late-migrating juveniles under the 20°C migration corridor and beneficial use designation, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature during the out-migration of the majority of the juveniles of each species is likely to be cool enough to avoid or minimize adverse effects. These species may be exposed to water at or above the migration corridor criterion in mixing zones of point-source discharges during these migrations, but the thermal plume criteria are likely to minimize adverse effects sufficiently to prevent adverse effects severe enough to reduce abundance or productivity at the population scale.

Lower Little Creek and Catherine Creek: According to ODFW (2003), adult SRB steelhead migrate upstream through this reach at a peak level of use from mid-February to mid-March, and at a lesser level of use from mid-March through May. Juvenile SRB steelhead migrate downstream through this reach at a peak level of use from October through mid-January, and from mid-March through mid-June. Juvenile SRB steelhead migrate downstream through this reach at a non-peak level of use from mid-January to mid-March, in the second half of June, and in September. The reach also is listed as having “presence” for rearing of SRB steelhead from September through June. The ODFW did not list spawning as occurring in this reach.

Also according to ODFW (2003), SR spring/summer Chinook salmon migrate upstream through this reach at a lesser level of use in the first half of May, and at peak use from the second half of May through June. Juvenile SR spring/summer Chinook salmon migrate downstream through this reach at a peak level of use from January through mid-April, and from October through mid-December. Juveniles also migrate downstream at a non-peak level of use from mid-April to mid-May, and in the second half of December.

These are snow-fed streams that are likely to experience maximum temperatures between late July and early September, much like Minam River, which is the closest stream for which water temperature data was available (Figure 14 above). Based on the above information, the peak and non-peak migration periods for adult and juvenile SRB steelhead and SR spring/summer Chinook salmon currently do not overlap with the late July to early September period when these waterways are likely to reach the 20°C in a scenario where this reach attains the migration corridor beneficial use. A small number of juvenile SRB steelhead rearing in early September may die or be injured due to increased rates of disease and predation, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. Declines in the spring snowpack over time due to rising air temperatures associated with climate change (ISAB 2007) could cause maximum summer temperatures to occur earlier in the summer, and thereby increase overlap with the downstream migration period for SRB steelhead, and the upstream migration period of SR spring/summer Chinook salmon. However, this potential chain of events will be difficult to confirm without consistent water temperature monitoring in this waterway.

Lower Coos River: Adult OC coho salmon in this reach migrate upstream beginning in early September at lesser use, with peak use beginning in the second half of September (ODFW 2003). Juveniles migrate downstream from mid-February to mid-July, with a peak from mid-March to Mid-May (ODFW 2003). Juvenile rearing in this reach occurs from early March through the first half of June (ODFW 2003). Based on this information, a small number of early-migrating adults may be exposed to the migration corridor criterion temperatures under this beneficial use designation during early September, and a small number of late-migrating juveniles may be exposed during the first half of July. Some of these fish are likely to suffer death, reduction of reproductive success, or injury due to adverse effects related to this criterion. However, the number of fish affected is likely to be too small to affect any of the VSP variables at the population scale due to the short exposures (1/2 month) for adults and juveniles and the small number of fish likely to be present at these extreme early and late, respectively, tail ends of the upstream and downstream migrations.

2.4.2 Effects of the Action on Designated Critical Habitat

Below we summarize effects of EPA's proposed approval action on the critical habitats of the subject ESA-listed species. For all effects on species and critical habitats, unless stated otherwise, the durations of the effects are likely to reflect the period of time that the component of the applicable standard is in effect, which as we explained earlier is indefinite. The proportion of critical habitat that will be exposed to effects of the proposed action varies by ESU/DPS. For species with critical habitat only in Oregon (i.e., UWR Chinook salmon, UWR steelhead, OC coho salmon), all of their critical habitat will be exposed to effects of the proposed action, although the percentage of critical habitat to be exposed varies with each criterion. For the other species, all of which have some of their critical habitat outside of Oregon, only the portion of their critical habitat that occurs in Oregon will be exposed to the effects of the proposed action.

Salmon and Steelhead Critical Habitat PCEs:

1. Freshwater spawning sites
    a. Substrate – No effect.
    b. Water quantity – No effect.
    c. Water quality – The PCE *water quality* likely will be affected as follows:

LCR Chinook salmon: IGDO will be reduced modestly at some sites for the Sandy River watershed, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species. Temperatures under the spawning criterion are likely to be cool enough to fully support conservation of the species.

UWR Chinook salmon: IGDO will be reduced modestly at some sites for the Clackamas River, Molalla River, North Santiam River, South Santiam River, Calapooia River, McKenzie River, and Middle Fork Willamette watersheds, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species. Temperatures under the spawning criterion are likely to be cool enough to fully support conservation of the species.

SR spring/summer run Chinook salmon: IGDO will be reduced modestly at some sites for the Wenaha River, Lostine/Wallowa River, Minam River, Catherine Creek, Upper Grande Ronde River, Imnaha River, Big Sheep Creek, and Lookingglass Creek watersheds, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species. Temperatures under the spawning criterion are likely to be cool enough to fully support conservation of the species.

SR fall-run Chinook salmon: No adverse effects are likely, as temperatures are likely to be at or near optimal during spawning and incubation, fully supporting conservation of the species.

CR chum salmon: Spawning temperatures are likely to be slightly above optimal for a few hours a day during the warmest week of the spawning and incubation period. For most of the spawning and incubation period, temperatures are likely to be optimal, fully supporting conservation of the species.

LCR coho salmon: Spawning temperatures are likely to be slightly above optimal for a few hours a day during the warmest week of the spawning and incubation period. For most of the spawning and incubation period, temperatures are likely to be cool enough to fully support conservation of the species.

OC coho salmon: Spawning temperatures are likely to be slightly above optimal for a few hours a day during the warmest week of the spawning and incubation period. For most of the spawning and incubation period, temperatures are likely to be cool enough to fully support conservation of the species.

SONCC coho salmon: Spawning temperatures are likely to be slightly above optimal for a few hours a day during the warmest week of the spawning and incubation period. For most of the spawning and incubation period, temperatures are likely to be cool enough to fully support conservation of the species.

LCR steelhead: IGDO will be reduced modestly at some sites for the Hood River watershed, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species.

UWR steelhead: No adverse effects are likely, as temperatures are likely to be at or near optimal during spawning and incubation, fully supporting conservation of the species.

MCR steelhead: IGDO will be reduced modestly at some sites for the Walla Walla River watershed, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species.

SRB steelhead: IGDO will be reduced modestly at some sites for the Imnaha River watershed, but only for the early part of the spawning and incubation season. For most of the spawning and incubation period, IGDO is likely to be at or near optimal concentrations, fully supporting conservation of the species.

2. Freshwater rearing sites
    a. Floodplain connectivity – No effect.
    b. Forage – No effect.
    c. Natural cover – No effect.
    d. Water quantity – No effect.
    e. Water quality – The PCE *water quality* likely will be affected as follows:

LCR Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to support conservation of the species.

UWR Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species. However, water temperatures in rearing habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UCR spring-run Chinook salmon: No adverse effects are likely as the species does not rear where the rearing/migration criterion and beneficial use apply.

SR spring/summer run Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species.

SR fall-run Chinook salmon: No adverse effects are likely as the species does not rear where the rearing/migration criterion and beneficial use apply.

CR chum salmon: No adverse effects are likely as the species does not rear where the rearing/migration criterion and beneficial use apply.

LCR coho salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species.

SONCC coho salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species.

SR sockeye salmon: No adverse effects are likely as the species does not rear where the rearing/migration criterion and beneficial use apply.

LCR steelhead: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species.

UWR steelhead: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species. However, water temperatures in rearing habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

MCR steelhead: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support rearing of the species. However, water temperatures in rearing habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UCR steelhead: No adverse effects are likely as the species does not rear where the rearing/migration criterion and beneficial use apply.

SRB steelhead: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species.

3. Freshwater migration corridors
    a. Free passage – No effect.
    b. Natural cover – No effect.
    c. Water quantity – No effect.
    d. Water quality – The PCE *water quality* likely will be affected as follows:

LCR Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UWR Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UCR spring-run Chinook salmon: Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation, but temperatures are likely to be adequate during the peak migration period to fully support conservation of the species.

SR spring/summer run Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation, but temperatures are likely to be adequate during the peak migration period to fully support conservation of the species.

SR fall-run Chinook salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be 1 to 2°C above optimal during adult migration and non-peak migration for juveniles due to approval of the migration corridor criterion and beneficial use designation, but are likely to be adequate to fully support conservation of the species.

CR chum salmon: Water temperature are likely to be slightly above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation, but temperatures are likely to be adequate during the peak migration period to fully support conservation of the species.

LCR coho salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation, but temperatures are likely to be adequate during the peak migration period to fully support conservation of the species.

OC coho salmon: In all waters except the lower Coos River, water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures are likely to be adequate during the peak migration period to fully support conservation of the species. Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation in the Lower Coos River, but temperatures are likely to be adequate during the peak migration period to fully support conservation of the species in this waterway.

SONCC coho salmon: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures are likely to be adequate during the peak migration period to fully support conservation of the species.

SR sockeye salmon: Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

LCR steelhead: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

<u>UWR steelhead</u>: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

<u>MCR steelhead</u>: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations in part of the species' migratory habitat, but only for part of each day during the non-peak migration period early in the summer. Water temperatures in the lower John Day River during smoltification due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

<u>UCR steelhead</u>: Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor criterion and beneficial use designation, but temperatures are likely to be adequate during the peak juvenile migration period to fully support conservation of the species. However, approximately 60% of migrating adults will be exposed to water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation that are likely to be too warm to support the conservation of the species.

<u>SRB steelhead</u>: Water temperature will be slightly higher than optimal in some large streams and rivers with low diurnal temperature variation due to approval of the rearing/migration criterion and beneficial use designations, but only for part of each day during a relatively small part of the rearing season (1 to 4 weeks during the summer maximum period). Overall, temperatures in these areas will remain cool enough to fully support conservation of the species. Water temperatures in migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

4. <u>Estuarine areas</u>
    a. Forage – No effect.
    b. Free passage – No effect.
    c. Natural cover – No effect.
    d. Salinity – No effect
    e. Water quality – The PCE *water quality* likely will be affected as follows:

LCR Chinook salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UWR Chinook salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UCR spring-run Chinook salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

SR spring/summer run Chinook salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

SR fall-run Chinook salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

CR chum salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

SR sockeye salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

LCR steelhead: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

LCR coho salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

OC coho salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

SONCC coho salmon: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be adequate to support the conservation of the species.

UWR steelhead: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

MCR steelhead: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

UCR steelhead: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

SRB steelhead: Water temperatures in the estuarine portion of migratory habitat due to the proposed approval of the migration corridor criterion and beneficial use designation are likely to be too warm to support the conservation of the species.

f. Water quantity – No effect.

5. Nearshore marine areas: No areas were designated.

Green Sturgeon PBFs:

1. Freshwater Riverine Systems
    a. Food resources – No effect.
    b. Migratory corridor – No effect.
    c. Substrate type or size – No effect.
    d. Water depth – No effect.
    e. Water flow – No effect.
    f. Water quality – No effect as we designated only estuarine areas as critical habitat in Oregon.

2. Estuarine Systems
    a. Food resources – No effect.
    b. Migratory corridor – No effect.
    c. Water depth – No effect.
    d. Water flow – No effect.
    e. Water quality − Although temperature mixing zones present a risk of thermal shock conditions in the vicinity of point-source discharges of heated water in tidal portions of the rivers and streams draining into Coos Bay (*i.e.*, Coos River), Winchester Bay (*i.e.*, Umpqua River), Yaquina Bay (*i.e.*, Yaquina River), and the lower Columbia River estuary from the mouth upstream to river kilometer 74, the narrative criterion for mixing zones is likely to sufficiently limit this risk so that water temperatures overall will remain cool enough to fully support conservation of this species.

3. <u>Coastal Marine Areas</u>
    a. Food resources – No effect.
    b. Migratory corridor – No effect.
    c. Water quality – No effect as EPA did not propose to approve any marine WQS.

<u>Eulachon PBFs</u>:

1. <u>Freshwater spawning sites and incubation</u>
    a. Flow – No effect.
    b. Water quality – No effect (though see water temperature below).
    c. Water temperature – Water temperatures due to the proposed approval of the rearing and migration criterion and beneficial use designation in the lower Umpqua River, the migration corridor criterion and beneficial use designation in the Columbia River, and the thermal plume criteria will be above adverse effects thresholds within mixing zones. However, the current mixing zones are small enough and spaced far enough apart that the proposed action (including EPA's conservation measures for eulachon as described above) overall is likely support the conservation of the species in those rivers.

       Future mixing zones in the Columbia and Umpqua rivers within the next 5 years are likely to be adequately controlled due to EPA's proposed review of new NPDES discharges. The 5-year timeframe will provide a record of how to effectively implement the thermal plume provisions to protect eulachon, and will serve as a basis for DEQ's future interpretation and implementation of the provisions. The record also will facilitate EPA's continuing oversight of NPDES permitting actions beyond the 5 years. We are confident that with these measures, adverse effects from future discharges in the Columbia and Umpqua rivers will be adequately controlled.
    c. Substrate – No effect.
    d. Unobstructed migratory corridor – No effect.
2. <u>Freshwater and estuarine migration corridors</u>
    e. Free passage – Approval of the rearing/migration and migration corridor criteria and beneficial uses is likely to degrade the PCE at the scale of the designation.
    a. Flow – No effect.
    b. Water quality – No effect (though see water temperature below).
    c. Water temperature – Same as for freshwater incubation sites and spawning above.
    d. Food – No effect.
3. <u>Nearshore and offshore marine foraging areas</u>
    a. Food – No effect.
    b. Water quality – No effect.

2.4.3 Effects of the Action on Southern Resident Killer Whales

This species does not occur where the subject water quality standards apply. We relied on the salmon determinations of effect to determine whether the proposed action would appreciably reduce the likelihood of survival and recovery of the Southern Residents in the long term. In this document, we conclude that the proposed action is likely to appreciably reduce the likelihood of survival and recovery of the following species:

1. LCR Chinook salmon
2. UWR Chinook salmon
3. SR sockeye salmon
4. UWR steelhead
5. LCR steelhead
6. MCR steelhead
7. UCR steelhead
8. SRB steelhead

In other words, the proposed action appreciably increases the risk of extinction of these listed species.

Some Chinook salmon stocks in Columbia River tributaries and on the Oregon Coast are not listed under the ESA but occur in the action area for this opinion. Analysis for the listed salmonid species earlier in this opinion demonstrated that the 20°C migration corridor criterion that EPA proposes to approve that poses a risk of extinction for Chinook salmon populations. The beneficial use designation that applies this criterion overlaps with non-listed Chinook salmon habitat in the Columbia River (for certain stocks that spawn above Bonneville Dam), the lower John Day River, which is a tributary of the Columbia River (from the mouth to the confluence with the North Fork John Day River), a short reach of the lower Coos River and two mid- to lower reaches of tributaries to the lower Coos River. We analyze effects of this criterion and beneficial use designation on non-listed stocks of Chinook salmon below.

According to ODFW (2003), the upstream migration and pre-spawn holding of spring Chinook salmon between Bonneville Dam and John Day dam on the Columbia River (which includes some listed LCR Chinook salmon populations and some non-listed populations from the Deschutes River) occur prior to June, and downstream migration of juveniles occurs at peak rates from May 1 to June 15. Fall Chinook salmon in this reach also includes some listed LCR Chinook salmon populations and some non-listed populations from the Deschutes River. For these fall Chinook salmon, upstream migration occurs at peak rates from August 16 through September 30. Adult holding occurs August through October. Juvenile rearing occurs at peak rates from July 1 to August 15. Downstream migration of juveniles is at a peak rate during the month of July.

Overall, fall Chinook salmon from the Deschutes River are likely to be exposed to the 20°C migration corridor criterion and beneficial use designation in the Columbia River during part of the peak periods for upstream migration of adults, downstream migration of juveniles, and pre-spawn holding of adults. Increases in deaths, impairment of migration behaviors, and reduction of gamete viability (with later reduction of spawning success) are likely for these fish under EPA's proposed approval action due to migration delay and possible increased fishing pressure in CWR (adults only), increased predation (juveniles only), and increased disease (adults and juveniles). These issues are likely to cause population-scale reductions in abundance and productivity that increase the likelihood of extinction in the long-term.

Non-listed fall Chinook salmon in the Deschutes River have peak upstream migration in that river from mid-July through November, and peak holding from mid-August through mid-October. Peak juvenile rearing is April 15 through June, and peak downstream migration is during June. These fish will be exposed to the 18°C rearing and migration criterion and beneficial use designation in the Deschutes River, as the migration corridor criterion is not designated in this area. At this temperature, a minor reduction in growth and increase in disease risk is likely to reduce the long-term survival of a small number of individuals of each species. However, the number of fish affected is likely to be so small that there will be no effect at the population scale.

Above John Day dam, the John day River produces non-listed spring and fall Chinook salmon. The non-listed spring Chinook salmon from the John Day River have peak upstream migration and holding in the John Day River in spring, so they will not be exposed to the 20°C migration corridor criterion and beneficial use designation in the Columbia River or the lower John Day River. Peak downstream migration is in May and June, so these fish will only be exposed to the 20°C migration corridor criterion and beneficial use designation in the John Day River at non-peak numbers. Fish that leave the John Day River in the second half of June may be exposed to waters at or near the 20°C migration corridor criterion in the Columbia River, increasing the risk of death due to increased predation and disease, but this is likely to be too small a percentage of the run to affect this stock at the population scale. These fish also will be exposed to the 18°C rearing and migration criterion and beneficial use designation in upstream areas. At this temperature, a minor reduction in growth and increase in disease risk is likely to reduce the long-term survival of a small number of individuals of each species. However, the number of fish so affected is likely to be so small that there will be no effect at the population scale.

The non-listed fall Chinook salmon from the John Day River have peak upstream migration and adult holding in September, and they may be exposed to waters at or near the 20°C migration corridor criterion in the lower John Day River during part of their upstream migration in early September. Some of these fish also are likely to be exposed to waters at or near the 20°C migration corridor criterion in the Columbia River as they migrate to the John Day River. Downstream migration is listed as occurring from May through September, with no peak period identified. Therefore, juveniles will be exposed to the 20°C migration corridor criterion and beneficial use designation in the lower John Day River, and in the Columbia River as they continue downstream. Increases in deaths are likely for these fish due to increased predation and disease issues under EPA's proposed approval action. These issues are likely to cause population-scale reductions in abundance and productivity that increase the likelihood of extinction in the long-term.

Non-listed fall Chinook salmon occur in the lower Coos River. Non-peak (<10% of the life-stage activity; ODFW 2003) upstream migration of adults is from mid-July through mid-September, and the peak upstream migration begins in mid-September, outside of the July to early September period when exposure to temperatures at or near the migration corridor criterion are likely. Peak holding of adults begins in early September and lasts through October. Juvenile rearing occurs from February through May, and downstream migration of juveniles occurs from March through mid-October, with a peak from mid-April through mid-September. Although the 20°C migration corridor criterion and beneficial use designation does increase the risk of disease incidence and migration blockage during non-peak migration of adults and peak migration of juveniles, this criterion is designated in only one short tidal reach of the lower Coos River and in the mid- to lower reaches of two tributaries to the Coos River that likely are mostly, if not entirely, tidal. These reaches have considerable marine influence over water temperature and are short enough that juveniles likely migrate through them without experiencing adverse effects large enough to cause significant numbers of deaths or injuries. Therefore, the 20°C migration corridor criterion and beneficial use designation is unlikely to cause population-scale declines in Coos River fall Chinook salmon.

As described above, EPA's proposed action also is likely to appreciably increase the risk of extinction of non-listed fall Chinook salmon from the Deschutes and John Day rivers.

Our analysis focuses on the short- and long-term reductions in Chinook salmon available to the whales as a result of the proposed action described in the opinion. Below we discuss the effects from (1) the short-term or annual reduction in Chinook salmon, and (2) the long-term appreciable increase in the risk of extinction for LCR Chinook salmon, UWR Chinook salmon, and fall Chinook salmon from the Deschutes and John Day rivers.

Short-Term Reductions in Chinook Salmon. Deaths of adult and juvenile Chinook salmon due to exposure to the water quality standards that EPA proposes to approve could affect the annual prey availability to the killer whales where the marine ranges of the affected Chinook salmon populations and the whales overlap. Mortality of juvenile salmon and steelhead from exposure to the water quality standards that EPA proposes to approve will translate to the effective loss of only a small number of adult-equivalent Chinook salmon in each ESU or stock 3 to 5 years after the juvenile mortality occurred (*i.e.*, by the time these juveniles would have grown to be adults and available prey of killer whales). Mortality of adults under the proposed action will translate into a somewhat larger number of adult-equivalent Chinook salmon in each ESU or stock 4 to 6 years after the adult mortalities occurred (*i.e.*, by the time the offspring of these adults would have grown to be adults and available prey of killer whales). These reductions would occur each year that the proposed criteria remain in place. We anticipate similar effects on non-listed Chinook salmon that may be prey items for the Southern Resident killer whales.

Given the total quantity of prey available to Southern Resident killer whales throughout their range, this projected annual reduction in prey is small, and although measurable, the percentage reduction in prey abundance is not likely to be different from zero by multiple decimal places (based on our previous analyses of the effects of salmon harvest on Southern Residents; *e.g.*, NMFS 2011f). Because the annual reduction is so small, there is also a low probability that any of the juvenile Chinook salmon, or the offspring of the adult Chinook salmon, that are likely to be killed by the proposed action could be intercepted by the killer whales due to the whales' vast range. Therefore, we anticipate that the short-term reduction of Chinook salmon (listed and non-listed) would have nearly zero effect on Southern Resident killer whales.

Long-Term Reductions in Chinook Salmon. We qualitatively evaluated the likelihood for localized depletions, and long-term implications for Southern Residents' survival and recovery, resulting from the increased risk of extinction for LCR Chinook salmon, UWR Chinook salmon, and fall Chinook salmon from the Deschutes and John Day rivers. In this way, we can determine whether the increased likelihood of extinction of prey species is also likely to appreciably reduce the likelihood of survival and recovery of Southern Residents.

Based on the best available data, LCR Chinook salmon, UWR Chinook salmon, and fall Chinook salmon from the Deschutes and John Day rivers likely are a part of the whales' outer coast diet. In fact, the whales are spending significantly more time off of the Columbia River than previously recognized, suggesting the importance of Chinook salmon from this river in their diet (Hanson *et al.* 2013). A reduction in prey from the proposed water quality criteria would occur over time as abundance declines for these four stocks of Chinook salmon. Hatchery programs, which account for a large portion of the production of some of these stocks, may provide a short-term buffer, but it is uncertain whether hatchery-only stocks could be sustained indefinitely.

We can scale the effect to some extent by examining the population sizes for the stock with the largest amount of readily available data (UWR Chinook salmon). For the years 2000 through 2010, the total number of adult UWR Chinook salmon passing Willamette Falls has varied from a high of about 98,000 fish to a low of about 13,000 fish (natural origin plus hatchery fish). Few of these are natural-origin fish; in 2010 (the last year for which data were readily available), just over 1,000 of the approximately 68,000 total fish were of natural origin (Fig. 76 in Ford 2011). The loss of these salmon stocks would preclude the potential for their future recovery to healthy, more substantial numbers. This is in contrast to past Chinook salmon harvest actions, which have met the conservation objectives of harvested stocks, were not likely to appreciably reduce the survival or recovery of listed Chinook salmon in the long term, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon. In this consultation, the proposed criteria will likely jeopardize the continued existence of the stated stocks of Chinook salmon. The long-term effects of this will include fewer populations contributing to Southern Residents' prey base, which will reduce the representation of diversity in life histories, spatial structure, resiliency in withstanding stochastic events, and redundancy to ensure there is a margin of safety for the salmon and Southern Residents to withstand catastrophic events.

Differences in adult salmon life histories and locations of their natal streams likely affect the distribution of salmon across the Southern Residents' coastal range. The continued decline and potential extinction of LCR Chinook salmon, UWR Chinook salmon and fall Chinook salmon from the Deschutes and John Day rivers, and consequent interruption in the geographic continuity of salmon-bearing watersheds in the Southern Residents' coastal range, is likely to alter the distribution of migrating salmon and increase the likelihood of localized depletions in prey, with adverse effects on the Southern Residents' ability to meet their energy needs. A fundamental change in the prey base off the mouth of the Columbia River (*i.e.,* an area of suggested importance to the whales) is likely to result in Southern Residents abandoning areas in search of more abundant prey or expending substantial effort to find depleted prey resources.

This potential increase in energy demands should have the same effect on an animal's energy budget as reductions in available energy, such as one would expect from reductions in prey.

Lastly, the long-term reduction of LCR Chinook salmon, UWR Chinook salmon, and fall Chinook salmon from the Deschutes and John Day rivers may lead to nutritional stress in the whales. Nutritional stress can lead to reduced body size and condition of individuals and can also lower reproductive and survival rates. Prey sharing would distribute more evenly the effects of prey limitation across individuals of the population that would otherwise be the case. Therefore, poor nutrition from the reduction of prey could contribute to additional mortality in this population. Food scarcity could also cause whales to draw on fat stores, mobilizing contaminants stored in their fat and affecting reproduction and immune function.

In summary, EPA's proposed action in the long term will increase the likelihood of extinction of LCR Chinook salmon, UWR Chinook salmon and fall Chinook salmon from the Deschutes and John Day rivers, which will reduce appreciably the likelihood of survival and recovery of the Southern Resident killer whales.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some types of human activities contribute to cumulative effects that adversely listed species and critical habitat PCEs. Many of these are activities occurred in the recent past and negatively affected the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past. Within the freshwater portion of the action area, non-Federal actions are likely to include activities tied to human population growth, water withdrawals (*i.e.*, those pursuant to senior state water rights) and various land uses. In the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, shoreline growth management and resource permitting.

As many cities border rivers, growth likely will increase contaminant loading from wastewater treatment plants and input of sediments from urban and suburban development into riverine, estuarine, and marine habitats. Urban runoff from impervious surfaces and roadways often contains oil, heavy metals, pesticides, and other chemical pollutants that flow into surface waters. Inputs of these point and non-point pollution sources into numerous rivers and their tributaries will continue to degrade water quality in available spawning and rearing habitat for salmon. Based on the increase in human population, NMFS expects an associated increase in the number of NPDES permits issued and a concomitant increase of pollutant loading.

Mining has historically been a major component of western state economies. With national output for metals projected to increase by 4.3% annually, output of western mines should increase markedly (Figueroa and Woods 2007). Increases in mining will add to existing significant levels of mining contaminants entering rivers. Given this trend, we expect existing water degradation in Oregon streams that feed into or provide spawning habitat for threatened and endangered species to be exacerbated.

As the western states have large tracts of irrigated agriculture, a 2.2% rise in agricultural output is likely (Figueroa and Woods 2007). Impacts from heightened agricultural production will likely result in two negative effects on listed species. The first is increased concentrations of pesticides, fertilizers, and herbicides in rivers due to agricultural runoff and drift during application. Second, increased water diversions for agriculture may reduce stream flows and the amount of habitat available for spawning and rearing. As water is drawn off, contaminants will become more concentrated in these waterways, exacerbating contamination issues in habitats for protected species.

The above non-Federal actions are likely to impose continuous but unquantifiable negative effects on the listed species and critical habitats addressed in this opinion. These effects include increases in sedimentation, increased point and non-point pollution discharges, and decreased infiltration of rainwater (leading to decreases in shallow groundwater recharge, hyporheic flow, and summer low flows). Some non-Federal actions likely to occur in or near surface waters in the action area, such as riparian improvement actions and fish habitat restoration projects, are likely to have beneficial effects on the listed species and critical habitats addressed in this opinion, at least at a stream-reach scale.

When considered together, these cumulative effects are likely to exert minor to moderate negative effects on salmon and steelhead population abundance and productivity, and minor, short-term negative effects on spatial structure (due to temporary blockages of fish passage related to altered stream flows). Similarly, the condition of critical habitat PCEs likely will be slightly to moderately degraded by cumulative effects.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

2.6.1 Species

As discussed under the Effects of the Action section above, some of the criteria that EPA proposes to approve are likely to result in death or injury to individual organisms of some of the affected species. Below we describe which impacts are likely to cause adverse effects at the population scale and at the species scale for the species subject to this consultation. The rationale for deciding whether the adverse effects will affect the listed species at the population and species scales is provided in detail in the analysis of effects above. We have combined the effects of approving the numeric criteria with approving the related beneficial use designations due to the difficulty of separating effects of these two closely related provisions. For all effects on species, unless stated otherwise, the duration of the effects is likely to reflect the period of time that the component of the standard is in effect, which is indefinite since there is no requirement in the CWA to update specific WQS on any specific schedule.

The status of each species addressed by this consultation varies considerably from very high risk (SR sockeye salmon) to moderate risk (*e.g.*, OC coho salmon, MCR steelhead). Similarly, the hundreds of individual populations affected by the proposed action vary considerably in their biological status. The environmental baseline generally is degraded for all of the species addressed in this opinion, although conditions vary depending on the amount and nature of human and natural disturbance that has occurred in a particular watershed. Some areas with wilderness or other protective designations have good-to-excellent conditions for creating and maintaining fish habitat, while many lowland areas are particularly dysfunctional in their ability to sustain fish production due to extensive and intensive human development and land use. Dams exert watershed or basin-wide negative effects on the environmental baseline for many of the listed species. Many of the adverse effects of dams in the FCRPS are being addressed through the reasonable and prudent alternative under the ESA section 7 consultation for the operation of this system.

Effects of climate change (mainly reduced stream flows and increased water temperature) likely will further challenge these cold-water species and make it more difficult for Oregon to meet its numeric temperature criteria. CWR will take on more importance if stream temperatures rise. Cumulative effects are likely to exert a minor negative effect on abundance and productivity of salmon, steelhead and eulachon populations, and minor short-term negative effects on spatial structure (due to temporary blockages of fish passage related to altered stream flows).

<u>LCR Chinook salmon</u>: A small number of individual eggs and alevins in the Cascade Spring stratum, Sandy River population are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in streams with significant amounts of fine substrate sediment. The number of eggs and alevins so affected is unlikely to be large enough to affect any of the VSP variables at the population scale.

A minor reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to approval of the rearing and migration (18°C) criterion and beneficial use are likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use during non-peak downstream migration in the Columbia River are likely to reduce the long-term survival of a small number of juveniles of this species in the Gorge Fall stratum. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

The Clackamas population will receive additional exposure to the rearing and migration (20°C) criterion in the Willamette River, reducing growth and increasing disease risk of juveniles in a manner that likely will be severe enough to reduce abundance and productivity at the population scale. Under the recovery plan for this species (NMFS 2013a), this population is listed as a "core" population, meaning historically it was one of the most productive. It is not listed as one of the genetic legacy populations, which best represent historical genetic diversity. The "contribution to recovery" for this population is listed as "contributing," which is between the lower "stabilizing" and the higher "primary." The baseline status of this population is "very low," and the target status is "moderate." The possible extirpation of this core population due to the proposed action likely would not be consistent with recovery of the species. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

<u>UWR Chinook salmon</u>: A small number of individual eggs and alevins are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion for the duration of the time the criterion is in effect in each of the historical populations of UWR Chinook salmon that exist, which are:

- Clackamas River population
- Molalla River population
- North Santiam River population
- South Santiam River population
- Calapooia River population
- McKenzie River population
- Middle Fork Willamette River population

The number of eggs and alevins to be affected by EPA's approval of the IGDO criterion is likely to be too small to affect any of the VSP variables at the population scale. A minor reduction in growth and an increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish affected in this manner is likely to be so small that there will be no effect on any of the VSP variables.

Maintaining the 20°C criterion and beneficial use designation in the Willamette River, absent implementation of the CWR narrative criterion, is likely to maintain temperatures that do not support the recovery of this species. Of the seven populations of UWR Chinook salmon that exist, extinction risk is "very high" for all but the McKenzie River population ("low" risk of extinction) and the Clackamas population ("moderate" risk of extinction) (Ford 2011). All of these populations must migrate through 50 miles of Willamette River designated at 20°C and then approximately 100 miles of Columbia River with the same designation. High summer water temperatures in the Willamette River below Willamette Falls and in the Columbia River estuary are listed as secondary limiting factors for juveniles of all populations of UWR Chinook salmon in the recovery plan for this species (ODFW and NMFS 2011, p. 5-27 to 5-30). Population-scale reductions in the VSP variables abundance and productivity are likely for this species due to approval of the migration corridor (20°C) criterion and beneficial use because of increased deaths of substantial numbers of juveniles. A small number of migrating adults also are likely to be killed due to increased disease rates or suffer reduced viability of gametes and reduced fitness, although adults of this species migrate mostly in cooler months. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

UCR spring-run Chinook salmon: A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature during the peak migration of adults and juveniles in the Columbia River in a scenario where the river is meeting the migration corridor criterion is likely to be cool enough to avoid or minimize adverse effects. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

SR spring/summer run Chinook salmon: A small number of individual eggs and alevins are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in each of the following populations. The populations are as follows in the Upper Grande Ronde and Imnaha River MPGs:

- Wenaha River population
- Lostine/Wallowa River population
- Minam River population
- Catherine Creek population
- Upper Grande Ronde River population
- Imnaha River population
- Big Sheep Creek population
- Lookingglass Creek population

The number of eggs and alevins to be affected by EPA's approval of the IGDO criterion is likely to be too small to affect any of the VSP variables at the population scale.

A minor reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to approval of the rearing and migration (18°C) criterion and beneficial use designation are likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables at the population scale.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature in a scenario where the Columbia and Snake rivers are meeting the migration corridor criterion during the peak migration of adults and juveniles is likely to be cool enough to avoid or minimize adverse effects.

Even when combined together, the effects of approving the criteria and beneficial use designations for rearing/migration and migration corridors will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

<u>SR fall-run Chinook salmon</u>: The extant population of Snake River fall-run Chinook salmon is the only remaining population from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex (IC-TRT 2003; McClure *et al.* 2005). The population is at “moderate” risk for all four VSP variables, with an overall status of “maintained (Ford 2011).”[75] We listed impacts from the mainstem Columbia River and Snake River hydropower systems (which include an altered temperature regime) among the limiting factors for this species (NOAA Fisheries 2011). Many of these impacts are being addressed through the RPA for the ESA section 7 consultation on the FCRPS.

A minor reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to approval of the rearing and migration (18°C) criterion and beneficial use designation are likely to reduce the long-term survival of a small number of juveniles of this species. However, the number of fish affected is likely to be so small that there will be no effect on any of the VSP variables.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration corridor (20°C) criterion and beneficial use are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because in most years, the majority of adult SR fall-run Chinook salmon have migrated upstream before the period of peak summer temperature when they would be exposed to the migration corridor criterion. Also, these fish migrate upriver more rapidly and spend less time in the CWR — on the order of hours to days for fall Chinook salmon compared to days to weeks for steelhead (Keefer et al. 2009). On average, 78% of juveniles in this ESU have passed Bonneville Dam before the time of year when they likely would be exposed to temperatures at or near the migration corridor criterion. Based on high rates of adult survival from Bonneville Dam to Lower Granite Dam, which have been meeting or exceeding goals in the 2008 biological opinion on operation of the FCRPS from 2008 through 2014 (the last year with complete data, Fig. 55), there does not appear to be a problem with mortality due to unknown reasons in CWR between Bonneville Dam and John Day Dam as there is for steelhead.

Even when combined together, the effects of approving the criteria and beneficial use designations for rearing/migration and migration corridors will be too small to affect any of the

[75] “Maintained” population status is for populations that do not meet the criteria for a viable population but do support ecological functions and preserve options for ESU/DPS recovery.

VSP variables at the population scale for SR fall-run Chinook salmon. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

CR chum salmon: Some deaths and injuries of eggs and alevins are likely to occur for this species due to approval of the 13.0°C salmon and steelhead spawning criterion and beneficial use designation, but the number of fish affected is likely to be small (*i.e.*, <0.25% of the incubating fish), and only a small percentage of those fish are likely to die. Therefore, we do not expect approval of this criterion and beneficial use designation by EPA to kill or injure enough CR chum salmon to affect any of the VSP variables at the population scale.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature during the peak migration of adults and juveniles is likely to be cool enough to avoid or minimize adverse effects.

Even when combined together, the effects of approving the criteria and beneficial use designations for spawning and migration corridors will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

LCR coho salmon: Some deaths and injuries of eggs and alevins are likely to occur for this species due to approval of the 13.0°C salmon and steelhead spawning criterion and beneficial use designation, but the number of fish affected is likely to be small because the criterion is only slightly above the temperature that would fully support spawning and incubation (12.8°C). Also, the species spawns in the fall when water temperatures are falling rapidly. Therefore, we do not expect approval of this criterion and beneficial use designation by EPA to kill or injure enough LCR coho salmon to affect any of the VSP variables at the population scale.

A minor reduction in growth of juveniles and an increase in disease risk for juveniles due to approval of the rearing and migration (18°C) criterion and beneficial use designation are likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use in the Columbia River are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature during the peak migration of adults and juveniles is likely to be cool enough in this river to avoid or minimize adverse effects.

Even when combined together, the effects of approving the criteria and beneficial use designations for spawning, rearing/migration and migration corridors will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

OC coho salmon: Some deaths and injuries of eggs and alevins are likely to occur for this species due to approval of the 13.0°C salmon and steelhead spawning criterion and beneficial use designation, but the number of fish affected is likely to be small because the criterion is only slightly above the temperature that would fully support spawning and incubation (12.8°C). Also, the species spawns in the fall when water temperatures are falling rapidly. Therefore, we do not expect approval of this criterion and beneficial use designation by EPA to kill or injure enough LCR coho salmon to affect any of the VSP variables at the population scale.

A minor reduction in growth and increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use designation is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

Even when combined together, the effects of approving the criteria and beneficial use designations for spawning and rearing/migration will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

SONCC coho salmon: Some deaths and injuries of eggs and alevins are likely to occur for this species due to approval of the 13.0°C salmon and steelhead spawning criterion and beneficial use designation, but the number of fish affected is likely to be small because the criterion is only slightly above the temperature that would fully support spawning and incubation (12.8°C). Also, the species spawns in the fall when water temperatures are falling rapidly. Therefore, we do not expect approval of this criterion and beneficial use designation by EPA to kill or injure enough LCR coho salmon to affect any of the VSP variables at the population scale.

A minor reduction in growth and increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use designation is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

Even when combined together, the effects of approving the criteria and beneficial use designations for spawning and rearing/migration will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

SR sockeye salmon: For SR sockeye adults, direct mortality and elevated disease rates under the 20°C migration corridor criterion and beneficial use designation are likely to contribute to population-scale reductions in the VSP variables abundance and productivity under the proposed action. This species is at extremely high risk across all four VSP measures (abundance, productivity, spatial structure and diversity; Ford 2011), and is unlikely to tolerate persistent reduction of survival due to water temperature, particularly in light of increasing stress due to climate change predicted by the scientific community (*e.g.*, ISAB 2007; UCGRP 2009). Considering these effects in concert with the environmental baseline and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

LCR steelhead: A small number of individual eggs and alevins in the Hood River population of the Gorge Summer stratum are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in streams with significant amounts of fine substrate sediment. The number of eggs and alevins so affected is unlikely to be large enough to affect any of the VSP variables at the population scale.

A minor reduction in growth of juveniles and increase in disease risk for adults and juveniles due to approval of the rearing and migration (18°C) criterion and beneficial use designation are likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

A reduction in growth of juveniles and an increase in disease risk for adults and juveniles due to exposure to the rearing and migration (20°C) criterion and beneficial use in the Columbia River are likely to reduce the long-term survival of some individuals in this species, but the numbers of fish are likely to be too small to affect any of the VSP variables at the population scale. This is because the water temperature during the peak migration of adults and juveniles is likely to be cool enough to avoid or minimize adverse effects.

The Clackamas population will receive additional exposure to the rearing and migration (20°C) criterion in the Willamette River, reducing growth and increasing disease risk of juveniles in a manner that likely will be severe enough to reduce abundance and productivity at the population scale. Under the recovery plan for this species (NMFS 2013a), this population is listed as a "core" population, meaning historically it was one of the most productive. It is not listed as one of the genetic legacy populations, which best represent historical genetic diversity. The "contribution to recovery" for this population is listed as "primary." The baseline status of this population is "moderate," and the target status is "low." The possible extirpation of this core population due to the proposed action likely would not be consistent with recovery of the species. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

Even when combined together, the effects of approving the IGDO criterion, and the criteria and beneficial use designations for rearing/migration and migration corridors, will be too small to affect any of the VSP variables at the population scale. Because there likely will be no effect at the population scale, the proposed action, in combination with the environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of this ESU by reducing its numbers, reproduction, or distribution.

UWR steelhead: A minor reduction in growth and increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use designation is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

Of the four populations of UWR steelhead that exist, extinction risk is “low” for all but one, the Calapooia River population, which is at a “moderate” risk of extinction (Ford 2011). All of these populations must migrate through 50 miles of Willamette River designated at 20°C and then approximately 100 miles of Columbia River with the same designation. High summer water temperatures in the Willamette River below Willamette Falls and in the Columbia River are listed as secondary limiting factors for juveniles of all populations of UWR steelhead in the recovery plan for this species (ODFW and NMFS 2011, p. 5-27 to 5-30).

Maintaining the 20°C criterion and beneficial use designation in the Willamette River, absent implementation of the CWR narrative criterion, is likely to maintain temperatures that do not support the recovery of this species. Population-scale reductions in the VSP variables abundance and productivity are likely for this species due to approval of the migration corridor (20°C) criterion and beneficial use designation because of the likely deaths of substantial numbers of juveniles. Adults of this species are unlikely to be exposed to this criterion because they migrate in the cooler months, although it is possible (although not confirmed) that some adults may have migrated into the summer under historical conditions. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

MCR steelhead: A small number of individual eggs and alevins in the Walla Walla and Umatilla MPG, Walla Walla River population are likely to suffer reduced short- or long-term survival due to EPA’s approval of the IGDO criterion in streams with significant amounts of fine substrate sediment. The number of eggs and alevins so affected is unlikely to be large enough to affect any of the VSP variables at the population scale.

A minor reduction in growth and increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use designation is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables (because of limited exposure as described above).

Significant portions of adult MCR steelhead will be exposed to the migration corridor criterion in the Columbia River during their migrations. The populations likely to be affected most severely are the ones that migrate during the warmest conditions (i.e, John Day, Umatilla[76]). Water temperature is listed as a limiting factor for all populations in the John Day and Umatilla rivers in the recovery plan for this DPS (NMFS 2009a, p. 6-20 to 6-21). For all populations of MCR steelhead, altered water temperatures in the Columbia River, predation and disease are listed as limiting factors (NMFS 2009a, p. 6-9 and 6-19 to 6-22).

Of the five populations in the John Day MPG, four are rated at "maintained"[77]with an overall "moderate" VSP risk rating) and one (North Fork John Day) is rated at "viable" (with an overall "highly viable" VSP risk rating) (NMFS 2009a; Ford 2011). For the John Day River MPG to reach "viable" status, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations should achieve "viable" status, with one population "highly viable (NMFS 2009a). The South Fork John Day population is at "maintained" status (Ford 2011) and must remain at this rating, or improve, for the John Day MPG-level viability criteria to be met (NMFS 2009a). To achieve the MPG-level recovery criteria, the North Fork John Day must maintain its "highly viable" status,[78] the Lower Mainstem John Day population must improve to "viable" status, and either the Middle Fork or Upper John Day population must improve to "viable" status (NMFS 2009a).

The Umatilla population also is rated at "maintained" with an overall "moderate" VSP risk rating. For the Umatilla/Walla Walla MPG to be viable, two populations should meet viability criteria, and one should be highly viable. The Umatilla River population is the only large population, and therefore should be viable. Either the Walla Walla River or Touchet River population also should be viable (NMFS 2009a). Therefore, the viability status of the Umatilla population must improve to "viable" to achieve the viability criteria.

All populations of MCR steelhead face mounting stress under a warming climate (ISAB 2007; NMFS 2009a; USGCRP 2009). The recovery plan predicts that:

> All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat can be expected to cause a reduction in the number of naturally produced adult steelhead returning to these populations across the DPS. This possibility further reinforces the importance of achieving survival improvements throughout the entire steelhead life cycle.

Maintaining the 20°C criterion and beneficial use designation, absent implementation of the CWR narrative criterion, is likely to maintain temperatures that do not support the recovery of this species because uncertainties about the distribution and protection of CWR will not be addressed. Increases in deaths and disease rates and impairment of migration behaviors are likely under this designated criterion. These issues are likely to cause population-scale reductions in the VSP variables abundance and productivity for MCR steelhead (particularly in the five John Day

[76] The five John Day populations are in the John Day MPG, and the Umatilla population is in the Walla Walla and Umatilla MPG.

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

[78] As stated earlier in the paragraph, there are other populations that could meet the "highly viable" status instead of the North Fork John Day population for the recovery criteria to be met.

populations and the single Umatilla population) should EPA approve the migration corridor beneficial use designation. The Umatilla population and some of the John Day populations must reach "viable" status for their MPGs to be viable. This species faces the additional challenge of the 20°C migration corridor interfering with smoltification in a portion of outmigrating juvenile steelhead from all populations in the John Day River, which is likely to further reduce their long-term survival. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

UCR steelhead: Water temperature are likely to be 1 to 2°C above optimal during the latter part of the non-peak migration period for juveniles due to approval of the migration corridor (20°C) criterion and beneficial use designation, leading to a small number of deaths and injuries, but temperatures are likely to be adequate during the peak juvenile migration period to fully support conservation of the species. However, approximately 60% of migrating adults will be exposed to water temperatures at or near 20°C in migratory habitat, without sufficient access to CWR, due to the proposed approval of the migration corridor criterion and beneficial use designation. Increases in deaths and disease rates and impairment of migration behaviors are likely under this designated criterion and beneficial use designation.

All four populations of UCR steelhead are at high risk of extinction (Ford 2011). Altered water temperature in the Columbia River is listed as a factor contributing to mortality of all populations of UCR steelhead in the recovery plan for this DPS (Upper Columbia Salmon Recovery Board 2007, p. 95), and all populations must pass through over 300 miles of river designated as 20°C. Population-scale reductions in the VSP variables abundance and productivity are likely for this species due to increased deaths and of migrating adults due to disease, reduced viability of gametes, and reduced fitness. Considering these effects in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

SRB steelhead: A small number of individual eggs and alevins are likely to suffer reduced short- or long-term survival due to EPA's approval of the IGDO criterion in the Imnaha River population for the duration of the time the criterion is in effect (most likely years to a decade). The number of eggs and alevins affected is likely to be too small to affect any of the VSP variables at the population scale.

A minor reduction in growth and increase in disease risk due to approval of the rearing and migration (18°C) criterion and beneficial use designation is likely to reduce the long-term survival of a small number of individuals of this species. However, the number of fish so affected is likely to be so small that there will be no effect on any of the VSP variables.

Population-scale reductions in the VSP variables abundance and productivity are likely for this species due to approval of the migration corridor (20°C) criterion and beneficial use, absent implementation of the CWR narrative criterion because of increased deaths of migrating adults and juveniles, disease and impairment of migration behaviors. The populations likely to be affected most severely are the ones that migrate during the warmest conditions (i.e, Upper Grande Ronde, Imnaha). The goal in our draft recovery plan (NMFS 2012d) for the Upper Grande Ronde population is that either this population or the Catherine Creek population should be "viable" or "highly viable". The other should be "maintained". Our recovery goal for the Imnaha population is "viable" or "highly viable". Considering the importance of these populations, the effects of the action in concert with challenges to viability from the environmental baseline, climate change and cumulative effects, as well as the status of the species, the proposed action is likely to appreciably reduce the likelihood of survival and recovery of this species.

Southern green sturgeon: Some sub-adult green sturgeon are likely to suffer sublethal adverse physiological effects such as reduced bioenergetic performance due to the thermal plume narrative criterion, and a few of these fish likely will eventually succumb to these effects. However, the number of fish is likely to be too small to be significant at the population scale due to the provisions in the criterion that limit exposure to warm temperatures. Overall, the proposed action is not likely to result in appreciable reductions in the likelihood of both survival and recovery of the listed species by reducing its numbers, reproduction, or distribution.

Eulachon: Degraded water quality is a moderate threat to the survival of eulachon (Gustafson *et al.* 2010). Although fish from the Umpqua River are part of the Columbia River subpopulation (Gustafson *et al.* 2010), and may not represent a large proportion of the subpopulation in years with large runs in the Columbia River, substantial losses of these fish in the Umpqua River likely would reduce genetic diversity of the species. Approval of the beneficial use designation for the 18°C rearing criterion in the Umpqua and Sandy rivers, combined with approval of the narrative criteria for thermal plumes, is likely to kill some eulachon adults, eggs and larvae, but not enough to reduce abundance at the scale of the Columbia River subpopulation for reasons explained in the analysis of effects.

Approval of the beneficial use designation for the 20°C rearing criterion in the Columbia River, combined with approval of the narrative criterion for thermal plumes, is likely to kill some eulachon adults, eggs and larvae, but not enough to reduce abundance at the scale of the Columbia River subpopulation, also for reasons explained in the analysis of effects. In all three rivers, adverse effects on eulachon generally will be limited due to the size and spacing of current NPDES discharges (although we are concerned about two discharges in the Columbia River named below), and to a commitment from EPA to send a letter to DEQ emphasizing the need to protect eulachon in NPDES permit reviews and to review future NPDES permits in the Columbia River and Umpqua River for 5 years following issuance of this opinion.[79] The 5-year timeframe will provide a record of how to effectively implement the mixing zone limitations to protect eulachon, and will serve as a basis for DEQ's future interpretation and implementation of the limitations. The record also will facilitate EPA's continuing oversight of NPDES permitting actions beyond the 5 years, consistent with EPA's memorandum of agreement on NPDES permits with DEQ (State of Oregon and United States Environmental Protection Agency 2010). Also, EPA will request in the letter to DEQ that the DEQ issue an administrative order or re-issue the NPDES permit for Dyno Nobel within 2 years of the issuance of this opinion to address

[79] October 27, 2015 letter from Christine Psyk, EPA to Kim Kratz, NMFS, regarding an amendment to EPA's proposed action to include a conservation measure to protect eulachon from thermal plumes in Oregon waters.

the current adverse effects on eulachon from the thermal plume associated with this discharge. The EPA also will recommend in the same letter that the DEQ prioritize the NPDES permit for Georgia Pacific's Wauna Mill for reissuance. We assisted EPA with the development of the conservation measures for eulachon described above, and are confident that they will sufficiently control adverse effects on eulachon such that the proposed action is not likely to result in appreciable reductions in the likelihood of both survival and recovery of the listed species by reducing its numbers, reproduction, or distribution.

2.6.2 Critical Habitat

Below we summarize effects of EPA's proposed approval action on the critical habitats of the subject listed species. We have combined the effects of approving the numeric criteria with approving the related beneficial use designations due to the difficulty of separating effects of these two closely related provisions. For all effects on critical habitats, unless stated otherwise, the duration of the effect is likely to reflect the period of time that the component of the standard is in effect, which is indefinite.

The quality of critical habitat varies depending on the amount and nature of human and natural disturbance that has occurred in a particular watershed. Some areas with wilderness or other protective designations are have rivers with good to excellent conditions for creating and maintaining fish habitat, while rivers in many lowland areas are particularly dysfunctional due to extensive and intensive human development and land use. Dams exert watershed or basin-wide negative effects on the quality of critical habitat for many of the listed species. The PCEs or PBFs in most watersheds have been degraded to various extents, but many watersheds still have medium to high conservation value due to the important role those watersheds serve in supporting the species' life cycle. The current conservation value of many areas of critical habitat is high. Effects of climate change likely will likely to result in generally negative trends for stream flow and water temperature conditions.

The effects of the proposed action previously reviewed in this opinion are likely to cause the following adverse effects on the freshwater critical habitat PCEs that will appreciably diminish the conservation value of critical habitat for listed species of salmon and steelhead:

- LCR Chinook salmon: freshwater rearing sites (water quality); freshwater migration sites (water quality)
- UWR Chinook salmon: freshwater rearing sites (water quality); freshwater migration sites (water quality)
- SR sockeye salmon: freshwater migration sites (water quality)
- LCR steelhead: Chinook salmon: freshwater rearing sites (water quality); freshwater migration sites (water quality)
- UWR steelhead: Chinook salmon: freshwater rearing sites (water quality); freshwater migration sites (water quality)
- MCR steelhead: Chinook salmon: freshwater rearing sites (water quality); freshwater migration sites (water quality)
- UCR steelhead: freshwater migration sites (water quality)
- SRB steelhead: freshwater migration sites (water quality)

For all species of salmon and steelhead not listed above, eulachon, and green sturgeon, effects on critical habitat are likely to be too minor to affect the conservation value of critical habitat to the species.

2.7 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is our biological opinion that the proposed action is likely to jeopardize the continued existence of LCR Chinook salmon, UWR Chinook salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, and SRB steelhead, and will destroy or adversely modify critical habitat that we have designated for these species. We also conclude that the proposed action is likely to jeopardize the continued existence of Southern Resident killer whale.

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon, UCR spring-run Chinook salmon, SR fall-run Chinook salmon, SR spring/summer Chinook salmon, CR chum salmon, LCR coho salmon, OC coho salmon, SONCC coho salmon, LCR steelhead, green sturgeon, or eulachon, or destroy or adversely modify critical habitat that we have designated for these species.

We also conclude that that the proposed action will not adversely modify critical habitat proposed for LCR coho salmon. You may request in writing that we adopt the conference opinion as a biological opinion after we designate critical habitat for LCR coho salmon. If we review the proposed action and find there have been no significant changes to the action that will alter the contents of the opinion and no significant new information has been developed (including during any required rulemaking process), we may adopt the conference opinion as the biological opinion on the proposed action, and no further consultation will be necessary.

2.8 Reasonable and Prudent Alternative

2.8.1. Proposed RPA

In accordance with 50 CFR 402.14(g)(5), we have developed the following RPA in cooperation with, and using the expertise of, the action agency and applicant. In this case, the applicant is the State of Oregon, as represented by the Oregon Department of Environmental Quality (hereafter, “DEQ”). The DEQ has committed in writing to carry out certain elements of the RPA, as described below.[80] However, EPA ultimately is responsible for implementation of the RPA.

1. Cold-water Refugia
    a. The EPA shall assist the DEQ in applying the cold water refugia (hereafter, “CWR”) narrative criterion in the migration corridor reach of the Willamette River. To apply the criterion, DEQ, with technical assistance and oversight from EPA, will develop a

[80] October 23, 2015 letter from Dick Pedersen, DEQ, to Dennis McLerran, EPA, regarding EPA’s consultation with NOAA Fisheries on EPA’s approval of Oregon’s 2003 temperature standard.

CWR plan for this river segment as described below. The purpose of the CWR plan is to adequately interpret the narrative criterion to allow for implementation of the criterion through DEQ's Clean Water Act authorities.

i. With technical assistance from EPA, DEQ will gather and synthesize readily available data, information and professional expertise, and use the "Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes" (Torgersen et al. 2012) as guidance, to characterize:
   1. the current spatial and temporal distribution of CWR,
   2. the current use of CWR by LCR Chinook salmon, UWR Chinook salmon, LCR steelhead, and UWR steelhead in the migration corridor reach of the Willamette River, and
   3. potential locations for the restoration or enhancement of CWR.

ii. Using the above information and professional expertise, DEQ will:
   1. assess whether the spatial and temporal extent of CWR present meets the CWR narrative criterion (i.e., whether CWR are "sufficiently distributed to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body"[81]);
   2. if DEQ concludes that the CWR criterion is not being met, characterize, to the maximum extent possible, the extent of additional CWR needed to attain the criterion; and
   3. identify and prioritize potential actions by DEQ and others to protect, restore or enhance CWR.

iii. DEQ and EPA will identify any scientific uncertainties and data gaps regarding the above elements and identify additional studies needed to address the uncertainties and data gaps.

iv. In coordination with EPA and NMFS, DEQ will complete a scope of work for the CWR plan within 1 year of the signing of this opinion that addresses the elements described above in 1.a.i. and 1.a.ii. The scope of work shall identify data sources and methods DEQ expects to use in completing the plans, and a schedule with milestones for completing the plans.

v. With oversight from EPA, the DEQ will complete the CWR plan for the lower Willamette River within 3 years of the signing of this opinion. DEQ and EPA will participate with NMFS in a meeting by November 30 of each year after this opinion is signed (beginning in the year 2016) to assess progress on completing the plan.

b. The EPA shall work with NMFS to facilitate an inter-agency team, including Oregon, to develop a CWR plan for the Columbia River that is consistent with the CWR plan elements described below. The purpose of the CWR plan is to adequately interpret the narrative criterion to allow for implementation of the criterion through DEQ's Clean Water Act authorities. The EPA shall work with the NMFS, the Columbia River Federal Caucus and the Northwest Power and Conservation Council (NWPCC) to align this work with Amendment 1 of the 2010 Supplemental FCRPS biological

[81] Under the CWR narrative criterion, CWR refugia are at "those portions of water body where, or times during the diel temperature cycle when, the water temperature is at least 2°C colder than the daily maximum temperature of the adjacent well mixed flow of the water body."

opinion and the water temperature and CWR strategies and objectives of the Columbia River Basin Fish and Wildlife Program of the NWPCC (Sub-Actions WQ 3.2 and CC.5).

   i. EPA shall gather and synthesize readily available data, information and professional expertise, and use the "Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes" (Torgersen et al. 2012) as guidance, to characterize:
      1. the current spatial and temporal distribution of CWR;
      2. the current use of CWR by SR fall Chinook salmon, SR sockeye salmon, SRB steelhead, UCR steelhead, and MCR steelhead; and
      3. potential locations for the restoration or enhancement of CWR.
   ii. Using the above information and professional expertise, EPA shall:
      1. assess whether the spatial and temporal extent of CWR present meets the CWR narrative criterion (i.e., are CWR "sufficiently distributed to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body");
      2. if EPA concludes that the CWR criterion is not being met, characterize, to the maximum extent possible, the extent of additional CWR needed to attain the criterion; and
      3. identify and prioritize potential actions by DEQ and/or other parties to protect, restore or enhance CWR.
   iii. The EPA, working with NMFS and the inter-agency team, shall finalize a scope of work for the CWR plan for the Columbia River within 9 months of the signing of this opinion that addresses the plan elements described above in 1.a.i. and 1.a.ii. The scope of work shall identify data sources and methods that EPA expects to use in completing the plan; a schedule with milestones for completing the plan; and a strategy to install continuous temperature data recorders during the summer (i.e., June through September) in Columbia River tributaries that are likely to provide CWR, preferably in the year 2016, but no later than the year 2017.
   iv. The EPA shall complete the CWR plan for the Columbia River within 3 years of the signing of this opinion.

2. Smoltification in John Day River
   a. The EPA shall work with DEQ to have a numeric criterion in place to protect steelhead smoltification in the John Day River (e.g., 14°C as a maximum 7DADM during April and May[82]) within 4 years of the signing of this opinion. This element of the RPA will not be necessary if, within 30 months of the signing of this opinion, based on the best available scientific information on water temperature patterns and smoltification locations and timing, EPA demonstrates, and NMFS concurs, that the current numeric criteria in the John Day River basin protect steelhead smoltification.

[82] Based on the analysis in this opinion, additional interagency consultation with EPA under section 7 of the ESA likely will not be necessary should a new smoltification criterion of 14°C as a maximum 7DADM during April and May for the lower John Day River be in place within 4 years of the signing of this opinion. However, should consultation on a new smoltification criterion be necessary, the 4-year timeline would be contingent upon timely completion of that consultation, provided consultation is initiated at least 135 days prior to completion of the 4-year deadline.

b. The EPA shall participate with NMFS in a meeting by November 30 of each year after this opinion is signed (beginning in the year 2016) to discuss progress on completing the steelhead smoltification criterion.

2.8.2 Compliance with RPA Criteria

A reasonable and prudent alternative (RPA) to the proposed action is one that avoids jeopardy by ensuring that the action's effects do not appreciably increase the risks to the species' potential for survival or to the species' potential for recovery. It also must avoid destruction or adverse modification of designated critical habitat. A detailed analysis of how the RPA will avoid jeopardy and destruction or adverse modification of critical habitat is set out in Section 2.8.3, below.

The RPA must also be: (1) consistent with the intended purpose of the action; (2) within the scope of the Federal agency's legal authority and jurisdiction; and (3) economically and technologically feasible. This RPA is consistent with the purpose of EPA's action, as it will ensure that Oregon's water quality criteria for water temperature will be protective of aquatic species. The EPA has authority, under the Clean Water Act, to ensure that state water quality standards are consistent with the requirements of the Clean Water Act requirements, which include ensuring that aquatic life is adequately protected.

Implementation of the RPA may impose some additional costs on Oregon and EPA because it requires them to develop CWR plans for the lower Willamette River and part of the Columbia River, but neither Oregon nor EPA conducted an economics analysis for the proposed action. The RPA is economically and technologically feasible for EPA since it requires the agency to develop a plan, a function that can be readily accommodated within the agency's normal course of business.

2.8.3 RPA Analysis of Effects

Under the proposed 20°C migration corridor criterion and beneficial use designation, six listed species of salmon and steelhead are likely to experience increased deaths, disease rates, and impairment of migration behaviors. When DEQ originally adopted this criterion in 2003, it was only acceptable to NMFS because it included a requirement that these water bodies must have cold water refugia (hereafter, "CWR") that are "sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body." However, as described above in section of this opinion, Oregon has not effectively used the narrative criterion pertaining to CWR to reduce the adverse effects likely to be experienced by migrating salmon and steelhead under the 20°C migration corridor criterion. Also, according to EPA, Oregon has not provided any analyses of or determinations as to the part of the narrative criterion that requires that CWR "are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body."

Under the RPA, DEQ and EPA will develop CWR plans for the Willamette and Columbia Rivers respectively. The purpose of the CWR plans is to adequately interpret the narrative criterion to allow for implementation of the criterion through DEQ's Clean Water Act authorities. Upon completion of these plans, the following information will be available:

1. the current spatial and temporal distribution of CWR,
2. the current use of CWR by listed species subject to the RPA, and
3. potential locations for the restoration or enhancement of CWR.

This information will allow EPA and DEQ to:

1. assess whether the spatial and temporal extent of CWR meets the CWR narrative criterion;
2. if the CWR criterion is not being met, characterize, to the maximum extent possible, the extent of additional CWR needed to attain the criterion; and
3. identify and prioritize potential actions needed to protect, restore or enhance CWR.

The information and actions to be developed under the RPA will allow for implementation of the CWR criterion through DEQ's CWA authorities (primarily involving NPDES permits, CWA section 401 certifications, and developing and implementing temperature TMDLs). Using these authorities, DEQ will is likely to be able to reduce the impacts of the 20°C criterion by appropriately controlling existing and future thermal discharges and nonpoint sources of heat. Over time, CWR are more likely to be available and functional, increasing the likelihood that adult and juvenile listed species of salmon and steelhead can reduce their disease risk during migration and avoid water temperatures high enough to impair migration. Also, the risk of predation by warm-water species likely will be reduced somewhat in CWR relative to warmer mainstem rivers. These changes are likely to protect future options for species recovery that might not otherwise be available, and ensure a reasonably high likelihood that the revised action will meet the conservation needs of the listed species and critical habitat PCEs. Adverse effects of the revised action under the RPA will be too small to affect any of the VSP variables at the population scale. Because there will be no effect at the population scale, the revised action, in combination with the status of the species, environmental baseline and cumulative effects, is not likely to result in an appreciable reduction of the likelihood of survival or recovery of any of the listed species by reducing their numbers, reproduction, or distribution.

Considering the amount of information that must be gathered and the resources available to EPA and DEQ, 3 years from the signing of this opinion is a reasonable period of time to complete these plans. In the meantime, actions required under the FCRPS biological opinion and actions recommended by NMFS in the recovery plans for the lower Columbia River and Willamette River are reasonably likely to ensure that the listed species do not go extinct, and the critical habitat PCEs either remain functional or retain the ability to become functional when enhanced or restored in the future.

Regarding Southern Resident killer whales, for the listed fish species that are prey for Southern Resident killer whales and are included in this opinion, the RPA will ensure that any reductions in reproduction, numbers, or distribution will be too small to cause effects at the scale of a fish population, ESU or DPS, thereby removing the long-term threat to killer whales from long-term reduction in prey availability.

2.8.4 RPA Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is our biological opinion that the proposed action as revised by the RPA is not likely to jeopardize the continued existence of LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, OC coho salmon, SONCC coho salmon, SR sockeye salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, green sturgeon, eulachon, or Southern Resident killer whales, or destroy or adversely modify critical habitat that we have designated for these species (where applicable).

We also conclude that that the proposed action as revised by the RPA will not adversely modify critical habitat proposed for LCR coho salmon. You may request in writing that we adopt the conference opinion as a biological opinion after we designate critical habitat for LCR coho salmon. If we review the proposed action and find there have been no significant changes to the action that will alter the contents of the opinion and no significant new information has been developed (including during any required rulemaking process), we may adopt the conference opinion as the biological opinion on the proposed action, and no further consultation will be necessary.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.9.1 Amount or Extent of Take

The proposed action will cause incidental take because it is the final step in putting in place water quality standards for intergravel dissolved oxygen and water temperature that would allow some deaths, injuries, and impairment of essential behavioral patterns to occur in listed species. The types of incidental take from the proposed action are likely to include the following:

For salmon and steelhead:

- Deaths of some eggs and alevins in some areas due to insufficient intergravel dissolved oxygen and temperatures that do not fully support incubation.
- Deaths, injuries, and harm due to reduced growth, reduced competitive success, and increased predation for some juveniles; increased disease risk, impaired migration, and harmful interactions with other habitat stressors for some juveniles and adults; unsuitable temperatures during adult pre-spawn holding for some adults; reduced gamete survival during pre-spawn holding for some adults; and reduction of swimming performance for some adults.[83]
- For MCR steelhead, includes harm for some juveniles due to impairment of smoltification.

For green sturgeon:

- Reduced long-term survival (i.e., increased deaths) for some sub-adult fish due to reduced bioenergetic performance.

For eulachon:

- Increased deaths of some adults, eggs, and larvae in thermal plumes.

Because Southern Resident killer whales do not occur in the action area, incidental take of this species is not likely to occur due to the proposed action as modified by the RPA. The incidental take pathways for the proposed action as modified by the RPA are given in Table 37.

[83] Not all factors will affect all species/ESUs/DPSs to the same extent. Also, or UWR steelhead, only juveniles will be affected.

Table 37. Incidental take pathways by species and water temperature criteria.

	Intergravel Dissolved Oxygen Criterion[1]	Water Temperature Criteria and Beneficial Use Designations			
Species	**8 mg L^{-1}**	**Spawning 13°C[1]**	**Rearing/ Migration 18°C[2]**	**Migration Corridor 20°C with CWR[2,3]**	**Thermal Plume Narrative Criterion[3]**
LCR Chinook Salmon	X		X	X	X
UWR Chinook Salmon	X		X	X	X
UCR Spring-Run Chinook Salmon				X	X
SR Spring/Summer-Run Chinook	X		X	X	X
SR Fall-Run Chinook Salmon			X	X	X
LCR Coho Salmon		X	X	X	X
OC Coho Salmon		X	X		X
SONCC Coho Salmon		X	X		X
LCR Steelhead	X		X	X	X
UWR Steelhead			X	X	X
MCR Steelhead	X		X	X	X
UCR Steelhead				X	X
SRB Steelhead	X		X	X	X
CR Chum Salmon		X		X	X
SR Sockeye Salmon				X	X
Eulachon				X	X
Green Sturgeon					X

[1]Deaths of some eggs and alevins due to insufficient intergravel dissolved oxygen or temperatures that are above optimal.
[2]Deaths, injuries, and harm due to reduced growth, reduced competitive success, and increased predation for some juveniles; increased disease risk, impaired migration, and harmful interactions with other habitat stressors for some juveniles and adults; unsuitable temperatures during adult pre-spawn holding for some adults; reduced gamete survival during pre-spawn holding for some adults; and reduction of swimming performance for some adults. Not all factors will affect all species/ESUs/DPSs to the same extent. For UWR steelhead, only juveniles will be affected. For MCR steelhead, includes harm for some juveniles due to impairment of smoltification.
[3] For sturgeon, reduced long-term survival (i.e., increased deaths) for some sub-adult fish due to reduced bioenergetic performance; for eulachon, increased deaths of some adults, eggs, and larvae in thermal plumes.

Incidental take due to this action cannot be accurately quantified as a number of fish because the action area includes all waterways where the IGDO, salmon and steelhead spawning use, salmon and trout rearing and migration use, migration corridor use, and thermal plume criteria apply. Data do not exist that would allow us to quantify how many fish of each species and life stage exist in each stream reach within these areas, especially considering that the numbers of fish vary with the season, environmental conditions, and changes in population size due to recruitment and mortality over the course of a year. Also, currently we have no means to determine which deaths or injuries in fish populations across the entire range of the listed species covered in this opinion are due to water temperature versus other factors such as other environmental stressors, competition, and predation. Finally, many waters where incidental take is likely to occur do not meet the temperature standard at this time, and it would be impossible in these waters to estimate which portion of the take is due to what is allowed under the temperature standard, and which portion is due to the exceedance of the standard. Because we cannot determine the amount of take, we will use a habitat measure for the extent of take as a surrogate for the amount of take.

For this action, NMFS will use the following as surrogates for the amount of incidental take due to the action to be taken by EPA under the RPA:

1. The spatial and temporal extent of the beneficial use designations for the salmon and steelhead spawning use (13.0°C)
2. The spatial extent of the beneficial use designations for the other two numeric temperature criteria that are associated with incidental take, namely:
    a. Salmon and trout rearing and migration use (18°C)
    b. Salmon and steelhead migration corridor use (20°C with sufficiently distributed cold water refugia

The surrogates described in numbers 1 and 2 above are quantifiable and may be monitored, serving their intended role as clear reinitiation triggers. They are proportional to the amount of take of the species because the greater the spatial extent (or for the spawning use, the spatial or temporal extent) of the designation, the greater the take of the species. Our analysis of effects was based on the designations that were current as of the time that the opinion was signed. Any decrease in the spatial or temporal extent of the salmon and steelhead spawning use designation (the most protective criterion) likely would mean more take of listed species would occur than we assumed, possibly triggering the need for EPA to reinitiate consultation. In a similar manner, any increase in the salmon and trout rearing and migration use at the expense of the core cold water use, or in the salmon and steelhead migration corridor use at the expense of the core cold water use or the salmon and trout rearing and migration use, would mean that more take of listed species would occur than we assumed, also possibly triggering the need for EPA to reinitiate consultation.

3. The time required to complete the cold water refugia (CWR) plans for the Willamette and Columbia rivers (i.e., 3 years from the signing of this opinion).

This surrogate (no. 3 above) also is quantifiable and may be monitored, serving its intended role as a clear reinitiation trigger. It is proportional the take of the species because we assumed that beginning 3 years from the signing of the opinion, DEQ, EPA and other parties would have the information from the CWR plans needed adequately interpret the CWR narrative criterion to allow for implementation of the criterion through DEQ's Clean Water Act authorities. Exceeding this period of time could mean that our assumptions about how long incidental take related to problems interpreting and implementing the CWR narrative criterion would continue were not correct, possibly triggering the need for EPA to reinitiate consultation.

4. The time required for DEQ to issue an administrative order or re-issue the NPDES permit for Dyno Nobel facility on the Columbia River (i.e., 2 years from the signing of this opinion).

This surrogate (no. 4 above) also is quantifiable and may be monitored, serving its intended role as a clear reinitiation trigger. It is proportional the take of the species because we assumed that the incidental take from this facility's discharge would be reduced beginning 2 years from the signing of the opinion. Exceeding this period of time could mean that our assumption about how long the current amount of incidental take related to this discharge would continue was not correct, possibly triggering the need for EPA to reinitiate consultation.

5. The time required to have a numeric criterion in place to protect steelhead smoltification in the John Day River (e.g.,14°C as a maximum 7DADM during April and May) (i.e., in 4 years from the signing of this opinion, unless within 30 months of the signing of this opinion, based on the best available scientific information on water temperature patterns and smoltification locations and timing developed during these 4 years, EPA demonstrates, and NMFS concurs, that the current numeric criteria in the John Day River basin protect steelhead smoltification).

This surrogate (no. 5 above) also is quantifiable and may be monitored, serving its intended role as a clear reinitiation trigger. It is proportional the take of the species because we assumed that the incidental take related to lack of a smoltification criterion would be reduced beginning 4 years from the signing of the opinion. Exceeding this period of time could mean that our assumption about how long the current amount of incidental take related to this discharge would continue was not correct, possibly triggering the need for EPA to reinitiate consultation.

2.9.2 Effect of the Take

In Section 2.7, we determined that the level of incidental take that we estimated, coupled with other effects of the proposed action, is not likely to result in jeopardy to the listed species or destruction or adverse modification of their critical habitats.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). The following measures are necessary and appropriate to minimize the impact of incidental take of listed species from the proposed action.

1. The EPA shall monitor and report to NMFS on the implementation of the RPA.
2. The EPA shall ensure completion of the monitoring and reporting program to ensure that the extent of take is not exceeded, and to confirm that the terms and conditions in this incidental take statement are effective in avoiding and minimizing incidental take.

2.9.4 Terms and Conditions

1. To implement reasonable and prudent measure # 1 (monitoring the implementation of the RPA) the EPA shall:
    a. Oversee DEQ's submittal of a scope of work for a cold water refugia (CWR) plan for the Willamette River, as required under the RPA, to NMFS within 1 year of the signing of this opinion.
    b. Participate with its applicant the state of Oregon (as represented by DEQ) and NMFS in a meeting by November 30 of each year after this opinion is signed (beginning in 2016) to assess progress on completing the CWR plan for the Willamette River.
    c. Submit a scope of work for a CWR plan for the Columbia River, as required under the RPA, to NMFS within 9 months of the signing of this opinion.
    d. Participate with NMFS in a meeting by November 30 of each year after this opinion is signed (beginning in the year 2016) to discuss progress on completing the steelhead smoltification criterion.
2. To implement reasonable and prudent measure #2 (monitoring and reporting program) the EPA shall:
    a. Notify NMFS if DEQ proposes a rule to alter the timing or location of any of the following beneficial use designations:
        i. Salmon and steelhead spawning use (13.0°C)
        ii. Salmon and trout rearing and migration use (18°C)
        iii. Salmon and steelhead migration corridor use (20°C with sufficiently distributed cold water refugia)
    b. Notify NMFS when the DEQ issues an administrative order or re-issues the NPDES permit for Dyno Nobel facility on the Columbia River.
    c. Notify NMFS when the DEQ re-issues the NPDES permit for Georgia Pacific's Wauna Mill on the Columbia River.
    d. Notify NMFS of each draft permit EPA plans to review for Columbia River discharges below Bonneville Dam and in the lower 24.2 miles of the Umpqua River that exceed 1 million gallons per day in flow and 20°C in temperature.
    e. Provide an annual email status report to NMFS on its review of draft permits as described in 2.d. above, including a summary of how each permit issued in the preceding year will minimize adverse effects on eulachon.
    f. Notify NMFS if EPA or DEQ proposes a new smoltification criterion for the lower John Day River.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

To improve the potential for recovery of listed species in the state of Oregon, the EPA should carry out management actions within their programs and authorities to reverse threats to survival as identified in recovery plans for salmon and steelhead, and for eulachon and green sturgeon when NMFS has completed recovery plans for those species.

Please notify NMFS if the EPA carries out this recommendation so that we will be kept informed of actions that are intended to improve the conservation of listed species or their designated critical habitats.

2.11 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) The amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these Data Quality Act (DQA) components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

3.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users is the Federal action agency (EPA). An individual copy was provided to EPA. This consultation will be posted on the NMFS West Coast Region website (http://www.westcoast.fisheries.noaa.gov/). The format and naming adheres to conventional standards for style.

3.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

3.3 Objectivity

***Information Product Category*:** Natural Resource Plan.

***Standards*:** This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01, *et seq*., and the MSA implementing regulations regarding EFH, 50 CFR 600.920(j).

***Best Available Information*:** This consultation and supporting documents use the best available information, as referenced in the Literature Cited section. The analyses in this opinion/EFH consultation contain more background on information sources and quality.

***Referencing*:** All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

***Review Process*:** This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

4. LITERATURE CITED

ADEC (Alaska Department of Environmental Conservation). 2011. Fish monitoring program: analysis of organic contaminants.

Allen, P.J., M. Nicholl, S. Cole, A. Vlazny, and J.J. Cech, Jr. 2006. Growth of larval to juvenile green sturgeon in elevated temperature regimes. Transactions of the American Fisheries Society 135:89-96.

Arntzen E.V., D.R. Geist, K.J. Murray, J .Vavrinec, III, E.M. Dawley, and D.E. Schwartz. 2009. Influence of the hyporheic zone on supersaturated gas exposure to incubating chum salmon. North American Journal of Fisheries Management 29(6):1714-1727.

Au, W.L., J.K. Horne, and C. Jones. 2010. Basis of acoustic discrimination of Chinook salmon from other salmons by echolocating *Orcinus orca*. Journal of the Acoustical Society of America 128(4):2225-2232.

Bain, D. 1990. Examining the validity of inferences drawn from photo-identification data, with special reference to studies of the killer whale (*Orcinus orca*) in British Columbia. Report of the International Whaling Commission, Special Issue 12:93-100.

Baird, R.W. 2000. The killer whale: foraging specializations and group hunting. P. 127-153 in J. Mann, R. C. Connor, P. L. Tyack, and H. Whitehead (editors). Cetacean societies: field studies of dolphins and whales. University of Chicago Press, Chicago.

Barbieri, M.M., S. Raverty, M.B. Hanson, S. Venn-Watson, J.K.B. Ford, and J.K. Gaydos. Spatial and temporal analysis of killer whales (*Orcinus orca*) strandings in the North Pacific Ocean and the benefits of a coordinated stranding response protocol. Marine Mammal Science 29:E448-E462.

Barker, S.L., D.W. Townsend, and J.S. Hacunda. 1981. Mortalities of Atlantic herring, *Clupea h. harengus*, smooth flounder, *Liopsetta putnami*, and rainbow smelt, *Osmerus mordax*, larvae exposed to acute thermal shock. Fishery Bulletin 79(1):198-200.

Barnett-Johnson, R., C.B. Grimes, C.F. Royer, and C.J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Canadian Journal of Fishery and Aquatic Sciences 64:1683-1692.

Berman, C.H. 1990. Effect of elevated holding temperatures on adult spring Chinook salmon reproductive success. M.S. Thesis. University of Washington, Seattle.

Bigg, M. 1982. As assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission 32:655-666.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12:383-405.

Bigler, B.S., D.W. Welch, and J.H. Helle. 1996. A review of size trends among North Pacific salmon (Oncorhynchus spp). Canadian Journal of Fisheries and Aquatic Sciences 53:455-456.

Bindoff, N.L., J. Willebrand, V. Artale, A. Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley, and A. Unnikrishnan. 2007. Observations: Oceanic climate change and sea level. In: Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (editors). Cambridge University Press. Cambridge, United Kingdom and New York.

Black, N., R. Ternullo, A. Schulman-Jangier, A. M. Hammers, and P. Stap. 2001. Occurrence, behavior, and photo-identification of killer whales in Monterey Bay, California. +Proceedings of the Biennial Conference on the Biology of Marine Mammals 14:26. Abstract only.

Blahm, T.H. and R.J. McConnell. 1971. Mortality of adult eulachon (*Thaleichthys pacificus*) subjected to sudden increases in water temperature. Northwest Science 45(3): 178-182.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-68. 246 p.

Brannon, E.L. 1965. The influence of physical factors on the development and weight of sockeye salmon embryos and alevins. Progress Report No. 12. International Pacific Salmon Fisheries Commission, New Westminster, B.C., Canada.

Brooks, B.W., C.K. Chambliss, J.K. Stanley, A. Ramirez, K.E. Banks, R.D. Johnson, and R.J. Lewis. 2005. Determination of select antidepressants in fish from an effluent-dominated stream. Environmental Toxicology and Chemistry 24:464-469.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Leirheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27. 281 p.

Busch, S., P. McElhany, and M. Ruckelshaus. 2008. A comparison of the viability criteria developed for management of ESA listed Pacific salmon and steelhead. U.S. Department of Commerce, Northwest Fisheries Science Center. Seattle.

Carson, K.A. 1985. A model of salmonid egg respiration. M.S. thesis. Agricultural and Chemical Engineering Department, Colorado State University, Fort Collins. 108 p.

CBD (Center for Biological Diversity). 2001. Petition to list the southern resident killer whale (*Orcinus orca*) as an endangered species under the Endangered Species Act.

Chapman, D.W. and K.P. McLeod. 1987. Development of criteria for fine sediment in the Northern Rockies ecoregion. Final Report. EPA contract no. 68-01-6986.

Clutton-Brock, T.H. 1988. Reproductive success: studies of individual variation in contrasting breeding systems. University of Chicago Press, Chicago.

Columbia River DART. 2014. Columbia Basin Research, University of Washington. Available at http://www.cbr.washington.edu/dart/query/river_graph_text (accessed August 14, 2014).

Coulson, T., T.G. Benton, P. Lundberg, S.R.X. Dall, B.E. Kendall, and J.M. Gaillard. 2006. Estimating individual contributions to population growth: evolutionary fitness in ecological time. Proceedings of the Royal Society of London, Series B: Biological Sciences 273:547-555.

Coutant, C.C. 1973. Effects of thermal shock on vulnerability of juvenile salmonids to predation. J. Fish. Res. Bd. Canada 30:965-973.

Crawford, B.A. and S. Rumsey. 2011. Guidance for monitoring recovery of salmon and steelhead listed under the federal Endangered Species Act (Idaho, Oregon, and Washington). National Marine Fisheries Service, Northwest Region. Seattle. 117 p. plus appendices.

Crozier, L.G., B.J. Burke, B.P. Sandford, G.A. Axel, and B.L. Sanderson. 2014. Adult Snake River sockeye salmon passage and survival within and upstream of the FCRPS. Report of the National Marine Fisheries Service to the U.S. Army Corps of Engineers. Portland, Oregon.

Cuffney, T. R., M. R. Meador, S. D. Porter, and M. E. Gurtz. 1997. Distribution of fish, benthic invertebrate, and algal communities in relation to physical and chemical conditions, Yakima River Basin, Washington 1990. U.S. Geological Survey, Water Resources Investigation Report 96-4280. Raleigh, North Carolina.

Cullon, D.L., M.B. Yunker, C. Alleyne, N.J. Dangerfield, S. O'Neill, M.J. Whiticar, and P.S. Ross. 2009. Persistent organic pollutants in Chinook salmon (*Oncorhynchus tshawytscha*): implications for resident killer whales of British Columbia and adjacent waters. Environmental Toxicology and Chemistry 28:148-161.

Darnerud, P.O. 2008. Brominated flame retardants as possible endocrine disrupters. Intern. J. Andrology 31:152-160.

Davenport, J. and A. Stene. 1986. Freezing resistance, temperature and salinity tolerance in eggs, larvae and adults of capelin, *Mallotus villosus*, from Balsfjord. Journal of the Marine Biological Association of the U.K. 66(01):145-157.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. Journal of the Fisheries Research Board of Canada 32:2295-2332.

Deagle, B.E., D.J. Tollit, S.N. Jarman, M.A. Hindell, A.W. Trites, and N.J. Gales. 2005. Molecular scatology as a tool to study diet: analysis of prey DNA in scats from captive Steller sea lions. Molecular Ecology 14:1831-1842.

deBruyn A.M. H., M.G. Ikonomou, and F.A.P.C. Gobas. 2004. Magnification and toxicity of PCBs, PCDDs, and PCDFs in upriver-migrating Pacific salmon. Environ. Sci. Technol. 38:6217-6224.

DeHart, K.B., I.A. Tattam, J.R. Ruzycki, and R.W. Carmichael. 2012. Productivity of spring Chinook salmon and summer steelhead in the John Day River basin. Annual technical report, contract period: February 1, 2011 – January 31, 2012. Oregon Department of Fish and Wildlife. BPA project number 1998-016-00, contract number 00051809.

DeHart, K.B., I.A. Tattam, J.R. Ruzycki, and R.W. Carmichael. 2012. Productivity of spring Chinook salmon and summer steelhead in the John Day River basin. Annual technical report, contract period: February 1, 2011 – January 31, 2012. Oregon Department of Fish and Wildlife. BPA project number 1998-016-00, contract number 00051809.

Dewberry, T.C. 2003. Development and application of anchor habitat approaches to salmon conservation: a synthesis of data and observation from the Siuslaw watershed, coastal Oregon. Unpublished draft report. Portland, Oregon. 16 p.

Drake, J., R. Emmett, K. Fresh, R. Gustafson, M. Rowse, D. Teel, M. Wilson, P. Adams, E.A.K. Spangler, and R. Spangler. 2008. Summary of scientific conclusions of the review of the status of eulachon (*Thaleichthys pacificus*) in Washington, Oregon and California (Draft). U. S. Department of Commerce, Northwest Fisheries Science Center. Seattle.

Dunham, J., J. Lockwood, and C. Mebane. 2001. Salmonid distribution and temperature. Issue Paper 2. Prepared as part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. EPA-910-D-01-002. U.S. Environmental Protection Agency, Region 10, Seattle. 22 p.

Durban, J., H. Fearnbach, D. Ellifrit, and K. Balcomb. 2009. Size and body condition of southern resident killer whales. Contract report to National Marine Fisheries Service, order no. AB133F08SE4742. February.

Ebbert, J., and S. Embrey. 2001. Pesticides in surface water of the Yakima River basin, Washington, 1999-2000: their occurrence and an assessment of factors affecting concentrations and loads. U.S. Department of the Interior, U.S. Geological Survey, Water Investigations Report 01-4211. Portland, Oregon.

Ecotrust, Oregon Trout, and The Wild Salmon Center. 2000. A Salmon anchor habitat strategy for the Tillamook and Clatsop State Forests. Updated version. Portland, Oregon. 29 p. plus appendices.

Emmons, C.K., M.B. Hanson, J.A. Nystuen, and M.O. Lammers. 2009. Assessing seasonal distribution, movements, and habitat use of southern resident killer whales in the coastal waters of Washington State using remote autonomous acoustic recorders. Abstract. 18th Biennial Conference on the Biology of Marine Mammals, Quebec City.

EPA (Environmental Protection Agency). 1998. Biological assessment of the revised Oregon water quality standards for dissolved oxygen, temperature, and pH. EPA Region 10, Seattle.

EPA (Environmental Protection Agency). 2002. Columbia River basin fish contaminant survey 1996-1998. EPA 901-R-02-006. Seattle.

EPA (Environmental Protection Agency). 2003. EPA Region 10 guidance for Pacific Northwest state and tribal temperature water quality standards. U.S. Environmental Protection Agency, Region 10, Office of Water, Seattle. 49 p.

EPA. 2013. Biological evaluation of the revised oregon water quality standards for temperature and intergravel dissolved oxygen. U.S. Environmental Protection Agency, Region 10. Seattle. Amended November 4.

Erickson, A.W. 1978. Population studies of killer whales (*Orcinus orca*) in the Pacific Northwest: a radio-marking and tracking study of killer whales. U.S. Marine Mammal Commission, Washington, D.C.

Ewald, G., P. Larsson, H. Linge, L. Okla, and N. Szarzi. 1998 Biotransport of organic pollutants to an inland Alaska Lake by migrating sockeye salmon (*Oncorhynchus nerka*). Arctic 51(1):40-47.

Fagen, W. F., and E. E. Holmes. 2006. Quantifying the extinction vortex. Ecology Letters 9:51-60.

Feely, R.A., T. Klinger, J.A. Newton, and M. Chadsey (editors). 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research special report.

Ferguson, J.W., G.M. Matthews, R.L. McComas, R.F. Absolon, D.A. Brege, M.H. Gessel, and L.G. Gilbreath. 2005. Passage of adult and juvenile salmonids through Federal Columbia River power system dams. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-64. 160 p.

Fernald, A.G., P.J. Wigington, and D.H. Landers. 2001. Transient storage and hyporheic flow along the Willamette River, Oregon: field measurements and model estimates. Water Resources Research 37(6):1681-1694.

Fiedler, P. C. and R. M. Laurs. 1990. Variability of the Columbia River plume observed in visible and infrared satellite imagery. International Journal of Remote Sensing 11(6):999-1010.

Ford, J.K.B. 2002. Killer whale *Orcinus orca*. P. 669-676 in W.F. Perrin, B. Würsig, and J.G. M. Thewissen (editors). Encyclopedia of marine mammals. Academic Press, San Diego.

Ford, M.J. (editor). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-113. 281 p.

Ford, J.K.B., G.M. Ellis, L.G. Barrett-Lennard, A.B. Morton, R.S. Palm, and K.C. Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Can. J. Zool. 76:1456-1471.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington State, second edition. UBC Press, Vancouver, British Columbia.

Ford, J.K.B., G.M. Ellis, and P.F. Olesiuk. 2005. Linking prey and population dynamics: did food limitation cause recent declines of ‘resident’ killer whales (*Orcinus orca*) in British Columbia? Fisheries and Oceans Canada, Nanaimo, British Columbia.

Ford, J.K.B. and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316:185-199.

Ford, J.K.B., B.M. Wright, G.M. Ellis, and J.R. Candy. 2010a. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. Department of Fisheries and Oceans, Canadian Science Advisory Secretariat Research Document 2009/101.

Ford, J.K.B., G.M. Ellis, P.F. Olesiuk and K.C. Balcomb. 2010b. Linking killer whale survival and prey abundance: food limitation in the oceans’ apex predator? Biology Letters 6:139-142.

Ford, M.J., M.B. Hanson, J.A. Hempelmann, K.L. Ayres, C.K. Emmons, G.S. Schorr, R.W. Baird, K.C. Balcomb, S.K. Wasser, K.M. Parsons, and K. Balcomb-Bartok. 2011a. Inferred paternity and male reproductive success in a killer whale (*Orcinus orca*) population. Journal of Heredity 102(5):537-553.

Ford, M., B. Hanson, D. Noren, C. Emmons, J. Hempelman, D. Van Doornik, M. Ford, A. Agness, L. La Voy, R. Baird, G. Schorr, J. Ford, J. Candy, B. Gisborne, K. Balcomb, K. Balcomb-Bartok, K. Ayres, and S. Wasser. 2011b. Evaluating prey as a limiting factor for southern resident killer whales. DFO's killer whale prey action planning workshop. March 8-9, 2011. Pender Island, B.C.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-69. 105 p.

Friesen, T.A., J.S. Vile, and A.P. Pribyl. 2005. Migratory behavior, timing, rearing, and habitat use of juvenile salmonids in the lower Willamette River. P. 63-138 in: Friesen, T.A. (editor). Biology, behavior, and resources of resident and anadromous fish in the Lower Willamette River. Final report of research, 2000-2004. Oregon Department of Fish and Wildlife, Clackamas, Oregon.

Fuhrer, G.J., J.L. Morace, H.M. Johnson, J.F. Rinella, J.C. Ebbert, S.S. Embrey, I.R. Waite, K.D. Carpenter, D.R. Wise, and C.A. Hughes. 2004. Water quality in the Yakima basin, Washington, 1999-2000. U.S. Department of the Interior, U.S. Geological Survey Circular 1237, water research investigations report 03-4026, Portland, Oregon.

Gamel, C. M., R. W. Davis, J. H. M. David, M. A. Meyer, and E. Brandon. 2005. Reproductive energetics and female attendance patterns of Cape fur seals (*Arctocephalus pusillus pusillus*) during early lactation. American Midland Naturalist 153(1):152-170.

Gaydos, J.K., S. Raverty, and J. St. Leger. 2013. Killer whale strandings in the eastern north Pacific Ocean: 2005-2013. Draft report. 8 p.

Geist, D.R., T.P. Hanrahan, E.V. Arntzen, G.A. McMichael, C.J. Murray, and Y.J. Chien. 2002. Physicochemical characteristics of the hyporheic zone affect redd site selection of chum salmon and fall Chinook salmon in the Columbia River. North American Journal of Fisheries Management 22(4):1077-1085.

Geist, D.R., S. Abernethy, K.D. Hand, V.I. Cullinan, J. A. Chandler, and P. A. Groves. 2006. Survival, development, and growth of fall Chinook salmon embryos, alevins, and fry exposed to variable thermal and dissolved oxygen regimes. Transactions of the American Fisheries Society 135(6):1462-1477.

Geist, D.R., E.V. Arntzen, C.J. Murray, K.E. McGrath, Y.J. Bott, T.P. Hanrahan. 2008. Influence of river level on temperature and hydraulic gradients in chum and fall Chinook salmon spawning areas downstream of Bonneville Dam, Columbia River. North American Journal of Fisheries Management 28(1):30–41.

Geraci, J.R., and D. J. St. Aubin (editors). 1990. Sea mammals and oil: confronting the risks. Academic Press, New York.

Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: processes of extinction. P. 19-34 in M. E. Soule (editor). Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Goniea, T.M., M.L. Keefer, T.C. Bjornn, C.A. Peery, D.H. Bennett, and L.C. Stuehrenberg. 2006. Behavioral thermoregulation and slowed migration by adult fall Chinook salmon in response to high Columbia River water temperatures. Transactions of the American Fisheries Society 135(2):408-419.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally ESUs of west coast salmon and steelhead. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-66. 598 p.

Grant, S. C. H., and P. S. Ross. 2002. Southern resident killer whales at risk: toxic chemicals in the British Columbia and Washington environment. Canadian Technical Report of Fisheries and Aquatic Sciences 2412.

Gregory, S., L. Ashkenas, D. Oetter, P. Minear, and K. Wildman. 2002a. Historical Willamette River channel change. P. 18-26 in: Willamette River Basin planning atlas: trajectories of environmental and ecological change. D. Hulse, S. Gregory, and J. Baker (editors). Oregon State University Press. Corvallis, Oregon.

Gregory, S., L. Ashkenas, D. Oetter, P. Minear, R. Wildman, P. Minear, S. Jett, and K. Wildman. 2002b. Revetments. P. 32-33 in: Willamette River Basin planning atlas: trajectories of environmental and ecological change. D. Hulse, S. Gregory, and J. Baker (editors). Oregon State University Press. Corvallis, Oregon.

Gregory, S., L. Ashkenas, P. Haggerty, D. Oetter, K. Wildman, D. Hulse, A. Branscomb, and J. Van Sickle. 2002c. Riparian vegetation. P. 40-43 in: Willamette River Basin planning atlas: trajectories of environmental and ecological change. D. Hulse, S. Gregory, and J. Baker (editors). Oregon State University Press. Corvallis, Oregon.

Gustafson, R.G., M.J. Ford, D. Teel, and J.S. Drake. 2010. Status review of eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-105. 360 p.

Gustafson, R.G., M.J. Ford, P.B. Adams, J.S. Drake, R.L. Emmett, K.L. Fresh, M. Rowse, E.A.K. Spangler, R.E. Spangler, D.J. Teel, and M.T. Wilson. 2011. Conservation status of eulachon in the California Current. Fish and Fisheries 13(2):121-138.

Hanson, M.B., and C.K. Emmons. 2010. Annual residency patterns of southern resident killer whales in the inland waters of Washington and British Columbia. Revised draft. October 30.

Hanson, M.B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayers, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva, and M.J. Ford. 2010. Species and stock identification of prey selected by endangered "southern resident" killer whales in their summer range. Endangered Species Research 11:69-82.

Hanson, B., C. Emmons, M. Sears, and K. Ayres. 2010a. Prey selection by southern resident killer whales in inland waters of Washington during the fall and early winter. Unpublished report. Draft. October 30.

Hanson, B., J. Hempelmann-Halos, and D. Van Doornik. 2010b. Species and stock identification of scale/tissue samples from southern resident killer whale predation events collected off the Washington coast during PODs 2009 cruise on the McArthur II. Unpublished memorandum. March 16.

Hanson, M.B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva, and M.J. Ford. 2010c. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research 11:69-82.

Hanson, M.B., C.K. Emmons, E.J. Ward, J.A. Nystuen, and M.O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. J. Acoust. Soc. Am. 134:3486-3495.

Hardell S., H. Tilander, G. Welfinger-Smith, J. Burger, and D.O. Carpenter. 2010. Levels of polychlorinated biphenyls (PCBs) and three organochlorine pesticides in fish from the Aleutian Islands of Alaska. PLoS One 5:e12396.

Hauser, D.D., W. Hauser, M.G. Logsdon, E.E. Holmes, G.R. VanBlaricom, and R.W. Osborne. 2007. Summer distribution patterns of southern resident killer whales *Orcinus orca*: core areas and spatial segregation of social groups. Marine Ecology Progress Series 351:301-310.

Hay, D.E., P.B. McCarter, R. Joy, M. Thompson, and K. West. 2002. Fraser River eulachon biomass assessments and spawning distributions: 1995-2002. PSARC Working Paper P2002-08. 60 p.

Hayward D., J. Wong, and A.J. Krynitsky. 2007. Polybrominated diphenyl ethers and polychlorinated biphenyls in commercially wild caught and farm-raised fish fillets in the United States. Environ. Res. 103:46-54.

Hebdon, J.L., P. Kline, D. Taki, and T.A. Flagg. 2004. Evaluating reintroduction strategies for Redfish Lake sockeye salmon captive brood progeny. American Fisheries Society Symposium 44:401-413.

Herman, D.P., D.G. Burrows, P.R. Wade, C. O. Matkin, R.G. LeDuc, L.G. Barrett-Lennard, and M.M. Krahn. 2005. Feeding ecology of eastern North Pacific killer whales *Orcinus orca* from fatty acid, stable isotope, and organochlorines analyses of blubber biopsies. Marine Ecology Progress Series 302:275-291.

Hicks, D. 2005. Lower Rogue watershed assessment. South Coast Watershed Council. Gold Beach, Oregon. August.

High, B., C.A. Peery, and D.H. Bennett. 2006. Temporary staging of Columbia River summer steelhead in coolwater areas and its effect on migration rates. Transactions of the American Fisheries Society 135:519-528.

Hilborn, R., S.P. Cox, F.M.D. Gulland, D.G. Hankin, N.T. Hobbs, D.E. Schindler, and A.W. Trites. 2012. The effects of salmon fisheries on southern resident killer whales: final report of the independent science panel. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for National Marine Fisheries Service (Seattle) and Fisheries and Oceans Canada (Vancouver). 61 p. plus appendices.

Hinck, J. E., C.J. Schmitt, T.M. Bartish, N.D. Denslow, V.S. Blazer, P.J. Anderson, J.J. Coyle, G.M. Dethloff, and D.E. Tillitt. 2004. Biomonitoring of Environmental Status and Trends (BEST) Program: environmental contaminants and their effects on fish in the Columbia River basin. Scientific Investigations Report 2004-5154. U.S. Department of the Interior, U.S. Geological Survey, Columbia Environmental Research Center. Columbia, Missouri.

Hites, R.A., J.A. Foran, D.O. Carpenter, M.C. Hamilton, B.A. Knuth, and S.J. Schwager. 2004a. Global assessment of organic contaminants in farmed salmon. Science 303:226-229.

Hites, R.A., J.A. Foran, S.J. Schwager, B.A. Knuth, M.C. Hamilton, and D.O. Carpenter. 2004b. Global assessment of polybrominated diphenyl ethers in farmed and wild salmon. Environmental Science and Technology 38:4545-4949.

Hochachka, W.M. 2006. Unequal lifetime reproductive success and its implication for small isolated populations. P. 155-173 in J.N.M. Smith, A.B. Marr, L.F. Keller and P. Arcese (editors). Biology of small populations: the song sparrows of Mandarte island. Oxford University Press, Oxford, U.K.

Holt, M.M., D.P. Noren, and C.K. Emmons. 2011. Effects of noise levels and call types on the source levels of killer whale calls. J. Acoust. Soc. Am. 130:3100-3106.

Holt, M.M. 2008. Sound exposure and southern resident killer whales (*Orcinus orca*): a review of current knowledge and data gaps. NOAA Technical Memorandum NMFS-NWFSC-89, U.S. Department of Commerce, Seattle.

Hollender, B.A. 1981. Embryo survival, substrate composition and dissolved oxygen in redds of wild brook trout. University of Wisconsin, Stevens Point. 87 p.

Howell, M.D., M.D. Romano, and T.A. Rien. 2001. Draft. Outmigration timing and distribution of larval eulachon, *Thaleichthys pacificus*, in the lower Columbia River, spring 2001. Washington Department of Fish and Wildlife, Vancouver, and Oregon Department of Fish and Wildlife, Clackamas.

IC-TRT (Interior Columbia Technical Recovery Team). 2003. Independent populations of Chinook, steelhead, and sockeye for evolutionarily significant units within the Interior Columbia River domain. Working draft. July.

IC-TRT. 2007. Viability criteria for application to Interior Columbia Basin salmonid ESUs. Review draft. Interior Columbia Technical Recovery Team, Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle.

Idaho Department of Environmental Quality. 2011. Idaho Department of Environmental Quality final 2010 integrated report. Boise, Idaho.

ISAB (Independent Scientific Advisory Board) (editor). 2007. Climate change impacts on Columbia River Basin fish and wildlife. In: climate change report, ISAB 2007-2. Independent Scientific Advisory Board, Northwest Power and Conservation Council. Portland, Oregon.

Jackson, J. and Y.W. Cheng. 2001. Improving parameter estimation for daily egg production method of stock assessment of pink snapper in Shark Bay, Western Australia. Journal of Agricultural, Biological and Environmental Statistics 6:243-257.

James, B.W., O.P. Langness, P.E. Dionne, C.W. Wagemann and B.J. Cady. 2014. Columbia River eulachon spawning stock biomass estimation. Report A, In: C. Mallette (editor). Studies of eulachon smelt in Oregon and Washington. Prepared for the National Oceanic and Atmospheric Administration, Washington, DC, by the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife. Grant no.: NA10NMF4720038.

Jay, D. A., J. Pan, P. M. Orton, and A. R. Horner-Devine. Asymmetry of Columbia River tidal plume fronts in an eastern boundary current regime. Journal of Marine Systems 78(3):442-459.

Jepson, M.A., M.A. Keefer, T.S. Clabough, and C.C. Caudill. 2013. Migratory behavior, run timing, and distribution of radio-tagged adult winter steelhead, summer steelhead, and spring Chinook salmon in the Willamette River − 2012. Technical report 2013-1 for the U.S. Army Corps of Engineers, Portland, Oregon.

Joint Columbia River Management Staff. 2009. 2010 joint staff report concerning stock status and fisheries for sturgeon and smelt. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife.

Keefer, M.L., C.A. Peery, and M.J. Heinrich. 2008. Temperature mediated en route migration mortality and travel rates of endangered Snake River sockeye salmon. Ecol. Freshwat. Fish 17(1):136-145.

Keefer, M.L., C.A. Peery, and B. High. 2009. Behavioral thermoregulation and associated mortality trade-offs in migrating adult steelhead (*Oncorhynchus mykiss*): variability among sympatric populations. Can. J. Fish. Aquat. Sci. 66:1734-1747.

Keefer, M. L., G.A. Taylor, D.F. Garletts, G.A. Gauthier, T.M. Pierce, and C.C. Caudill. 2010. Prespawn mortality in adult spring Chinook salmon outplanted above barrier dams. Ecology of Freshwater Fish 19:361-372.

Kelly B.C., S.L. Gray, M.G. Ikonomou, J.S. MacDonald, S.M. Bandiera, and E.G. Hrycay. 2007. Lipid reserve dynamics and magnification of persistent organic pollutants in spawning sockeye salmon (*Oncorhynchus nerka*) from the Fraser River, British Columbia. Environ. Sci. Technol. 41:3083-3089.

Langer, O.E., B.G. Shepherd, and P.R. Vroom. 1977. Biology of the Nass River eulachon (*Thaleichthys pacificus*). Department of Fisheries and Environment Canada, Fisheries and Marine Service, Technical Report Series no. PAC/T-77-10.

Lawson, P.W., E.P. Bjorkstedt, M.W. Chilcote, C.W. Huntington, J.S. Mills, K.M. Moores, T.E. Nickelson, G.H. Reeves, H.A. Stout, T.C. Wainwright, and L.A. Weitkamp. 2007. Identification of historical populations of coho salmon (*Onchorynchus kisutch*) in the Oregon Coast evolutionarily significant unit. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-79. 129 p.

Levin, P.S., and J.G. Williams. 2002. Interspecific effects of artificially propagated fish: an additional conservation risk for salmon. Conservation Biology 16:1581-1587.

Lister, D.B., L.M. Thorson, and I. Wallace. 1981. Chinook and coho salmon escapements and coded-wire tag returns to the Cowichan-Koksilah river system, 1976-1979. Can. Manuscript Rep. Fish. Aquat. Sci. 1608. 168 p.

Lower Columbia Fish Recovery Board. 2010. Washington lower Columbia salmon recovery & fish and wildlife subbasin plan. Olympia, Washington. May 28.

Lower Columbia River Estuary Partnership. 2007. Lower Columbia River and estuary ecosystem monitoring: water quality and salmon sampling report. Portland, Oregon.

Maguire, M. 2001. Chetco River watershed assessment. South Coast Watershed Council. Gold Beach, Oregon.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069-1079.

Maret, T.R., T.A. Burton, G.W. Harvey, and W.H. Clark. 1993. Field testing of new monitoring protocols to assess brown trout spawning habitat in an Idaho stream. North American Joundal of Fisheries Management 13:567-580.

Marine, K.R. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult Chinook salmon (*Oncorhynchus tshawytscha*), with suggestions for approaches to the assessment of temperature induced reproductive impairment of chinook salmon stocks in the American River, California. University of California, Davis. 30 p. plus appendices.

Marine, K.R. and J.J. Cech, Jr. 2004. Effects of High water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River chinook salmon. North American Journal of Fisheries Management 24:198-210.

Mason, J.C. 1969. Hypoxial stress prior to emergence and competition among coho salmon fry. J. Fish. Res. Bd. Canada 26:63-91.

Materna, E. 2001. Issue paper 4: temperature interaction. Prepared as part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. EPA-910–D-01-004. U.S. Environmental Protection Agency, Region 10, Seattle. 33 p.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the ‘Exxon Valdez’ oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series 356:269-281.

Mayfield, R.B. and J.J. Cech. 2004. Temperature effects on green sturgeon bioenergetics. Transactions of the American Fisheries Society 133:961-970.

McCarter, P.B., and D.E. Hay. 1999. Distribution of spawning eulachon stocks in the central coast of British Columbia as indicated by larval surveys. Canadian Stock Assessment Secretariat research document 99/177. Fisheries and Oceans Canada, Ottawa.

McCarter, P.B., and D.Hay. 2003. Eulachon embryonic egg and larval outdrift sampling manual for ocean and river surveys. Can. Tech. Rep. Fish. Aquat. Sci. 2451.

McClure, M., T. Cooney, and Interior Columbia Technical Recovery Team. 2005. Updated population delineation in the interior Columbia Basin. Memorandum to NMFS NW Regional Office, co-managers and other interested parties. May 11.

McComas, R.L., G.A. Michael, L. Gilbreath, T.J. Carlson, S.G. Smith, and J.W. Feguson. 2008. Estimates of post-FCRPS juvenile salmonid survival through the lower Columbia River estuary using JSATS acoustic tags, 2005-2007. PowerPoint presentation to the Regional Forum Implementation Team. March 6.

McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle. 279 p.

McCullough, D.A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue paper 5: summary of technical literature examining the physiological effects of temperature on salmonids. Prepared as part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. EPA-910-D-01-005. U.S. Environmental Protection Agency, Region 10, Seattle. 114 p.

McCullough, D.A. Are coldwater fish populations of the United States actually being protected by temperature standards? Freshwater Reviews 3(2):147-199.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-42. 156 p.

McElhany, P., C. Busack, M. Chilcote, S. Kolmes, B. McIntosh, J. Myers, D. Rawding, A. Steel, C. Steward, D. Ward, T. Whitesel, and C. Willis. 2006. Revised viability criteria for salmon and steelhead in the Willamette and Lower Columbia basins. Review draft. Willamette/Lower Columbia Technical Recovery Team and Oregon Department of Fish and Wildlife. 178 p.

McElhany P, Chilcote M, Myers J, Beamesderfer R. 2007. Viability status of Oregon salmon and steelhead populations in the Willamette and Lower Columbia basins Part 3: Columbia River chum. Report prepared for the Oregon Department of Fish and Wildlife and National Marine fisheries Service.

Mearns, A. J., M. B. Matta, D. Simecek-Beatty, M. F. Buchman, G. Shigenaka, and W. A. Wert. 1988. PCB and chlorinated pesticide contamination in U.S. fish and shellfish: a historical assessment report. NOAA Technical Memorandum NOS OMA 39. Seattle.

Melbourne, B. A., and A. Hastings. 2008. Extinction risk depends strongly on factors contributing to stochasticity. Nature 454:100-103.

Missildine, B. R., R. J. Peters, G. Chin-Leo, and D. Houck. 2005. Polychlorinated biphenyl concentrations in adult Chinook salmon (*Oncorhynchus tshawytscha*) returning to coastal and Puget Sound hatcheries of Washington State. Environmental Science and Technology 39(18):6944-6951.

Mongillo, T.M., G.M. Ylitalo, L.D. Rhodes, S.M. O'Neill, D.P. Noren, and M.B. Hanson. In prep. Exposed to a mixture of toxic chemicals: implications to the health of the endangered southern resident killer whale. NOAA Technical Memorandum.

Montory M., E. Habit, P. Fernandez, J. O. Grimalt, and R. Barra. 2010. PCBs and PBDEs in wild Chinook salmon (*Oncorhynchus tshawytscha*) in the Northern Patagonia, Chile. Chemos. 78:1193-1199.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Muir, W.D., and J.G. Williams. 2012. Improving connectivity between freshwater and marine environments for salmon migrating through the lower Snake and Columbia River hydropower system. Ecological Engineering 48:19-24.

Myers, J.M., C. Busack, D. Rawding, A.R. Marshall, D.J. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-73. 311 p.

Naish, K.A., J.E. Taylor III, P.S. Levin, T.P. Quinn, J.R. Winton, D. Huppert, and R. Hilborn. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology 53:61-194.

Nakamoto, R.J., T.T. Kisanuki, and G.H. Goldsmith. 1995. Age and growth of Klamath River green sturgeon (*Acipenser medirostris*). Project # 93-FP-13. U.S. Fish and Wildlife Service. 20 p.

Naughton, G.P., C.C. Caudill, T.S.labough, M.L. Keefer, M.J. Knoff, and M.A. Jepson. 2012. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: relationships among fate, fish condition, and environmental factors, 2011. Technical Report 2012-2. University of Idaho, Moscow.

Naughton, G.P., C.C. Caudill, T.S. Clabough, M.L. Keefer, M.J. Knoff, and M.A. Jepson. 2013. Migration behavior and spawning success of spring Chinook salmon in Fall Creek and the North Fork Middle Fork Willamette River: relationships among fate, fish condition, and environmental factors, 2012.

Nickelson, T. E., M F. Solazzi, and S. L. Johnson. 1986. Use of hatchery coho salmon (*Oncorhynchus kisutch*) presmolts to rebuild wild populations in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 43:2443-2449.

NMFS (National Marine Fisheries Service). Undated. Green sturgeon recovery plan. Appendix J, green sturgeon growth analysis. Draft. National Marine Fisheries Service, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 1999. Biological and conference opinion, approval of Oregon water quality standards for dissolved oxygen, temperature, and pH. National Marine Fisheries Service, Northwest Region, Seattle. July 7.

NMFS (National Marine Fisheries Service). 2006. Endangered Species Act section 7 consultation biological opinion on the issuance of section 10(a)(1)(A) ESA permits to conduct scientific research on the southern resident killer whale (*Orcinus orca*) distinct population segment and other endangered and threatened species. National Marine Fisheries Service, Northwest Region, Seattle. March 9.

NMFS (National Marine Fisheries Service). 2008a. Recovery plan for southern resident killer whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Regional Office. Seattle.

NMFS (National Marine Fisheries Service). 2008b. Supplemental comprehensive analysis of the Federal Columbia River Power System and mainstem effects of USBR Upper Snake and other tributary actions. National Marine Fisheries Service, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008c. Endangered Species Act – section 7 consultation final biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Consultation on the implementation of the National Flood Insurance program in the state of Washington phase one document – Puget Sound region. National Marine Fisheries Service, Northwest Region. Seattle. September 22.

NMFS (National Marine Fisheries Service). 2008d. Endangered Species Act – section 7 consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Consultation on the Willamette River basin flood control project. National Marine Fisheries Service, Northwest Region. Seattle. July 11.

NMFS (National Marine Fisheries Service). 2008e. Endangered Species Act – section 7 consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Consultation on the approval of revised regimes under the Pacific Salmon Treaty and the deferral of management to Alaska of certain fisheries included in those regimes. National Marine Fisheries Service, Northwest Region. Seattle. December 22.

NMFS (National Marine Fisheries Service). 2008f. Endangered Species Act – section 7 consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Consultation on treaty Indian and non-Indian fisheries in the Columbia River basin subject to the 2008-2017 US v. Oregon Management Agreement. National Marine Fisheries Service, Northwest Region. Seattle. May 5.

NMFS (National Marine Fisheries Service). 2008g. Endangered Species Act – section 7 consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Consultation on remand for operation of the Columbia River Power System and 19 Bureau of Reclamation projects in the Columbia basin. National Marine Fisheries Service, Portland, Oregon. May 5.

NMFS (National Marine Fisheries Service). 2008h. Endangered Species Act - section 7 consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation.Consultation on the Willamette River Basin Flood Control Project. National Marine Fisheries Service, Northwest Region, Seattle. July 11.

NMFS (National Marine Fisheries Service). 2008i. Endangered Species Act – section 7 consultation biological opinion. Proposal to issue permit No. 10045 to Samuel Wasser for studies of southern resident killer whales, pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973. National Marine Fisheries Service, Northwest Region. Seattle. July 8.

NMFS (National Marine Fisheries Service). 2009a. Middle Columbia River steelhead distinct population segment ESA recovery plan. National Marine Fisheries Service, Northwest Region. Seattle.

NMFS (National Marine Fisheries Service). 2009b. Endangered Species Act – section 7 consultation biological opinion. Biological opinion on the effects of the Pacific coast salmon plan on the southern resident killer whale (*Orcinus orca*) distinct population segment. National Marine Fisheries Service, Northwest Region. Seattle. May 5

NMFS (National Marine Fisheries Service). 2010. Federal recovery outline, North American green sturgeon southern distinct population segment. National Marine Fisheries Service, Southwest Region. Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2011a. 5-year review: summary and evaluation of Lower Columbia River Chinook, Columbia River chum, Lower Columbia River coho, and Lower Columbia River steelhead. National Marine Fisheries Service, Northwest Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2011b. Draft recovery plan for Idaho Snake River spring/summer Chinook and steelhead populations in the Snake River spring/summer Chinook salmon evolutionarily significant unit and Snake River steelhead distinct population segment. National Marine Fisheries Service. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2011c. 2011 Report to Congress: Pacific Coastal Salmon Recovery Fund FY 2000 – 2010. National Marine Fisheries Service, Northwest Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2011d. Southern resident killer whales (*Orcinus orca*) 5-year review: summary and evaluation. National Marine Fisheries Service, Northwest Region. Seattle. January.

NMFS (National Marine Fisheries Service). 2011e. Columbia River estuary ESA recovery plan module for salmon and steelhead. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). National Marine Fisheries Service, Northwest Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2011f. Evaluation of and recommended determination on a resource management plan (RMP), pursuant to the salmon and steelhead 4(d) rule − comprehensive management plan for Puget Sound Chinook: harvest management component. May 27.

NMFS (National Marine Fisheries Service). 2011g. 5-year review: summary and evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River Basin steelhead. National Marine Fisheries Service, Northwest Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2012a. Designation of critical habitat for Lower Columbia River coho salmon and Puget Sound steelhead, Draft biological report. National Marine Fisheries Service, Protected Resources Division. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2012b. Jeopardy and adverse modification of critical habitat biological opinion for the Environmental Protection Agency's proposed approval of certain Oregon administrative rules related to revised water quality criteria for toxic pollutants. National Marine Fisheries Service, Northwest Region. Seattle. August 14.

NMFS (National Marine Fisheries Service). 2012c. Characterizing the population size, structure, foraging ecology, and movement patterns of southern resident killer whales and congener ecotypes in the eastern north Pacific Ocean. Center for Whale Research. File No. 15569. June 5.

NMFS (National Marine Fisheries Service). 2012d. Draft recovery plan for Oregon spring/summer Chinook salmon and steelhead populations. NMFS, West Coast Region. Portland, Oregon. March.

NMFS (National Marine Fisheries Service). 2013a. ESA recovery plan for lower Columbia River coho salmon, lower Columbia River Chinook salmon, Columbia River chum salmon, and Lower Columbia River steelhead. National Marine Fisheries Service, Northwest Region. Seattle.

NMFS (National Marine Fisheries Service). 2013b. Federal recovery outline, Pacific eulachon southern distinct population segment. National Marine Fisheries Service, Northwest Region. Seattle.

NMFS (National Marine Fisheries Service). 2013c. Partitioning multiple pressures impacting southern resident killer whales. Renewal. Wasser, S. File No. 17344. March 19.

NMFS (National Marine Fisheries Service). 2014. Final recovery plan for southern Oregon/Northern California coast coho salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, California.

NMFS (National Marine Fisheries Service). 2015a. ESA recovery plan for Snake River sockeye salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2015b. Proposed ESA recovery plan for Oregon Coast coho salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service, West Coast Region. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2015c. Green sturgeon recovery plan (draft), Appendix J, green sturgeon growth analysis. National Marine Fisheries Service, West Coast Region. Santa Rosa, California.

NOAA Fisheries. 2005. Assessment of NOAA Fisheries' critical habitat analytical review teams for 12 evolutionarily significant units of West Coast salmon and steelhead. National Marine Fisheries Service, Protected Resources Division. Portland, Oregon.

NOAA (National Oceanic and Atmospheric Administration) Fisheries Service. 2011. Biennial report to Congress on the recovery program for threatened and endangered species October 1, 2008 – September 30, 2010. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Washington, D.C.

Noren D. P., L. Rea, and T. Loughlin. 2009. A model to predict fasting capacities and utilization of body energy stores in weaned Steller sea lions (*Eumetopias jubatus*) during periods of reduced prey availability. Canadian Journal of Zoology 87:852-864.

Norman, S.A., C.E. Bowlby, M.S. Brancato, J. Calambokidis, and 15 others. 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management 6:87-99.

NWPPC (Northwest Power Planning Council). 1986. Compilation of information on salmon and steelhead losses in the Columbia River basin. Report to the Northwest Power Planning Council, Portland, Oregon.

DEQ (Oregon Department of Environmental Quality). 1996. Methodologies and quality assurance procedures for collecting dissolved oxygen concentration data in surface water. Guidance document. Prepared by Laboratory Division, Oregon Department of Environmental Quality, Portland.

DEQ. 2003a. Table 101B, beneficial use designations − fish uses, mainstem Columbia River. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/futables/table101b.pdf (accessed September 24, 2014).

DEQ. 2003b. Figure 286B, salmon and steelhead spawning use designations, Sandy basin, Oregon. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/fufigures/figure286b.pdf (accessed September 30, 2014).

DEQ 2003c. Figure 286A, fish use designations, Sandy basin, Oregon. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/fufigures/figure286a.pdf (accessed September 30, 2014).

DEQ. 2003d. Figure 220B, salmon and steelhead spawning use designations, mid coast basin, Oregon. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/fufigures/figure220b.pdf (accessed September 30, 2014).

DEQ. 2003e. Figure 220A, fish use designations, mid coast basin, Oregon. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/fufigures/figure220a.pdf (accessed September 30, 2014).

DEQ. 2003f. Figure 320A, fish use designations, Umpqua basin, Oregon. Oregon Department of Environmental Quality, Portland. Available at: http://www.deq.state.or.us/wq/rules/div041/fufigures/figure320a.pdf (accessed September 30, 2014).

DEQ. 2005. Part 4(B) final report. Oregon Plan for Salmon and Watersheds, Oregon coastal coho assessment water quality report. Oregon Department of Environmental Quality, Portland.

DEQ. 2006. Chapter 3 Umpqua basin stream temperature TMDL. Oregon Department of Environmental Quality, Portland.

DEQ. 2008. Rogue River basin TMDL. Chapter 2: temperature. Oregon Department of Environmental Quality, Portland.

DEQ. 2010. John Day River basin TMDL
Appendix A: temperature model calibration report. Oregon Department of Environmental Quality, Portland.

DEQ. 2005. Part 4(B) Final report. Oregon Plan for Salmon and Watersheds Oregon coastal coho assessment water quality report. Oregon Department of Environmental Quality, Portland.

ODFW (Oregon Department of Fish and Wildlife). 2002. 1:24K Fish habitat distribution development project procedures manual. Oregon Department of Fish and Wildlife, Salem. Available at https://nrimp.dfw.state.or.us/nrimp/24k/docs/complete_manual.pdf (accessed November 23, 2014).

ODFW. 2003. Timing tables. Oregon Department of Fish and Wildlife, Salem. Available at https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=timingtables (accessed August 6, 2014).

ODFW. 2010. Lower Columbia River conservation and recovery plan for Oregon populations of salmon and steelhead. Oregon Department of Fish and Wildlife, Salem.

ODFW and NMFS. 2011. Upper Willamette River conservation and recovery plan for Chinook salmon and steelhead. Oregon Department of Fish and Wildlife and National Marine Fisheries Service, Northwest Region. Seattle.

ODFW and WDFW (Washington Department of Fish and Wildlife). 2015. Oregon and Washington Departments of Fish and Wildlife joint staff report - winter fact sheet no. 2a. Columbia River Compact/Joint State Hearing. January 28.

O'Hara, T. M., P. F. Hoekstra, C. Hanns, S. M. Backus, and D. C. G. Muir. 2005. Concentrations of selected persistent organochlorines contaminants in store-bought foods from northern Alaska. International Journal of Circumpolar Health 64(4):303-313.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Reports of the International Whaling Commission 12:209-243.

Olesiuk, P. F., G. M. Ellis, and J. K. Ford. 2005. Life history and population dynamics of northern resident killer whales (*Orcinus orca*) in British Columbia. Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document 2005/045.

O'Neill, S. M., J. E. West, and J. C. Hoeman. 1998. Spatial trends in the concentration of polychlorinated biphenyls (PCBs) in Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in Puget Sound and factors affecting PCB accumulation: results from the Puget Sound Ambient Monitoring Program. P. 312-328 in: Puget Sound Research 1998 Proceedings. Puget Sound Water Quality Action Team. Seattle.

O'Neill, S.M., G.M. Ylitalo, J.E. West., J. Bolton, C.A. Sloan, and M.M. Krahn. 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (*Oncorhynchus spp*.) and their contributions to contaminant levels in northern and southern resident killer whales (*Orcinus orca*). Presentation at 2006 Southern Resident Killer Whale Symposium. Seattle.

O'Neill, S. M., and J. E. West. 2009. Marine distribution, life history traits, and the accumulation of polychlorinated biphenyls in Chinook salmon from Puget Sound, Washington. Transactions of the American Fisheries Society 138:616-632.

Osborne, R. W. 1999. A historical ecology of Salish Sea "resident" killer whales (*Orcinus orca*): with implications for management. Doctoral dissertation. University of Victoria, Victoria, British Columbia.

Parente, W.D, and W.J. Ambrogetti. 1970. Survival of eulachon eggs (*Thaleichthys pacificus*) at different water temperatures. Prepublication copy, not for citation; for review by Technical Advisory Committee, Columbia River Thermal Effects Study. Bureau of Commercial Fisheries, Biological Laboratory, Seattle.

Parker, K. 1985. Biomass model for the egg production method. P. 5-6 in: R. Lasker (editor). An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. U.S. Department of Commerce, NOAA Technical Report 36. Washington, D.C:

PFMC (Pacific Fisheries Management Council). 2010. Preseason report III – Analysis of council adopted management measures for 2010 ocean salmon fisheries. Pacific Fishery Management Council. Portland, Oregon. April.

PFMC (Pacific Fisheries Management Council). 2011. Review of 2010 ocean salmon fisheries. Pacific Fishery Management Council. Portland, Oregon. February.

Phillips, R.W. and H.J. Campbell. 1962. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. P. 60-73 in: 14th Annual Report. Pacific Marine Fisheries Commission. Portland, Oregon. 108 p.

PNERC (Pacific Northwest Ecosystem Research Consortium). 2002. Willamette River basin planning atlas: trajectories of environmental and ecological change. Institute for a Sustainable Environment, University of Oregon, Eugene.

Poirier, J. M., T.A. Whitesel, and J.R. Johnson. 2012. Chum salmon spawning activity in tributaries below Bonneville Dam: the relationship with tailwater elevation and seasonal precipitation. River Research and Applications 28(7):882-892.

Poole, G.C., and C.H. Berman. 2001. An ecological perspective on instream temperature: Natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27:787-802.

Poole, G., J. Dunham, M. Hicks, D. Keenan, J. Lockwood, E. Materna, D. McCullough, C. Mebane, J. Risley, S. Sally Sauter, S. Spalding, and D. Sturdevant. 2001a. Technical synthesis − scientific issues relating to temperature criteria for salmon, trout, and char native to the Pacific Northwest. A summary report submitted to the Policy Workgroup of the EPA Region 10 Water Temperature Criteria Guidance Project. EPA 910-R-01-007. U.S. Environmental Protection Agency, Region 10, Seattle. 24 p.

Poole, G., J. Risley, and M. Hicks. 2001b. Issue paper 3: spatial and temporal patterns of stream temperature (revised). EPA-910-D-01-003. U.S. Environmental Protection Agency, Region 10, Seattle. 31 p.

Poole, G.C., J.B. Dunham, U.M. Keenan, S.T. Sauter, D.A. McCullough, C. Mebane, J.C. Lockwood, D.A. Essig, M.P. Hicks, D.J. Sturdevant, E.J. Materna, S.A. Spalding, J. Risley, and M. Deppman. 2004. The case for regime-based water quality standards. Bioscience 54:155-161.

Quigley, T.M. and S.J. Arbelbide (tech. eds.). 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: volume 3. Gen. Tech. Rep. PNW-GTR-405. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society and University of Washington, Seattle.

Quinn, T.P., S. Hodgson, and C. Peven. 2007. Temperature, flow, and the migration of adult sockeye salmon (*Oncorhynchus nerka*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 54:1349-1360.

Reeves, G. H., F. H. Everest, and J. D. Hall. 1987. Interactions between the redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdneri*) in western Oregon: the influence of water temperature. Canadian Journal of Fisheries and Aquatic Sciences 44:1603-1613.

Reeves, G. H., L. E. Benda, K. M. Burnett, P. A. Bisson, and J. R. Sedell. 1995. A disturbance-based approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349.

Rice, S., and A. Moles. 2006. Assessing the potential for remote delivery of persistent organic pollutants to the Kenai River in Alaska. Alaska Fishery Research Bulletin 12(1):153-157.

Richter A., and S.A Kolmes. 2005. Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science 13:23-49.

Rogue Basin Coordinating Council. 2006. Watershed health factors assessment: Rogue River basin. Rogue Basin Coordinating Council. Talent, Oregon. March 31.

Rombaugh, P.J. 1986. Mathematical model for predicting the DO requirements of steelhead (Salmo gairdneri) embryos and alevins in hatchery incubators. Aquaculture 59:119-137.

Rounds, S.A. 2007. Temperature effects of point sources, riparian shading, and dam operations on the Willamette River, Oregon. U.S. Geological Survey Scientific Investigations Report 2007-5185. 34 p.

Saulitis, E., C. Matkin, L. Barrett-Lennard, K. Heise, and G. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) population in Prince William Sounds, Alaska. Marine Mammal Science 16(1):94-109.

Scheuerell, M.D., and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14:448-457.

Scheffer, V. B., and J. W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. American Midland Naturalist 39:257-337.

Schreck, C. B., J. C. Snelling, R. E. Ewing, C. S Bradford, L. E. Davis, and C. H. Slater. 1994. Migratory behavior of adult spring Chinook salmon in the Willamette River and its tributaries. Oregon Cooperative Fish and Wildlife Research Unit for Bonneville Power Administration, Division of Fish and Wildlife. Report DOE/BP-92818-4. Portland, Oregon.

Schroeder, R.K., K.R. Kenaston and L.K. McLaughlin. 2007. Spring Chinook salmon in the Willamette and Sandy Rivers. Annual progress report, 2006-2007, F-163-R-11/12. Oregon Department of Fish and Wildlife, Salem.

Schultz, T., W. Wilson, J. Ruzycki, R. Carmichael, J. Schricker, and D. Bondurant. 2006. Escapement and productivity of spring Chinook and summer steelhead in the John Day River basin, 2003-2004 annual report. Project no. 199801600. BPA report DOE/BP-00005840-4.

Sedell, J.R., and J.L. Froggatt. 1984. Importance of streamside forests to large rivers: the isolation of the Willamette River, Oregon, USA from its floodplain by snagging and streamside forest removal. Internationale Vereinigung für Theoretische und angewandte Limnologie Verhandlungen 22:1828-1834.

Sharr, S., C. Melcher, T. Nickelson, P. Lawson, R. Kope, and J. Coon. 2000. 2000 review of amendment 13 to the Pacific Coast salmon plan. OCN workgroup report. Pacific Fisheries Management Council. Portland, Oregon. Exhibit B.3.b.

Shaw, S. D., D. Brenner, M. L. Berger, D. O. Carpenter, C-S. Hong, and K. Kannan. 2006. PCBs, PCDD/Fs, and organochlorine pesticides in farmed Atlantic salmon from Maine, eastern Canada and Norway, and wild salmon from Alaska. Environmental Science and Technology 40:5347–5354.

Shaw, S., M. L. Berger, D. Brenner, D. O. Carpenter, L. Tao, C-S. Hong, and K. Kannan. 2008. Polybrominated diphenyl ethers (PBDEs) in farmed and wild salmon marketed in the northeastern United States. Chemosphere 71:1422-1431.

Sherwood, C.R., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simenstad. 1990. Historical changes in the Columbia River estuary. Progress in Oceanography 25(1-4):299-352.

Silver, S.J., C.E. Warren, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at different water velocities. Transactions of the American Fisheries Society 92(4):327-343.

Skaugsett, A.E. 1980. Fine organic debris and dissolved oxygen in streambed gravels in the Oregon Coast Range. M.S. thesis. Forest Engineering Department, Oregon State Univ., Corvallis. 77 p.

Smith, W.E., and R.W. Saalfeld. 1955. Studies on Columbia River smelt, *Thaleichthys pacificus* (Richardson). Fisheries Research Papers. Washington Dept. Fisheries 1(3)3-26.

Snyder, G. R., and T. H. Blahm. 1971. Effects of increased temperature on cold-water organisms. Journal of the Water Pollution Control Federation 43(5):890-899.

Sowden, T.K. and G. Power. 1985. Prediction of rainbow trout embryo survival in relation to groundwater seepage and particle size of spawning substrates. Transactions of the American Fisheries Society 114:804-812.

Spence, B.C. 1995. Variation in timing of fry emergence and smolt migration of coho salmon (*Oncorhynchus kisutch*). PhD. Thesis. Oregon State University, Corvallis.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc. Corvallis, Oregon. National Marine Fisheries Service, Portland, Oregon.

Stanford, J. A., F. R. Hauer, S. V. Gregory, and E. B. Synder. 2005. Columbia River basin. P. 591-653 in A. C. Benke and C. E. Cushing (editors). Rivers of North America. Elsevier Academic Press, Burlington, Massachusetts.

Stansby, M.E. 1976. Chemical characteristics of fish caught in the northeast Pacific Ocean. Marine Fisheries Review 38:1-11.

State of Oregon. 2005. Oregon coastal coho assessment. Part 1: synthesis of the coastal coho ESU assessment. Salem, Oregon.

State of Oregon and United States Environmental Protection Agency. 2010. National pollutant discharge elimination system memorandum of agreement between the State of Oregon and United States Environmental Protection Agency Region 10. 36 p. Available United States Environmental Protection Agency, Region 10, Seattle.

Stone, D. 2006. Polybrominated diphenyl ethers and polychlorinated biphenyls in different tissue types from Chinook salmon (*Oncorhynchus tshawytscha*). Bulletin of Environmental Contamination and Toxicology 76:148-154.

Storch, A.J., E.S. Van Dyke, O.P. Langness, P.E. Dionne, C.W. Wagemann, and B.J. Cady. 2014. Freshwater distribution of eulachon in Oregon and Washington. Report B, In: C. Mallette (editor). Studies of eulachon smelt in Oregon and Washington. Prepared for the National Oceanic and Atmospheric Administration, Washington, D.C., by the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife. Grant No.: NA10NMF4720038.

Stout, H.A., P.W. Lawson, D.L. Bottom, T.D. Cooney, M.J. Ford, C.E. Jordan, R.J. Kope, L.M. Kruzic, G.R. Pess, G.H. Reeves, M.D. Scheuerell, T.C. Wainwright, R.S. Waples, E. Ward, L.A. Weitkamp, J.G. Williams, and T.H. Williams. 2012. Scientific conclusions of the status review for Oregon Coast coho salmon (*Oncorhynchus kisutch*). U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-118. 242 p.

Tang, J., M.D. Bryant, and E.L. Brannon. 1987. Effect of temperature extremes on the mortality and development rates of coho salmon embryos and alevins. Prog. Fish-Cult. 49(3):167-174.

Trites, A. W., and C. P. Donnelly. 2003. The decline of Steller sea lions *Eumetopias jubatus* in Alaska: a review of the nutritional stress hypothesis. Mammal Review 33(1):3-28.

Turnpenny, A.W.H. and R. Williams. 1980. Effects of sedimentation on the gravels of an industrial river system. J. Fish. Biol. 17:681-693.

Upper Columbia Salmon Recovery Board. 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. Upper Columbia Salmon Recovery Board. Wenatchee, Washington.

USDC (United States Department of Commerce). 2009. Endangered and threatened wildlife and plants: final rulemaking to designate critical habitat for the threatened southern distinct population segment of North American green sturgeon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 74(195):52300-52351.

USDC. 2010. Endangered and threatened wildlife and plants, final rulemaking to establish take prohibitions for the threatened southern distinct population segment of North American green sturgeon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 75(105):30714-30728.

USDC. 2011. Endangered and threatened species: designation of critical habitat for the southern distinct population segment of eulachon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 76(203):65324-65352.

USDC. 2013a. Endangered and threatened species: designation of a nonessential experimental population for Middle Columbia River Steelhead above the Pelton Round Butte Hydroelectric Project in the Deschutes River Basin, OR. Department of Commerce, National Oceanic and Atmospheric Administration. Federal Register 78(10):2893-2907.

USDC. 2013b. Endangered and threatened species: recovery plans. Notice of intent to prepare a recovery plan for Pacific eulachon. Department of Commerce, National Oceanic and Atmospheric Administration. Federal Register 78(128):40104.

USDC. 2013c. Endangered and threatened species; designation of critical habitat for Lower Columbia River coho salmon and Puget Sound steelhead; Proposed rule. U.S Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register 78(9):2726-2796.

USDC. 2014. Endangered and threatened wildlife; final rule to revise the Code of Federal Regulations for species under the jurisdiction of the National Marine Fisheries Service. U.S Department of Commerce. Federal Register 79(71):20802-20817.

USGCRP. 2009. Global climate change impacts in the United States. U.S. Global Change Research Program. Washington, D.C. 188 p.

Vaux, W.G. 1962. Interchange of stream and intragravel water in a salmon spawning riffle. Special Scientific Report – Fisheries No. 405. U.S. Dept. of the Interior, Fish and Wildlife Service. 11 p.

Veldhoen, N., M. G. Ikonomou, C. Dubetz, N. MacPherson, T. Sampson, B. C. Kelly, and C. C. Helbing. 2010. Gene expression profiling and environmental contaminant assessment of migrating Pacific salmon in the Fraser River watershed of British Columbia. Aquatic Toxicology 97(3):212-225.

Wainwright, T.C., M.W. Chilcote, P.W. Lawson, T.E. Nickelson, C.W. Huntington, J.S. Mills, K.M.S. Moore, G.H. Reeves, H.A. Stout, and L.A. Weitkamp. 2008. Biological recovery criteria for the Oregon Coast coho salmon evolutionarily significant unit. U.S. Department of Commerce. Seattle. NOAA Technical Memorandum NMFS-NWFSC-91. 199 p.

Washington Department of Ecology. 2002. Evaluating standards for protecting aquatic life in Washington surface water quality standards, temperature criteria. Draft discussion paper and literature summary. Revised December 2002. Publication Number 00-10-070. Washington Department of Ecology. Olympia.

Ward, E. J., E. E. Holmes, and K. C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology 46:632-640.

Ward, E. 2010. Demographic model selection. Northwest Fisheries Science Center, December. Unpublished report.

Ward, E. J., B. X. Semmens, E. E. Holmes, and K. C. Balcomb. 2011. Effects of multiple levels of social organization on survival and abundance. Conservation Biology 25(2):350-355.

Ward, E.J., M.J. Ford, R.G. Kope, J.K.B. Ford, L.A. Velez-Espino, C.K. Parken, L.W. LaVoy, M.B. Hanson, and K.C. Balcomb. 2013. Estimating the impacts of Chinook salmon abundance and prey removal by ocean fishing on Southern Resident killer whale population dynamics. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-123.

WDOE and WDOH (Washington Department of Ecology and Washington Department of Health) 2006. Washington state polybrominated diphenyl ether (PBDE) chemical action plan: final plan. January 19.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2001. Washington and Oregon eulachon management plan. Olympia, Washington.

Wedemeyer, G. 1973. Some physiological aspects of sublethal heat stress in the juvenile steelhead trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*). J. Fish. Res. Bd. Canada 30:831-834.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. National Marine Fisheries Service, Northwest Fisheries Science Center, Coastal Zone and Estuarine Studies Division, Seattle.

Weitkamp, L. and K. Neely. 2002. Coho salmon (*Oncorhynchus kisutch*) ocean migration patterns: insight from marine coded-wire tag recoveries. Canadian Journal of Fisheries and Aquatic Sciences 59:1100-1115.

Wentz, D.A., B.A. Bonn, K.D. Carpenter, S.R. Hinkle, M.L. Janet, F.A. Rinella, M.A. Uhrich, I.R. Waite, A. Laenen, and K.E. Bencala. 1998. Water quality in the Willamette basin, 1991-1995. U.S. Geological Survey Circular 1161.

West, J., S. O'Neil, G. Lippert, and S. Quinnell. 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington: results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. August, 2001. Washington Department of Fish and Wildlife, Olympia.

Wetzel, R.G. 2001. Limnology: lake and river ecosystems. 3rd Edition. Academic Press, San Diego, CA.

Wiles, G.J. 2004. Washington state status report for the killer whale. Washington Department of Fish and Wildlife, Olympia.

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin, and A. Agrawal. 2006a. Historical population structure of coho salmon in the Southern Oregon/Northern California coasts evolutionarily significant unit. Technical Memorandum NOAA-TM-NMFS-SWFSC-390. 71 p.

Williams, R., D. Lusseau, and P. S. Hammond. 2006b. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation 133:301-11.

Williams, T.H., B.C. Spence, W. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, T.E. Nickelson, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon/Northern California coast evolutionarily significant unit. U.S. Department of Commerce. La Jolla, California. NOAA Technical Memorandum NMFS-SWFSC-432. 96 p.

Williams, T.H., S.T. Lindley, B.C. Spence, and D.A. Boughton. 2011. Status review update for Pacific salmon and steelhead listedListed under the Endangered Species Act: southwest. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division. Santa Cruz, California.

Willson, M. F., R. H. Armstrong, M. C. Hermans, and K Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Rep. 2006-12. U.S. Dept. Commer., AFSC, Auke Bay Laboratory, Juneau.

Wilson, W., T. Schultz, J. Ruzycki, R. Carmichael, J. Haire, and J. Schricker. 2007. Escapement and productivity of spring Chinook and summer steelhead in the John Day River basin, 2004-2005. Technical report, project no. 199801600. BPA report DOE/BP-00020364-1.

Wilson, W., K. DeHart, J. R. Ruzycki, and R. Carmichael. 2011. Productivity of spring Chinook salmon and summer steelhead in the John Day River basin. Annual technical report January 1, 2010–January 31, 2011. BPA project no. 1998-016-00. Contract number 46071.

Wimberly, M.C., T.A. Spies, C.J. Long, and C. Whitlock. 2000. Simulating historical variability in the amount of old forests in the Oregon Coast Range. Conservation Biology 14(1):167-180.

Winship, A. J., and A. W. Trites. 2003. Prey consumption of Steller sea lions (*Eumetopias jubatus*) off Alaska: how much prey do they require? Fishery Bulletin 101(1):147-167.

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reeves, and J.R. Sedell. 1994. Ecological health of river basins in forested regions of eastern Washington and Oregon. General Technical Report PNW-GTR-326, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Woodward, D. F., W. G. Brumbaugh, A. J. DeLonay, E. E. Little, and C. E. Smith. 1994. Effects of rainbow trout fry of a metals-contaminated diet of benthic invertebrates from the Clark Fork River, Montana. Transactions of the American Fisheries Society 123:51-62.

Yearsley, J., D. Karna, S. Peene and B. Watson. 2001. Application of a 1-D heat budget model to the Columbia River system. Final report 901-R-01-001. U.S. Environmental Protection Agency, Region 10, Seattle.

Yearsley, J.R. 2009. A semi-Lagrangian water temperature model for advection-dominated river systems. Water Resources Research 45, W12405, doi:10.1029/2008WR007629.

Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology 20(1):190-200.

Zamon, J. E., T. J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter observations of southern resident killer whales (*Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. Northwest Naturalist 88:193-198.

Appendix A:
October 27, 2015 Letter from Christine Psyk, EPA to Kim Kratz, NMFS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF WATER AND WATERSHEDS

OCT 27 2015

Mr. Kim Kratz
Assistant Regional Administrator
Oregon and Washington Coastal Office
National Marine Fisheries Service
1201 Northeast Lloyd Boulevard, Suite 1100
Portland, Oregon 97232

Dear Mr. Kratz:

Thank you for the opportunity to work with you and your staff on developing reasonable and prudent alternatives (RPAs) and reasonable and prudent measures (RPMs) associated with NMFS's Biological Opinion on Oregon's Temperature Water Quality Standards. We appreciate the collaborative nature of the efforts NMFS has made to complete this Opinion. At this time, we would like to amend the scope of the EPA's action with the inclusion of the following conservation measure to protect eulachon from thermal plumes in Oregon waters:

The EPA will send a letter to Oregon Department of Environmental Quality (ODEQ) within 6 months of the signing of this Opinion regarding thermal discharges permitted under the National Pollutant Discharge Elimination System (NPDES) in the Columbia, Umpqua, and Sandy Rivers and the protection of eulachon. EPA's letter will raise the importance of applying Oregon's mixing zone water quality standards in order to minimize adverse effects on eulachon, including reference to critical timeframes and temperature thresholds for eulachon identified in NMFS' Biological Opinion, and highlighting the importance of technologies to limit mixing zone sizes to the smallest extent practicable, including submerged ports and multi-port diffusers.

In the letter, the EPA will request that the ODEQ issue an administrative order or re-issue the NPDES permit for Dyno-Nobel within two years from the issuance of this Opinion to address the current adverse effects on eulachon from the thermal plume associated with this discharge. Also, for the discharges in the Columbia River below Bonneville Dam and those in the lower 24.2 miles of the Umpqua River that exceed 1 million gallons per day in flow and 20°C in temperature, the EPA will request that ODEQ provide the EPA a copy of all draft NPDES permits, fact sheets and mixing zone analyses for the EPA's review consistent with the NPDES-MOA with ODEQ. The EPA also will recommend that the ODEQ prioritize the NPDES permit for Georgia Pacific Wauna Mill for reissuance.

The EPA will review all of the draft permit documents for the discharges described in the preceding paragraph subject to this conservation measure that are received over the next five years and use its CWA authorities, as necessary, to ensure Oregon's mixing zone water quality standards are applied to minimize adverse effects to eulachon. The EPA will notify NMFS of each draft permit it plans to review by email. The EPA also will provide an annual email status report to NMFS on the implementation of this measure that will include a summary of how each permit issued in the preceding year will minimize adverse effects on eulachon.

The five year timeframe for this conservation measure will provide a record of how to effectively implement the mixing zone provisions to protect eulachon and serve as a basis for ODEQ's future interpretation and implementation of the provisions. The record will also facilitate EPA's continuing oversight of NPDES permitting actions beyond five years, consistent with the EPA's NPDES-MOA with ODEQ.

We understand that the above conservation measure may also be included as a RPM in the final Opinion. We look forward to continuing our conversations with the NMFS staff and management as you finalize the Opinion, and please do not hesitate to contact me or John Palmer of my staff at (206) 553-6521.

Sincerely,

Christine Psyk, Associate Director
Office of Water and Watersheds

cc: Mr. Michael Tehan, NOAA
Mr. Jeffrey Lockwood, NOAA
Ms. Jennifer Wigal, ODEQ
Ms. Debra Sturdevant, ODEQ