https://doi.org/10.25923/7yyb-8d86

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, Oregon 97232-1274

March 13, 2019

Refer to NMFS No: WCR-2018-9616

Mike Linnell
State Director
USDA Wildlife Services
Animal Plant Health Inspection Service
720 O'Leary Street NW
Olympia, WA 98502

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Aquatic Mammal Damage Management program carried out by the Animal and Plant Health Inspection Service, Wildlife Services in Washington State

Dear Mr. Linnell:

Thank you for your letter dated April 30, 2018, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for your Aquatic Mammal Damage Management program, carried out under the authority of the Animal Damage Control Act of March 2, 1931, as amended (7 U.S.C. 426–426c; 46 Stat. 1468) and the Rural Development, Agriculture and Related Agencies Appropriation Act of 1988.

We also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)) (MSA), and concluded that the action would adversely affect the EFH of Pacific Coast salmon. Therefore, we have included the results of that review in Section 3 of this document.

In the biological opinion (opinion), NMFS concludes that the proposed action is not likely to jeopardize the continued existence of ESA-listed Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River (LCR) Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Snake River (SR) spring/summer-run Chinook salmon, SR fall-run Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), Hood Canal summer-run chum salmon, LCR coho salmon (*O. kisutch*), PS steelhead (*O. mykiss*), LCR steelhead, Middle Columbia River (MCR) steelhead, UCR steelhead, or Snake River Basin (SRB) steelhead, or their designated critical habitat. Rationale for our conclusions is provided in the attached opinion. Although Wildlife Services–Washington (WS–Washington) determined the action was also likely to adversely affect UWR spring-run Chinook salmon, Lake Ozette (LO) sockeye salmon (*O. nerka*), SR sockeye salmon, and UWR steelhead, and their critical habitat, we determined that all the effects on these species are either so small in size, or are so extremely unlikely, that they met the threshold for "not likely to adversely affect."

As required by section 7 of the ESA, NMFS provided an incidental take statement (ITS) with the opinion. The ITS describes reasonable and prudent measures (RPMs) NMFS considers necessary or appropriate to minimize incidental take associated with the proposed action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements that the Animal Plant Health Inspection Service, WS–Washington and any person who performs the action must comply to carry out the RPMs. Incidental take from the proposed action that meets these terms and conditions will be exempt from the ESA take prohibition.

Our EFH analysis includes four conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects to EFH. If your response is inconsistent with the EFH conservation recommendation, WS–Washington must explain why, including the justification for any disagreements over the effects of the action and the recommendation. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, we ask that you clearly identify the number of conservation recommendations accepted.

Please contact Jody Walters of the Columbia Basin Branch at (509) 962-8911 ext. 803, jody.walters@noaa.gov, if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Area Office
NOAA Fisheries, West Coast Region

Enclosure

cc: [File]
Chuck Wheeler, NMFS; chuck.wheeler@noaa.gov

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

Animal and Plant Health Inspection Service, Wildlife Services' Aquatic Mammal Damage Management program in Washington

NMFS Consultation Number: WCR-2018-9616

Action Agency: Natural Resources Conservation Service

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	No	No
Puget Sound Chinook salmon	T	Yes	No	No
Upper Willamette River spring-run Chinook salmon	T	No	N/A	N/A
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
Puget Sound steelhead	T	Yes	No	No
Hood Canal summer-run chum salmon	T	Yes	No	No
Snake River sockeye salmon	E	No	N/A	N/A
Lake Ozette sockeye salmon	T	No	N/A	N/A
Lower Columbia River steelhead	T	Yes	No	No
Upper Willamette River steelhead	T	No	N/A	N/A
Middle Columbia River steelhead	T	Yes	No	No
Upper Columbia River steelhead	T	Yes	No	No
Snake River Basin steelhead	T	Yes	No	No

Fishery Management Plan that Describes EFH in the Action Area	Would the action adversely affect EFH?	Are EFH conservation recommendations provided?
Pacific Coast Salmon	Yes	Yes

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

Issued By:

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Area Office
NOAA Fisheries, West Coast Region

Date: March 13, 2019

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ACRONYM GLOSSARY

A&P	Abundance and Productivity
BA	Biological Assessment
BDA	Beaver Dam Analogue
BRT	Biological Review Team
CBR	Certified Beaver Relocator
CFR	Code of Federal Regulations
CHART	Critical Habitat Analytical Review Team
CR	Columbia River
DDT	Dichlorodiphenyltrichloroethane
Decision Model	Wildlife Services–Decision Model
DIP	Demographically Independent Population
DPS	Distinct Population Segment
DQA	Data Quality Act
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FR	Federal Register
ft	feet
ft^2	square feet
GIS	Geographic Information Systems
HC	Hood Canal
HUC	Hydrologic Unit Code
IC	Interior Columbia
ICTRT	Interior Columbia Basin Technical Recovery Team
IWDM	Integrated Wildlife Damage Management
ITS	Incidental Take Statement
LAA	Likely to Adversely Affect
LCR	Lower Columbia River
LO	Lake Ozette
LWD	Large Woody Debris
m^2	square meters
MBP	Methow Beaver Project
MCFEG	Mid-Columbia Fisheries Enhancement Group
MCR	Middle Columbia River
mm	millimeter
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NFH	National Fish Hatchery
NFIP	National Flood Insurance Program
NLAA	Not Likely to Adversely Affect
NMFS	National Marine Fisheries Service
OMB	Office of Management and Budget
opinion	Biological Opinion

PBF	Physical and/or Biological Feature
PCB	Polychlorinated Biphenyls
PCE	Primary Constituent Element
PS	Puget Sound
PSTRT	Puget Sound Technical Recovery Team
RCW	Revised Code of Washington
Reclamation	Bureau of Reclamation
RM	River Mile
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
SLOPES	Standard Local Operating Procedures for Endangered Species
SR	Snake River
SRB	Snake River Basin
SS/D	Spatial Structure/Diversity
T&E	Threatened and Endangered
TA	Technical Assistance
TRT	Technical Recovery Team
UCR	Upper Columbia River
UCSRB	Upper Columbia Salmon Recovery Board
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USFS	United States Forest Service
UWR	Upper Willamette River
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
WS	Wildlife Services

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 (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402.

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). A complete record of this consultation is on file at the NMFS Columbia Basin Branch office.

1.2 Consultation History

We received a request for consultation and biological assessment (BA) from the Animal Plant Health Inspection Service, Wildlife Services–Washington (WS–Washington) on April 30, 2018. Their consultation request is for their Aquatic Mammal Damage Management program in Washington State, carried out under authority of the Animal Damage Control Act of March 2, 1931, as amended (7 U.S.C. 426–426c; 46 Stat. 1468) and the Rural Development, Agriculture and Related Agencies Appropriation Act of 1988. The WS–Washington determined that their program is “Likely to Adversely Affect” (LAA) the Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*), Lower Columbia River (LCR) Chinook salmon, Upper Willamette River (UWR) spring-run Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Snake River (SR) spring/summer-run Chinook salmon, SR fall-run Chinook salmon, Hood Canal (HC) summer-run chum salmon (*O. keta*), Columbia River (CR) chum salmon, LCR coho salmon (*O. kisutch*), Lake Ozette (LO) sockeye salmon (*O. nerka*), SR sockeye salmon, PS steelhead (*O. mykiss*), LCR steelhead, UWR steelhead, Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin (SRB) steelhead, and their designated critical habitats.

We initiated consultation on April 30, 2018. Throughout the consultation, we held several meetings and phone conferences and corresponded by email with WS–Washington. Some of these discussions also included NMFS colleagues from the Washington–Oregon Coastal Office, and personnel from WS–Oregon. Through these discussions, we worked to gain a better understanding of WS–Washington’s Aquatic Mammal Damage Management program, especially pertaining to beavers, the potential effects of the proposed program, and potential ways to minimize effects. On September 6, 2018, a meeting between WS–Washington and NMFS resulted in WS–Washington tentatively agreeing to reduce the scope of their proposed action in ESA-listed salmonid habitat pending more internal discussions with their district supervisors. NMFS also committed to providing WS–Washington with better Geographic Information Systems coverage of listed fish habitat so WS–Washington could better assess their program relative to that habitat. On a September 26, 2018, phone conference, we tentatively agreed to a slightly modified version of the September 6 changes. On October 5, 2018, NMFS sent an email to WS–Washington, spelling out those changes, and asking for WS–Washington's confirmation. At a meeting at NMFS' Ellensburg office on October 9, 2018, Mike Linnell (State Director, WS–Washington) agreed to those final changes, which are reflected in the Federal Proposed Action section below.

Although WS-Washington determined the action was LAA UWR spring-run Chinook salmon, LO sockeye salmon, SR sockeye salmon, and UWR steelhead, and their critical habitat, in conducting our effects analysis on these four species and critical habitats, we determined that all the effects are either so small in size (cannot be meaningfully measured, detected, or evaluated), or are so extremely unlikely, that they met the threshold for "not likely to adversely affect." Accordingly, in this document we address those five species in section 2.12, providing our explanation as to why all the effects are insignificant and/or discountable.

1.3 Proposed Federal Action

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

The WS–Washington proposes to continue conducting an Integrated Wildlife Damage Management Program (IWDM) in Washington for the protection of agriculture, natural resources, property, and human health and safety. The mammal species associated with the proposed action include beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*), mink (*Neovison vison*), nutria (*Myocastor coypus*), and river otter (*Lutra canadensis*). The scope of the proposed action is throughout private, federal, state, tribal, county, and municipal lands and properties in Washington, where requested and where funding is available. Any removal of aquatic mammals on federal or other public lands is coordinated in advance with the land management agency. Similarly, before management actions are conducted on private lands or other public lands, work initiation documents are signed with the landowner or administrator. These documents describe the methods to be used and the species to be managed, along with any other point of interest or restrictions for implementing the management. Management is directed toward individual offending animals and/or localized groups depending on the circumstances.

Some examples of aquatic mammal damage that can result in WS–Washington involvement include:

- Plugging of head gates and other irrigation system components.
- Erosion potential within levies, dikes, road and railroad beds from vegetation destruction and burrowing.
- Flooding and prevention of flooding of agricultural lands and roads.

- Flooding, cutting, and gnawing of ornamental and commercial trees, tree plantations, wetland restoration projects, and other vegetation.
- Flooding and prevention of flooding to private property and structures.
- Burrowing activity under and along roads, railways, walkways, water conveyance ditches, and dikes.
- Damage to boats, docks, boat houses, and marinas.
- Risks to human health and safety resulting from the above examples.

The WS–Washington's view is that the most effective approach to resolving wildlife damage is to integrate the use of several management methods simultaneously or sequentially. The IWDM is the implementation and application of safe and practical methods for the prevention and control of damage caused by wildlife, based on analyses and the informed judgment of trained personnel. The philosophy behind IWDM is to implement effective management techniques in a cost-effective manner while minimizing the adverse effects on humans, target and non-target species, and the environment. IWDM draws from the largest possible array of options to create a combination of techniques appropriate for the specific circumstances. The IWDM may incorporate cultural practices (e.g., removal of artificial food sources), habitat modification, animal behavior (e.g., scaring), removing local individuals or groups, or any combination of these, depending on the characteristics of the specific damage problems. Consideration is given to the following factors before selecting or recommending control methods and techniques:

- Species responsible for damage.
- Magnitude, geographic extent, frequency, and duration of the problem.
- Status of target and non-target species, including threatened and endangered (T&E) species.
- Local environmental conditions.
- Potential biological, physical, economic, and social impacts.
- Potential legal restrictions.
- Costs of control options.
- What other strategies can be implemented, if prevention efforts (lethal and non-lethal techniques) fail to stop damage.

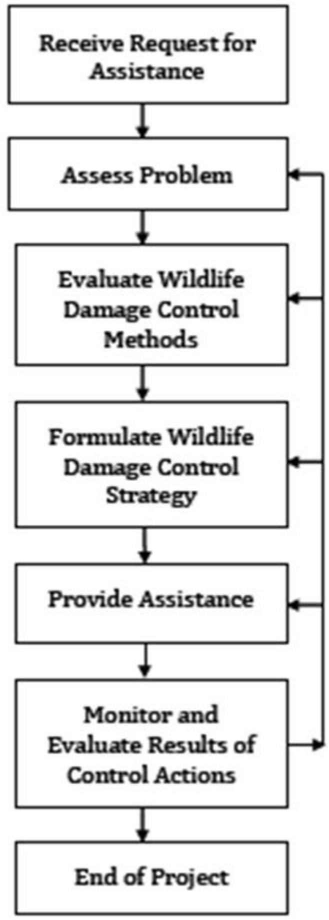

Figure 1. Animal and Plant Health Inspection Service–Wildlife Services Decision Model

The WS–Washington personnel use the WS–Decision Model (Figure 1) (Slate et al. 1992; Wildlife Services 2014); hereafter called the Decision Model, to determine the appropriate actions for responding to a request for assistance. When WS–Washington receives a request for assistance, trained and experienced field personnel determine the appropriate IWDM methods to recommend and/or implement by using the Decision Model. After WS–Washington personnel receive a request for assistance, they assess the problem and evaluate the effectiveness of the various methods available for IWDM. They then recommend a strategy based on a variety of factors, including short-term and long-term effectiveness of the method, possible restrictions due to laws, regulations, or site-specific conditions, environmental considerations, and cost. The employee discusses with the requestor the options and methods deemed to be practical and effective for the situation, which are incorporated into a management strategy. If WS–Washington determines that operational management actions[1] are appropriate, WS–Washington personnel would enter into a written cooperative agreement, which identifies the tools, actions,

[1] Operational management actions are those that WS–Washington may physically conduct and may include the use of exclusion, harassment, shooting, trapping, and relocation. WS–Washington policy is that preference be given to nonlethal methods.

and timeframe WS–Washington could employ, as well as the dollar amount that the requestor would be required to reimburse WS–Washington for providing such assistance. After the employee provides the appropriate assistance, the employee and/or the requestor monitors the effectiveness of the employed methods. Management strategies are adjusted, modified, or discontinued, as needed, depending on the employee's evaluation of the results.

For efficiency in providing IWDM assistance to multiple requestors at a given time, WS–Washington discusses with the requestor which methods will be requestor-implemented and which, if any, will be provided by WS–Washington. Because WS–Washington receives limited funding, requestors are asked and expected to implement methods that they are able to, reducing their need for WS–Washington efforts. This allows WS–Washington efforts to be focused on those activities that the requestor is less skilled or equipped to do, such as lethal control actions, while still providing professional guidance.

The WS–Washington's role sometimes only involves technical assistance (TA), e.g., providing advice, recommendations, and sometimes materials to land and resource owners and managers. In the case of beaver damage, TA may include providing recommendations for protecting woody vegetation from beaver gnawing (e.g., installing barriers, applying repellents), installing pond-leveling devices to manage water levels behind a beaver dam to prevent flooding, or installing devices to block beaver access. As part of technical assistance and outreach efforts, WS–Washington emphasizes the importance of beaver dams to salmonid ecology, and wetland and stream ecology in general (e.g., raising groundwater levels, providing habitat complexity), and communicates that leaving beavers on site is preferred, when feasible. When applicable, WS–Washington will recommend that the land owner or resource manager contact a third party (such as a beaver conservation group) who can advise on no-kill options (e.g., pond levelers, tree wraps), and provide operational assistance in the form of labor, materials, and financial resources to keep the beavers on site. This recommendation will include sites where emergency beaver removals have already occurred, if beavers are likely to return to the site.

Outreach, education, and communication of resources occurs throughout the execution of the Decision Model steps, before, during, and after service delivery. When TA is deemed insufficient, WS–Washington may provide operational assistance. WS–Washington documented 235 TA outreach sessions related to beaver in Washington during 2010–2015.

1.3.1 Historical Practice/Information

The WS–Washington removed (i.e., killed) an average of 485 beaver per year during 2013–2017. About 75 percent of those removals were related to public safety, while the remainder were not considered safety related. Most actions occurred in irrigation structures, drainage conveyances and ditches, ponds along roads and railways, lakes, and adjacent to culverts. Some activities occur in mainstem sections of larger rivers (e.g., the Yakima, Snoqualmie, Columbia, and Snake rivers), large lakes, and isolated ponds. In most cases, WS–Washington is contacted because of recent beaver activity, occurring within the past 12-month period, and not as a result of dams in existence for greater than a year.

The WS–Washington did not record the locations of past beaver removal sites, the number of sites, or the number of animals removed at each site. Thus, to help assess the scope of their proposed action, WS–Washington queried field personnel to recall where they removed beaver over the 6-year period from 2010 through 2015. The majority of identified locations were outside ESA-listed salmonid habitat (i.e., designated critical habitat or other habitat occupied by ESA-listed salmon and steelhead). Using the queried field personnel information, WS–Washington also mapped the locations where beaver were removed from 2010 through 2015 (Appendix A of the BA). This information shows that removal sites were not concentrated within the range of any single salmon or steelhead independent population.

1.3.2 Proposed Limits and Details of Proposed Action

Although WS–Washington cannot predict exactly where future beaver removal requests will occur, based on historical practice, they propose two key limitations to their proposed beaver removal activities:

1. Subject to the exceptions set out below, WS–Washington will remove beavers from a maximum of 20 sites over any given 5-year period within ESA-listed salmonid habitat (i.e., designated critical habitat or other habitat occupied by ESA-listed salmon and steelhead). Under this proposal, a site is only counted once, no matter how often WS–Washington has to remove beavers from the same site.

2. The WS–Washington will not remove beavers from more than three sites within any sixth-field Hydrologic Unit Code (HUC_6) over any given 5-year period.

In addition to the 20 site criteria, WS–Washington also proposes to remove beavers from additional sites within ESA-listed salmonid habitat in the following situations:

- Stream channels greater than 33 feet (10 m) wide (Suzuki and McComb 1998), and in lakes, because at these sites beavers are unlikely to build dams and therefore are unlikely to provide salmonid habitat.
- "Built environment" sites where beaver activity poses a threat to public infrastructure and/or public safety (e.g., as identified by an engineer or road supervisor). At these sites, the jurisdictional entity will remove the beaver dam, regardless of whether beavers are removed or not in order to protect infrastructure and ensure public safety.[2]
- Habitat restoration sites, where the beavers are preventing the restoration (e.g., plant establishment) from succeeding.
- Sites where beaver dams have blocked culverts or other transportation crossings to the extent that fish passage is prevented.

When responding to beaver damage involving streams in ESA-listed fish habitat or in essential fish habitat, WS–Washington will use best efforts to scan for adult salmonids or salmonid redds before undertaking actions. If present, adults on redds will be not be disturbed, and redds will be

[2] Public safety-related situations include, but are not limited to, removing beaver that are blocking culverts under roads/railways, creating dams that threaten or cause flooding onto roads/railways, creating open water on and adjacent to airports (which attract ducks, geese, and other birds that could cause bird-strikes), falling trees at public parks, recreation areas, walking trails, and damaging stormwater and wastewater treatment facilities.

avoided.WS–Washington will document all future beaver removal sites, including the date, location, and project cooperator (e.g., Washington State Department of Transportation) (Appendix B of the BA). When beaver removals are unavoidable, WS–Washington will document the resource damaged or at risk, due to beaver presence, and why options to leave the animals in place were not feasible. WS–Washington has not requested an end date for this programmatic consultation.

1.3.3 Types of Management Methods

Non-lethal methods are primary, preventative practices, such as barriers to restrict animal access, water-level control devices, and deterrents. Requestors may be encouraged to use these methods, where they are likely to be effective. In addition, some methods, such as foothold traps, can be used non-lethally or lethally, often depending on the species involved and the circumstances. Animals captured in live traps can be released or relocated if authorized by the Washington Department of Fish and Wildlife (WDFW). The WS–Washington may transfer live-trapped beaver to approved entities with appropriate authorizations or permits.

Lethal methods include firearms, quick-kill/body gripping traps, and foothold traps. Non-lethal capture techniques are often used along with euthanasia (when feasible) and may include foothold traps, cage traps, and suitcase traps.

1.3.4 Relocation

Beaver relocation can be time-consuming and expensive compared to lethal removal. The WS–Washington may need to have expenses covered to assist with relocation. Many of the agreements WS–Washington has are with counties, where landowners may request assistance with beaver damage, and beaver relocation costs may not be included in the county-approved work agreement. However, as part of the proposed action, if beaver removal is the selected method as determined by the Decision Model, WS–Washington has committed to live-trapping beavers when practical, so they can be transferred to individuals or groups who will be certified to relocate the animals to suitable areas (Mike Linnell, State Director, Washington/Alaska Wildlife Services, personal communication, September 6, 2018). The WS–Washington has been in contact with potential cooperators for beaver relocation [e.g., Beavers Northwest, Cowlitz Tribe, Methow Beaver Project (MBP), WDFW] and has transferred several this year for relocation to areas where they are unlikely to cause additional damage (Mike Linnell, State Director, Washington/Alaska Wildlife Services, personal communication, January 31, 2019).

The WDFW maintains the regulatory authority for movement of wildlife in Washington and any relocation of nuisance beaver would be in accordance with Washington State law (e.g., RCW 77.36.160 and RCW 77.32.585). WS–Washington may assist with the relocation of beaver where WDFW has determined it appropriate. The WDFW is leading a working group to develop new beaver relocation protocols and plans to implement those protocols in early 2019 (personal communication, S. Simek, WDFW Carnivore, Furbearer, and Small Game Section Manager, to Mike Linnell, WS–Washington, April 25, 2018). WS–Washington is an active member of this working group, which also includes the U.S. Forest Service (USFS), several beaver conservation groups, and tribal representatives. These protocols will set beaver relocation standards, including the requirements to become a Certified Beaver Relocator (CBR), guidelines for post release monitoring by the CBRs, and criteria for determining relocation success (personal communication, Mike Linnell, WS–Washington, January 31, 2019).

1.3.5 Beaver Dam/Blockage Removal

Beaver dam or blockage removal are not part of the proposed action and thus potential effects resulting from any such removal (e.g., fish being injured by the operation of equipment in water) are not analyzed in this opinion.

1.3.6 Toxicants

The WS–Washington previously consulted on and used zinc phosphide to control nutria (NMFS Tracking No. 2008/00345). The method has not been requested since 2005, and WS–Washington will no longer use zinc phosphide for any aquatic mammal damage activities. Should the need arise to use zinc phosphide, WS–Washington will consult under ESA as necessary.

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). We are not aware of any interrelated or interdependent actions associated with the proposed action.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving T&E species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of T&E 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 habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

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

This opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features (PBFs) essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

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

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 expected 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 by: (1) reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- Suggest a reasonable and prudent alternative to the proposed action, if necessary.

2.2 Rangewide Status of the Species and Critical Habitat

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

One factor affecting the status of ESA-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 and distribution of ESA-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. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2016; Mote et al.

2014). Rain-dominated watersheds, and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Mote et al. 2014; Tague et al. 2013).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1–1.4°F as an annual average, and up to 2°F in some seasons, based on average linear increase per decade (Abatzoglou et al. 2014; Kunkel et al. 2013). Recent temperatures in all but 2 years since 1998 ranked above the 20th century average (Mote et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3–10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014).

Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (Independent Scientific Advisory Board 2007a; Mote et al. 2013; Mote et al. 2014; USGCRP 2009). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (Independent Scientific Advisory Board 2007a; USGCRP 2009). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

The combined effects of increasing air temperatures and decreasing spring-through-fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5 to 5.3 °C increases in Columbia basin streams and a peak temperature of 26°C in the Willamette (NWFSC 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009).

Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (Independent Scientific Advisory Board 2007b). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Isaak et al. 2012; Mantua et al. 2010). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011; Tillmann and Siemann 2011; Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999; Raymondi et al. 2013; Winder and Schindler 2004). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Raymondi et al. 2013; Wainwright and Weitkamp 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (Lawson et al. 2004; McMahon and Hartman 1989).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0 to 3.7°C by the end of the century (Intergovernmental Panel on Climate Change 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Reeder et al. 2013; Tillmann and Siemann 2011).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38 to 109-percent increase in acidity is projected by the end of this century in all but the most stringent CO_2 mitigation scenarios, and is essentially irreversible over a time scale of centuries (Intergovernmental Panel on Climate Change 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al. 2012; Feely et al. 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10 to 32 inches by 2081–2100 (Intergovernmental Panel on Climate Change 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Reeder et al. 2013; Tillmann and Siemann 2011). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick 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, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; USGCRP 2009; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (Northwest Fisheries Science Center 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Reeder et al. 2013; Tillmann and Siemann 2011).

The adaptive ability of these T&E species is depressed, due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these evolutionarily significant units (ESUs) (Northwest Fisheries Science Center 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of the Species

For Pacific salmon, steelhead, and certain other species, we commonly use the four “viable salmonid population” (VSP) criteria (McElhany et al. 2000b) 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. 2000b).

“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. (2000b) use the terms “population growth rate” and “productivity” interchangeably when referring to production over the entire life cycle. They also refer to “trend in abundance,” which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species’ populations has been determined, we assess the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, 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. 2000b).

The summaries that follow describe the status of the 13 ESA-listed species, and their designated critical habitats, that 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 (FR) (Table 1), as well as applicable recovery plans and 5-year status reports. These additional documents are incorporated by reference.

Table 1. Listing status, status of critical habitat designations and protective regulations, and relevant Federal Register (FR) decision notices for Endangered Species Act 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 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
Puget Sound	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	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
Hood Canal summer-run	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	2/24/16; 81 FR 9252	6/28/05; 70 FR 37160
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
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
Puget Sound	T 5/11/07; 72 FR 26722	2/24/16; 81 FR 9252	P 2/7/07; 72 FR 5648

Status of Lower Columbia River Chinook Salmon

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (National Marine Fisheries Service 2013). 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-run 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-run Chinook salmon populations to improve their probability of persistence.

For late fall-run 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. Of the 32 demographically independent populations (DIPs) in this ESU, only the two late-fall-run populations (Lewis River and Sandy River) could be considered viable or nearly so (Northwest Fisheries Science Center 2015).

Spatial structure and diversity. The ESU includes all naturally-produced populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, with the exception of spring-run Chinook salmon in the Clackamas River. On average, fall-run Chinook salmon hatchery programs have released 50 million fish annually, with spring-run and upriver bright programs releasing a total of 15 million fish annually. As a result of this high level of hatchery production and low levels of natural production, many of the populations contain over 50 percent hatchery fish among their naturally-spawning assemblages.

The ESU spans three distinct ecological regions: Coastal, Cascade, and Gorge. Distinct life-histories (run and spawn timing) within ecological regions in this ESU were identified as major population groups (MPGs). In total, 32 historical DIPs were identified in this ESU, nine spring-run, 21 fall-run, and two late-fall-run, organized in six MPGs (based on run timing and ecological region; LCR Chinook populations exhibit three different life history types based on return timing and other features: fall-run (or “tules”), late-fall-run (or “brights”), and spring-run.

Abundance and productivity (A&P). Of the seven spring-run DIPs in this MPG only the Sandy River spring-run population appears to be a currently self-sustaining population. Both of the two spring-run historical DIPs in the Spring-run Gorge MPG are extirpated or nearly so. In general, the DIPs in the Coastal fall-run MPG are dominated by hatchery-origin spawners. In surveys conducted in both 2012 and 2013, no Chinook salmon were observed in Scappoose Creek. Overall, the fall-run Cascade MPG exhibits stable population trends, but at low abundance levels, and most populations have hatchery contribution exceeding the target of 10 percent identified in NMFS’ Lower Columbia River Recovery Plan (National Marine Fisheries Service 2013). Many of the populations in the Fall-run Gorge MPG have limited spawning habitat available. Additionally, the prevalence of returning hatchery-origin fish to spawning grounds presents a considerable threat to diversity. Natural-origin returns for most populations are in the hundreds of fish. The two populations in the late fall-run MPG are the most viable of the ESU. The Lewis River late fall DIP has the largest natural abundance in the ESU and has a strong short-term positive trend and a stable long term trend, suggesting a population near capacity. The Sandy River late fall run has not been directly monitored in a number of years; the most recent estimate was 373 spawners in 2010 (Takata 2011).

Limiting factors. Limiting factors for this species include NMFS’ National Marine Fisheries Service (2013):

- Reduced access to spawning and rearing habitat
- Hatchery-related effects
- Harvest-related effects on fall-run Chinook salmon
- An altered flow regime and Columbia River plume
- Reduced access to off-channel rearing habitat
- Reduced productivity resulting from sediment and nutrient-related changes in the estuary
- Contaminants

Status of Upper Columbia River Spring-run Chinook Salmon

A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007a). Achieving recovery (i.e., delisting the species) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the Upper Columbia Salmon Recovery Board (UCSRB) Plan. The plan calls for meeting or exceeding the same basic spatial structure and diversity criteria adopted from the Interior Columbia Basin Technical Recovery Team (ICTRT) viability report for recovery (Northwest Fisheries Science Center 2015). None of the three populations are viable with respect to A&P, and they all have a greater than 25 percent chance of extinction in 100 years (Upper Columbia Salmon Recovery Board 2007b).

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. The composite spatial structure and diversity risks for all three of the extant natural populations in this MPG are rated at high (Table 2). The natural processes component of the spatial structure and diversity risk is low for the Wenatchee and Methow River populations and moderate for the Entiat River population. All three of the extant populations in this MPG are rated at high risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and a lack of genetic diversity among the natural-origin spawners (Interior Columbia Technical Recovery Team 2008; Northwest Fisheries Science Center 2015).

Table 2. Upper Columbia River spring-run Chinook Salmon Evolutionarily Significant Unit population viability status summary.*

	Abundance and Productivity (A&P) Metrics[1]				Spatial Structure and Diversity (SS/D) Metrics			
Population	**ICTRT Minimum Threshold**	**Natural Spawning Abundance**	**ICTRT Productivity**	**Integrated A&P Risk**	**Natural Processes Risk**	**Diversity Risk**	**Integrated SS/D Risk**	**Overall Viability Rating**
Wenatchee River 2005–2014	2,000	545 ↑ (311–1,030)	0.60 ↑ (0.27,15/20)	High	Low	High	High	High Risk
Entiat River 2005–2014	500	166 ↑ (78–354)	0.94 ↑ (0.18, 12/20)	High	Moderate	High	High	High Risk
Methow River 2005–2014	2,000	379 ↑ (189–929)	0.46 ■ (0.31, 16/20)	High	Low	High	High	High Risk

*Current Abundance and Productivity (A&P) estimates are geometric means. The range in annual abundance, standard error, and number of qualifying estimates for production are in parentheses. Upward arrows = current estimates increased from prior review. Square = no change since prior review (Northwest Fisheries Science Center 2015). The Wenatchee, Entiat, and Methow River populations are considered a high risk for both A&P and composite spatial structure/diversity (SS/D), as they are noted in the above table.

Abundance and productivity. Overall A&P remains rated at high risk for each of the three extant populations in this MPG/ESU (Table 2) (Northwest Fisheries Science Center 2015). The 10-year geometric mean abundance of adult natural-origin spawners has increased for each population relative to the levels reported in the 2011 status review, but natural-origin escapements remain below the corresponding ICTRT thresholds. The combinations of current A&P for each population result in a high risk rating when compared to the ICTRT viability curves (Northwest Fisheries Science Center 2015).

Limiting factors. Limiting factors include (NOAA Fisheries 2011; Upper Columbia Salmon Recovery Board 2007b):

- Effects related to hydropower system in the mainstem Columbia River, including complicated 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 (LWD) 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 Snake River Spring/Summer-run Chinook Salmon

NMFS released a recovery plan for this species in 2017 (NOAA Fisheries 2017b). 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 (U.S. Department of Commerce 2014). The ICTRT 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 3) (Interior Columbia Basin Technical Recovery Team 2003; McClure et al. 2005). The majority of extant spring/summer Chinook salmon populations in the Snake River spring/summer Chinook salmon ESU remain at high overall risk of extinction, with a low probability of persistence within 100 years. Since the 2010 status review (Ford 2011), one of the Chinook salmon populations (Chamberlain Creek in the Middle Fork Salmon River MPG) improved to an overall rating of maintained, due to increased abundance. Natural-origin abundance in most other populations in the ESU also increased in recent years, but the increases were not substantial enough to change the viability ratings (Northwest Fisheries Science Center 2015).

Table 3. Major population groups, populations, and scores for the key elements (Abundance and Productivity, Diversity, and Spatial Structure) used to determine current overall viability risk for Snake River spring/summer-run Chinook salmon (Northwest Fisheries Science Center 2015). 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**	**Natural Processes Risk**	**Diversity**	**Integrated SS/D**	**Overall Viability Risk**
Lower Snake River	Tucannon River	H	L	M	M	H
	Asotin Creek					E
Grande Ronde and Imnaha rivers	Wenaha River	H	L	M	M	H
	Lostine/Wallowa River	H	L	M	M	H
	Minam River	H	L	M	M	H
	Catherine Creek	H	M	M	M	H
	Upper Grande Ronde R.	H	H	M	H	H
	Imnaha River	H	L	M	M	H
	Lookingglass Creek	**	**	**	**	E
South Fork Salmon River	Little Salmon River	*	L	L	L	H
	South Fork mainstem	H	L	M	M	H
	Secesh River	H	L	L	L	H
	EF/Johnson Creek	H	L	L	L	H
Middle Fork Salmon River	Chamberlin Creek	M	L	L	L	MT
	Big Creek	H	VL	M	M	H
	Lower Mainstem MF	*	M	M	M	H
	Camas Creek	H	L	M	M	H
	Loon Creek	H	L	M	M	H
	Upper Mainstem MF	H	L	M	M	H
	Sulphur Creek	H	L	M	M	H
	Bear Valley Creek	H	VL	L	L	H
	Marsh Creek	H	L	L	L	H
Upper Salmon River	Salmon Lower Main	H	L	L	L	H
	Salmon Upper Main	H (M)	L	L	L	H
	Lemhi River	H	H	H	H	H
	Pahsimeroi River	H (M)	M	H	H	H
	Salmon East Fork	H	L	H	H	H
	Yankee Fork	H	M	H	H	H
	Valley Creek	H	L	M	M	H
	North Fork	*	L	L	L	H
	Panther Creek	**	**	**	**	E

*Insufficient data
**These cells are blank in original report.

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

- Degraded tributary habitat including impaired fish passage, reduced stream complexity and channel structure, excess fine sediment, high summer water temperatures, diminished stream flows reduced floodplain connectivity and function, reduced riparian function and LWD recruitment.
- 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
- Reduced estuary and plume habitat
- Altered function of estuary and plume habitat
- Toxic Pollutants

Status of Snake River Fall-run Chinook Salmon

NMFS released a recovery plan for this species in 2017 (NOAA Fisheries 2017a). 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 (U.S. Department of Commerce 2014).

The ICTRT 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 (Interior Columbia Basin Technical Recovery Team 2003; McClure et al. 2005). The population is at moderate risk for diversity and spatial structure (Ford 2011).

Biological risk summary. The following is a summary from the status review update. More detailed information on the status and trends of these listed resources, and their biology and ecology are in the status update (Northwest Fisheries Science Center 2015).

Overall population viability for the Lower Mainstem Snake River fall-run Chinook salmon population is determined based on the combination of ratings for current A&P and combined spatial structure/diversity (Table 4) (NOAA Fisheries 2017a; Northwest Fisheries Science Center 2015). The population is currently rated as viable, at low (1–5 percent) risk of extinction within 100 years, based on current population, low risk rating for abundance/productivity, and a moderate risk rating for spatial structure/diversity (NOAA Fisheries 2017a).

Table 4. Lower mainstem Snake River fall-run Chinook salmon population risk ratings integrated across the four viable salmonid population (VSP) metrics. Viability Key: Highly Viable (HV); Viable (V); Maintained (M); High Risk (HR); Green shaded cells—meets criteria for Highly Viable; Gray shaded cells—does not meet viability criteria (darkest cells are at greatest risk).

	Very Low	**Low**	**Moderate**	**High**
Very Low (<1%)	HV	HV	V	M
Low (1–5%)	V	V	V Lower Mainstem Snake River	M
Moderate (6–25%)	M	M	M	HR
High (>25%)	HR	HR	HR	HR

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
- Warm ocean years
- Toxic pollutants

Status of Puget Sound Chinook Salmon

The PS Chinook salmon ESU was listed as threatened on June 28, 2005 (70 FR 37160), and reaffirmed as threatened on April 14, 2014 (79 FR 20802). We adopted the recovery plan for this ESU in January 2007. The recovery plan consists of two documents: the Puget Sound salmon recovery plan (Shared Strategy for Puget Sound 2007) and a supplement (National Marine Fisheries Service 2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002a). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured.
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU (Table 5) achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region.
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable.
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an

ESU-wide recovery scenario; production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

- Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

Spatial structure and diversity. The PS Chinook salmon ESU includes all naturally-spawning populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. The ESU also includes the progeny of numerous artificial propagation programs (U.S. Department of Commerce 2014). The PSTRT identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The PSTRT distributed the 22 populations among five major biogeographical regions, or MPGs, that are based on similarities in hydrographic, biogeographic, and geologic characteristics (Table 5).

Between 1990 and 2014, the proportion of natural-origin spawners has trended downward across the ESU, with the Whidbey Basin the only MPG with consistently high fractions of natural-origin spawner abundance. All other MPG have either variable or declining spawning populations with high proportions of hatchery-origin spawners (Northwest Fisheries Science Center 2015).Overall, the new information on abundance, productivity, spatial structure, and diversity, since the 2010 status review supports no change in the biological risk category (Northwest Fisheries Science Center 2015).

Table 5. Extant Puget Sound Chinook salmon populations in each biogeographic region (Northwest Fisheries Science Center 2015; Ruckelshaus et al. 2002b).

Biogeographic Region	Population (Watershed)
Strait of Georgia	North Fork Nooksack River
	South Fork Nooksack River
Strait of Juan de Fuca	Elwha River
	Dungeness River
Hood Canal	Skokomish River
	Mid Hood Canal River
Whidbey Basin	Skykomish River
	Snoqualmie River
	North Fork Stillaguamish River
	South Fork Stillaguamish River
	Upper Skagit River
	Lower Skagit River
	Upper Sauk River

Biogeographic Region	Population (Watershed)
	Lower Sauk River
	Suiattle River
	Upper Cascade River
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

Abundance and productivity. Available data on total abundance since 1980 indicate that although abundance trends have fluctuated between positive and negative for individual populations, there are widespread negative trends in natural-origin Chinook salmon spawner abundance across the ESU (Ford 2011). Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Across the ESU, most populations have declined in abundance since the last status review in 2011, and indeed, this decline has been persistent over the past 7 to 10 years. Further, escapement levels for all populations remain well below the technical recovery team (TRT) planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery (Northwest Fisheries Science Center 2015).

Limiting factors. Limiting factors for this species include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation and loss of in-river LWD
- Excessive fine-grained sediment in spawning gravel
- Degraded water quality and temperature
- Degraded nearshore conditions
- Impaired passage for migrating fish
- Altered flow regime

Status of Columbia River Chum Salmon

Columbia River chum salmon are included in the Lower Columbia River Recovery Plan (National Marine Fisheries Service 2013). 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, and floodplains. Even with improvements observed during the last 5 years, the majority of DIPs in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (Northwest Fisheries Science Center 2015).

Spatial structure and diversity. The ESU includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, as well as four artificial propagation programs (Grays River Hatchery, Big Creek Hatchery, Lewis River Hatchery, and Washougal Hatchery). With the exception of the Grays River stock of fish raised at Big Creek Hatchery, all of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. Ford (2011) concluded that the vast majority (14 out of 17) chum populations remain extirpated or nearly so. The ESU is comprised of three MPGs—the Coastal Range MPG, the Cascade Range MPG, and the Gorge MPG.

In this ESU there have been a number of large-scale efforts to improve habitat accessibility, one of the primary metrics for spatial structure. On the Hood River, Powerdale Dam was removed in 2010 and, while this dam previously provided for fish passage, removal of the dam is thought to eliminate passage delays and injuries. Condit Dam, on the White Salmon River, was removed in 2012 and this provided access to previously inaccessible habitat. Both of these dams were above Bonneville Dam, and at present there are few fish available (122 adults in 2014) to colonize these recently accessible habitats.

Abundance and productivity. Populations in the Coast Range MPG other than the Grays River DIP exist at very low abundances, intermittently observed in very low numbers (fewer than ten) in most tributaries other than the Grays River. Two chum spawning aggregates in the mainstem Columbia River just upstream of the I-205 Bridge are part of the Washougal River aggregate. In November 2013, two adult chum salmon were observed at the North Fork Dam in the Clackamas River. Chum salmon have also been collected at a number of hatcheries and weirs throughout the Cascade Range MPG, but only in very limited numbers (fewer than ten). While the absolute numbers of fish present in many populations are critically low, they may represent important reserves of genetic diversity. Within the Gorge MPG, the Lower Gorge population includes chum salmon returning to Hamilton, Hardy, and Duncan Creeks, and the Ives Island area of the mainstem Columbia River below Bonneville Dam. Other mainstem Columbia River spawning aggregations include Multnomah and Horsetail Creeks on the Oregon shoreline, and in the St. Cloud area along the Washington shoreline. The overall trend since 2000 is negative, with the recent peak in abundance (2010 to 2011) being considerably lower than the previous peak in 2002. The Upper Gorge population is comprised of a small number (105.6±47.7) that migrate past Bonneville Dam to the upper Gorge population area in most years. (Data from http://www.nwp.usace.army.mil/Missions/Environment/Fish/Counts.aspx accessed 4 March 2015).

Limiting factors. Limiting factors for this species are (National Marine Fisheries Service 2013):

- Degraded estuarine and nearshore marine habitat
- Degraded freshwater habitat
- Degraded stream flow as a result of hydropower and water supply operations
- Reduced water quality
- Current or potential predation

- An altered flow regime and Columbia River plume
- Reduced access to off-channel rearing habitat in the lower Columbia River

Status of Hood Canal Summer-run Chum Salmon

We adopted a recovery plan for Hood Canel (HC) summer-run chum salmon in May of 2007. The recovery plan consists of two documents: the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon recovery plan (Hood Canal Coordinating Council 2005) and a supplemental plan (National Marine Fisheries Service 2007). The recovery plan adopts ESU and population level viability criteria recommended by the PSTRT (Sands et al. 2007). The PSTRT's biological recovery criteria will be met when the following conditions are achieved:

- Spatial Structure: (1) spawning aggregations are distributed across the historical range of the population; (2) most spawning aggregations are within 20 km of adjacent aggregations; (3) major spawning aggregations are distributed across the historical range of the population and are not more than approximately 40 km apart. Further, a viable population has spawning, rearing, and migratory habitats that function in a manner that is consistent with population persistence.

- Diversity: Depending on the geographic extent and ecological context of the population, a viable population includes one or more persistent spawning aggregations from each of the two to four major ecological diversity groups historically present within the two populations (see also McElhany et al. 2000a).

- A&P: Achievement of minimum abundance levels associated with persistence of HC Summer Chum ESU populations that are based on two assumptions about productivity and environmental response (Table 6).

Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (Northwest Fisheries Science Center 2015).

Table 6. Hood Canal summer-run chum salmon Evolutionarily Significant Unit abundance and productivity recovery goals (Sands et al. 2007).

Population	Low Productivity Planning Target for Abundance (productivity in parentheses)	High Productivity Planning Target for Abundance (productivity in parentheses)
Strait of Juan de Fuca	12,500 (1.0)	4,500 (5.0)
Hood Canal	24,700 (1.0)	18,300 (5.0)

Spatial structure and diversity. The ESU includes all naturally-spawning populations of summer-run chum salmon in Hood Canal tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington, as well as several artificial propagation programs. The PSTRT identified two independent populations for the HC summer chum, one which includes the spawning aggregations from rivers and creeks draining into the Strait of Juan de Fuca, and one which includes spawning aggregations within Hood Canal proper (Sands et al. 2009).

Spatial structure and diversity measures for the HC summer chum recovery program have included the reintroduction and sustaining of natural-origin spawning in multiple small streams where summer chum spawning aggregates had been extirpated. Supplementation programs have been very successful in both increasing natural spawning abundance in six of eight extant streams (Salmon, Big Quilcene, Lilliwaup, Hamma, Jimmycomelately, and Union) and increasing spatial structure, due to reintroducing spawning aggregations to three streams (Big Beef, Tahuya, and Chimacum). Spawning aggregations are present and persistent within five of the six major ecological diversity groups identified by the PSTRT (Table 7). As supplementation program goals have been met in most locations, they have been terminated except in Lilliwaup/Tahuya, where supplementation is ongoing (Northwest Fisheries Science Center 2015). Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria.

Table 7. Seven ecological diversity groups as proposed by the Puget Sound Technical Recovery Team for the Hood Canal summer chum Evolutionarily Significant Unit by geographic region and associated spawning aggregation**.**

Geographic Region (population)	**Proposed Ecological Diversity Groups**	**Spawning aggregations: Extant* and Extinct***
Eastern Strait of Juan de Fuca	Dungeness	Dungeness R (unknown status)
	Sequim-Admiralty	Jimmycomelately Cr* Salmon Cr* Snow Cr* Chimacum Cr**
Hood Canal	Toandos	Unknown
	Quilcene	Big Quilcene R* Little Quilcene R*
	Mid-West Hood Canal	Dosewallips R* Duckabush R*
	West Kitsap	Big Beef Cr** Seabeck Cr** Stavis Cr** Anderson Cr** Dewatto R** Tahuya R** Mission Cr** Union R*
	Lower West Hood Canal	Hamma R* Lilliwaup Cr* Skokomish R*

Abundance and productivity. Smoothed trends in estimated total and natural population spawning abundances for both Hood Canal and Strait of Juan de Fuca populations have generally increased over the 1980 to 2014 time period. The Hood Canal population has had a 25 percent increase in abundance of natural-origin spawners in the most recent 5-year time period over the 2005 to 2009 time period. The Strait of Juan de Fuca has had a 53 percent increase in abundance of natural-origin spawners in the most recent 5-year time period.

Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year t minus the smoothed natural spawning abundance in year (t-4), have increasing over the past 5 years, and were above replacement rates in 2012 and 2013. However, productivity rates have been varied above and below replacement rates over the entire time period up to 2014. Point No Point Treaty Tribes and Washington Department of Fish and Wildlife (2014) provide a detailed analysis of productivity for the ESU, each population, and by individual spawning aggregation, and report that 3 of the 11 stocks exceeded the co-manager's interim productivity goal of an average of 1.6 Recruit/Spawner over 8 years. They also report that natural-origin Recruit/Spawner rates have been highly variable in recent brood years, particularly in the Strait of Juan de Fuca population. Only one spawning aggregation (Chimacum) meets the co-manager's interim recovery goal of 1.2 recruits per spawner in 6 of most recent 8 years. Productivity of individual spawning aggregates shows only two of eight aggregates have viable performance (Northwest Fisheries Science Center 2015).

Limiting factors. Limiting factors for this species include (Hood Canal Coordinating Council 2005; NOAA Fisheries 2011):

- Reduced floodplain connectivity and function
- Poor riparian condition
- Loss of channel complexity (reduced LWD and channel condition, loss of side channels, channel instability)
- Sediment accumulation
- Altered flows and water quality

Status of Lower Columbia River Coho Salmon

This species is included in the Lower Columbia River Recovery Plan (National Marine Fisheries Service 2013). 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 ESU includes all naturally-spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as multiple artificial propagation programs. Most of the populations in the ESU contain a substantial number of hatchery-origin spawners. Myers et al. (2006) identified three MPGs (Coastal, Cascade, and Gorge) containing a total of 24 DIPs in the LCR coho salmon ESU.

There have been a number of large-scale efforts to improve accessibility, one of the primary metrics for spatial structure, in this ESU. On the Hood River, Powerdale Dam was removed in 2010 and, while this dam previously provided fish passage, removal of the dam is thought to have eliminated passage delays and injuries. Condit Dam, on the White Salmon River, was removed in 2011, providing access to long-inaccessible habitat. Fish passage operations (trap and haul) were begun on the Lewis River in 2012, reestablishing access to historically-occupied habitat above Swift Dam, though juvenile passage efficiencies are still relatively poor. Presently, the trap and haul program for the Upper Cowlitz, Cispus, and Tilton River populations are the only means by which coho salmon can access spawning habitat for these populations. A trap and haul program also currently maintains access to the North Toutle River above the sediment retention structure with coho salmon and steelhead being passed above the dam (Northwest Fisheries Science Center 2015).

Abundance and productivity. Long-term abundances in the Coast Range Cascade MPG were generally stable. Scappoose Creek is exhibiting a positive abundance trend. Clatskanie River coho salmon population maintains moderate numbers of naturally-produced spawners. Washington tributaries indicate the presence of moderate numbers of coho salmon, with total abundances in the hundreds to low thousands of fish. Oregon tributaries have abundances in the hundreds of fish. In the Western Cascade MPG, the Sandy and Clackamas Rivers were the only two populations identified in the original 1996 Status Review that appeared to be self-sustaining natural populations. Natural-origin abundances in the Columbia Gorge MPG are low, with hatchery-origin fish contributing a large proportion of the total number of spawners, most notably in the Hood River. With the exception of the Hood and Big White Salmon Rivers, much of the spawning habitat accessibility is relatively poor. There was no clear trend in the abundance data.

Limiting factors. Limiting factors for this species include (National Marine Fisheries Service 2013):

- Degraded estuarine and near-shore marine habitat
- Fish passage barriers
- Degraded freshwater habitat: hatchery-related effects
- Harvest-related effects
- An altered flow regime and Columbia River plume
- Reduced access to off-channel rearing habitat in the lower Columbia River
- Reduced productivity resulting from sediment and nutrient-related changes in the estuary
- Juvenile fish wake strandings
- Contaminants

Status of Lower Columbia River Steelhead

This species is included in the Lower Columbia River Recovery Plan (National Marine Fisheries Service 2013). 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 needed among the South Fork Toutle and Clackamas winter steelhead populations.

Spatial structure and diversity. The Distinct Population Segment (DPS) includes all naturally-spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive), and the Willamette and Hood Rivers, Oregon (inclusive), as well as multiple artificial propagation programs. There are four MPGs comprised of 23 DIPs, including six summer-run steelhead populations and 17 winter-run populations (Northwest Fisheries Science Center 2015). 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.

There have been a number of large-scale efforts to improve accessibility (one of the primary metrics for spatial structure) in this ESU. Trap and haul operations were begun on the Lewis River in 2012 for winter-run steelhead, reestablishing access to historically-occupied habitat above Swift Dam. In 2014, 1,033 adult winter steelhead (integrated program fish) were transported to the upper Lewis River; however, juvenile collection efficiency is still below target levels. In addition, there have been a number of recovery actions throughout the ESU to remove or improve culverts and other small-scale passage barriers. Many of these actions (including the removal of Condit Dam on the White Salmon River) have occurred too recently to be fully evaluated.

Total steelhead hatchery releases in the LCR Steelhead DPS have decreased since the last status review, declining from a total (summer- and winter-run) release of approximately 3.5 million to 3 million from 2008 to 2014. Some populations continue to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few hatchery origin spawners.

Abundance and productivity. The winter-run Western Cascade MPG includes native winter-run steelhead in 14 DIPs from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas and Sandy River winter-run steelhead populations which recently display increased natural-origin abundance and low levels of hatchery-origin fish on the spawning grounds (Jacobsen et al. 2014). In the summer-run Cascade MPG, there are four summer-run steelhead populations. Absolute abundances have been in the hundreds of fish. Long- and short-term trends for three DIPs (Kalama, East Fork Lewis and Washougal) are positive, though the 2014 surveys indicate a drop in abundance for all three. The winter-run Gorge MPG has three DIPs. In both the Lower and Upper Gorge population surveys for winter steelhead are very limited. Abundance levels have been low, but relatively stable, in the Hood River. In recent years, spawners from the integrated hatchery program have constituted the majority of the naturally-spawning fish. The Wind River and Hood River are the two DIPs in the summer-run Gorge MPG. Hood River summer-run steelhead have not been monitored since the last status review. Adult abundance in the Wind River remains stable, but at a low level (hundreds of fish). The overall status of the MPG is uncertain.

Limiting factors. Limiting factors for this species include (National Marine Fisheries Service 2013):

- Degraded estuarine and nearshore marine habitat
- Degraded freshwater habitat

- Reduced access to spawning and rearing habitat
- Avian and marine mammal predation
- Hatchery-related effects
- An altered flow regime and Columbia River plume
- Reduced access to off-channel rearing habitat in the lower Columbia River
- Reduced productivity resulting from sediment and nutrient-related changes in the estuary
- Juvenile fish wake strandings
- Contaminants

Status of Middle Columbia River Steelhead

A recovery plan is available for this species (National Marine Fisheries Service 2009). 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 (U.S. Department of Commerce 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 (U.S. Department of Commerce 2013a). The ICTRT identified 17 extant populations in this DPS (Interior Columbia Basin Technical Recovery Team 2003; McClure et al. 2005). The populations fall into four MPGs: Cascade eastern slope tributaries (five extant and two extirpated populations), 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 8) (Interior Columbia Basin Technical Recovery Team 2003; McClure et al. 2005). Viability ratings for these populations range from extirpated to viable (Table 8) (Ford 2011; National Marine Fisheries Service 2009).

Table 8. Major population groups, populations, and scores for the key elements (Abundance and Productivity, and Spatial Structure/Diversity) used to determine current overall viability risk for Mid-Columbia River steelhead (Ford 2011; National Marine Fisheries Service 2009). 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 Distinct Population Segment.

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

* Re-introduction efforts underway (National Marine Fisheries Service 2009)
**These cells are blank in original report.

Biological risk summary. The following is a summary from the status review update. More detailed information on the status and trends of these listed resources, and their biology and ecology are in the status update (Northwest Fisheries Science Center 2015).

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 described in the Mid-Columbia Steelhead recovery plan. In addition, several of the factors cited by the 2005 Biological Review Team (BRT) remain as concerns or key uncertainties. Natural-origin returns to the majority of populations in two of the four MPGs in this DPS increased modestly relative to the levels reported in the previous 5-year review. Abundance estimates for two of three populations with sufficient data in the remaining two MPGs (Eastside Cascades and Umatilla/Walla-Walla) were marginally lower. Natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. Three of the four MPGs in this DPS include at least one population rated at low risk for A&P (Table 37 in Northwest Fisheries Science Center 2015). The survival gaps for the remaining populations are generally smaller than those for the other Interior Columbia Basin listed DPSs (Figure 52 in Northwest Fisheries Science Center 2015). Updated information indicates that stray levels into the John Day River populations have decreased in recent years. Out-of-basin hatchery stray proportions, although reduced, remain high in spawning reaches within the Deschutes River basin populations. In general, the majority of population level viability ratings remained unchanged from prior reviews for each MPG within the DPS.

Limiting factors. Limiting factors for this species include (National Marine Fisheries Service 2009; 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 Upper Columbia River Steelhead

The UCR steelhead DPS was originally listed under the ESA in 1997. The Upper Columbia River Recovery Plan calls for "…restoring the distribution of naturally-produced spring Chinook salmon and steelhead to previously occupied areas where practical, and conserving their genetic and phenotypic diversity." (Upper Columbia Salmon Recovery Board 2007a). In 2015, the 5-year review for the UCR steelhead concluded the species should maintain its threatened listing classification (Northwest Fisheries Science Center 2015).

Spatial structure and diversity. The UCR steelhead DPS includes all naturally-spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams within the Columbia River Basin, upstream from the Yakima River, Washington, to the United States–Canada border, as well as six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop National Fish Hatchery (NFH), Omak Creek and the Ringold steelhead hatchery programs. NMFS has defined the UCR steelhead DPS to include only the anadromous members of this species (70 FR 67130). The UCR steelhead DPS is composed of three MPGs, two of which are isolated by dams.

With the exception of the Okanogan population, the Upper Columbia River populations were rated as low risk for spatial structure. Each population is at high risk for diversity, 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.

Abundance and productivity. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural-origin A&P remain well below viability thresholds for three out of the four populations. The most recent estimates of natural-origin spawner abundance for each of the four populations in the UCR Steelhead DPS show fairly consistent patterns throughout the years. None of the populations have reached their recovery goal numbers during any of the years (500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee). In spite of recent increases, natural-origin A&P remain well below viability thresholds for three out of the four populations, and the Okanogan River natural-origin spawner abundance estimates specifically are well below the recovery goal for that population. Three of four extant natural populations are considered to be at high risk of extinction and one at moderate risk (Table 9).

Table 9. Summary of the key elements (Abundance and Productivity, and Spatial Structure/Diversity) and scores used to determine current overall viability risk for Upper Columbia River steelhead populations (Northwest Fisheries Science Center 2015). Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH).

Population (Watershed)	ICTRT Min Threshold	A&P	Natural Processes Risk	Diversity	Integrated SS/D	Overall Viability Risk
Wenatchee River	1,000	L	L	H	H	MT
Entiat River	500	H	M	H	H	H
Methow River	1,000	H	L	H	H	H
Okanogan River	750	H	H	H	H	H

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

- 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, LWD recruitment, stream flow, and water quality
- Hatchery-related effects
- Predation and competition
- Harvest-related effects

Status of Snake River Basin Steelhead

This ESU was first listed as endangered under the ESA in 1991. NMFS just released a recovery plan for this species (NOAA Fisheries 2017b). None of the major population groups in this DPS are meeting the specific objectives in the recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain (Table 10).

Spatial structure and diversity. The SRB steelhead DPS includes all naturally-spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho, as well as six artificial production programs: the Tucannon River, Dworshak NFH, Lolo Creek, North Fork Clearwater River, East Fork Salmon River, and the Little Sheep Creek/Imnaha River Hatchery steelhead hatchery programs. With one exception, spatial structure ratings for all of the SRB steelhead populations were low or very low risk, given the evidence for distribution of natural production with populations. The exception was the Panther Creek population, which was given a high risk rating for spatial structure based on the lack of spawning in the upper sections. No new information was provided for the 2015 status update that would change those ratings (Table 10) (Northwest Fisheries Science Center 2015).

Table 10. Summary of the status of Snake River Basin steelhead populations relative to the Interior Columbia Basin Technical Recovery Team viability criteria. Ratings with "?" are based on limited or provisional data series (Northwest Fisheries Science Center 2015).

	Abundance/Productivity Metrics				**Spatial Structure and Diversity (SS/D) Metrics**			
Population	***ICTRT Minimum Threshold***	***Natural Spawning Abundance***	***ICTRT Productivity***	***Integrated A/P Risk***	***Natural Processes Risk***	***Diversity Risk***	***Integrated SS/D Risk***	**Overall Viability Rating**
Tucannon River	1,000	NA	NA	High??	Low	Moderate	Moderate	HIGH RISK??
Asotin Creek	500	(This cell was blank in the original document)	NA	Moderate?	Low	Moderate	Moderate	MAINTAINED? (HIGH RISK??)
Lower Grande Ronde River	1,000	NA	NA	(This cell was blank in the original document)	Low	Moderate	Moderate	MAINTAINED?
Joseph Creek	500	1,839	1.86	Very Low	Very Low	Low	Low	HIGHLY VIABLE
Upper Grand Ronde	1500	1,649 (.21)	3.15 (.40)	Viable (Moderate)	Very Low	Moderate	Moderate	VIABLE
Wallowa River	1,000	NA	NA	High??	Very Low	Low	Low	MODERATE?
Lower Main. Clearwater R.	1,500	2,099 (.15)	2.36(.16)	Moderate?	Very Low	Low	Low	MAINTAINED?
South Fork Clearwater R.	1,000	NA	NA	High	Low	Moderate	Moderate	MAINTAINED/ HIGH RISK?

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity (SS/D) Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	***Natural Spawning Abundance***	***ICTRT Productivity***	***Integrated A/P Risk***	***Natural Processes Risk***	***Diversity Risk***	***Integrated SS/D Risk***	
Lolo Creek	500	NA	NA	High	Low	Moderate	Moderate	MAINTAINED/ HIGH RISK?
Selway R.	1,000	1,650 (0.17)	2.33 (0.18)	Moderate?	Very Low	Low	Low	MAINTAINED?
Lochsa R.	1,000	1,650 (0.17)	2.33 (0.18)	Moderate?	Very Low	Low	Low	MAINTAINED?
Little Salmon R.	500	NA	NA	Moderate?	Low	Moderate	Moderate	MAINTAINED?
South Fork Salmon R.	1,000	1,028 (0.17)	1.80 (.148)	Moderate?	Very Low	Low	Low	MAINTAINED?
Secesh R.	500	1,028 (0.17)	1.80 (.148)	Moderate?	Low	Low	Low	MAINTAINED?
Chamberlain Creek	500	2,213 (0.16)	2.38 (.104)	Moderate?	Low	Low	Low	MAINTAINED?
Lower Middle Fork Salmon R.	1,000	2,213 (0.16)	2.38 (.104)	Moderate?	Very Low	Low	Low	MAINTAINED?
Upper Middle Fork Salmon R.	1,000	2,213 (0.16)	2.38 (.104)	Moderate?	Very Low	Low	Low	MAINTAINED?
Panther Creek	500	NA	NA	Moderate	High	Moderate	High	HIGH RISK?
North Fork Salmon R.	500	NA	NA	Moderate	Low	Moderate	Moderate	MAINTAINED?
Lemhi R.	1,000	NA	NA	Moderate	Low	Moderate	Moderate	MAINTAINED?

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity (SS/D) Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	***Natural Spawning Abundance***	***ICTRT Productivity***	***Integrated A/P Risk***	***Natural Processes Risk***	***Diversity Risk***	***Integrated SS/D Risk***	
Pahsimeroi R.	1,000	NA	NA	Moderate	Moderate	Moderate	Moderate	MAINTAINED?
Up Main. Salmon R.	1,000	NA	NA	Moderate	Very Low	Moderate	Moderate	MAINTAINED?

Abundance and productivity. Population-specific adult population abundance is generally not available for the SRB steelhead, due to difficulties conducting surveys in much of their range. Evaluations in the 2015 status review were done using both a set of metrics corresponding to those used in prior BRT reviews, as well as a set corresponding to the specific viability criteria based on ICTRT recommendations for this DPS. The BRT level metrics were consistently done across all ESUs and DPSs to facilitate comparisons across domains. The most recent 5-year geometric mean abundance estimates for the two long-term data series' of direct population estimates (Joseph Creek and Upper Grande Ronde Mainstem populations) both increased compared to the prior review estimates; each of the populations increased an average of 2 percent per year over the past 15 years. Hatchery-origin spawner estimates for both populations continued to be low, and both populations are currently approaching the peak abundance estimates observed since the mid-1980s (Northwest Fisheries Science Center 2015).

Limiting factors. Limiting factors for this species include (NMFS 2011a; 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 LWD 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

Status of Puget Sound Steelhead

The PSTRT produced viability criteria, including population viability analyses, for 20 of 32 DIPs and three MPGs in the DPS (Hard et al. 2015). It also completed a report identifying historical populations of the DPS (Myers et al. 2015). The DIPs are based on genetic, environmental, and life history characteristics. Populations display winter, summer, or summer/winter-run timing (Myers et al. 2015). The TRT concludes that the DPS is currently at "very low" viability, with most of the 32 DIPs and all three MPGs at "low" viability.

The designation of the DPS as “threatened” is based upon the extinction risk of the component populations. Hard et al. (2015), identify several criteria for the viability of the DPS, including that a minimum of 40 percent of summer-run and 40 percent of winter-run populations historically present within each of the MPGs must be considered viable using the VSP-based criteria. For a DIP to be considered viable, it must have at least an 85 percent probability of meeting the viability criteria, as calculated by Hard et al. (2015).

We are developing a recovery plan for this species.

Spatial structure and diversity. The PS steelhead DPS is the anadromous form of *O. mykiss* that occur in rivers, below natural barriers to migration, in northwestern Washington State that drain to Puget Sound, Hood Canal, and the Strait of Juan de Fuca between the United States–Canada border and the Elwha River, inclusive. The DPS also includes six hatchery stocks that are considered no more than moderately diverged from their associated natural-origin counterparts: Green River natural winter-run, Hamma Hamma winter-run, White River winter-run, Dewatto River winter-run, Duckabush River winter-run, and Elwha River native winter-run (U.S. Department of Commerce 2014). Steelhead are the anadromous form of *O. mykiss* that occur in rivers, below natural barriers to migration, in northwestern Washington State (Ford 2011). Non-anadromous “resident” *O. mykiss* occur within the range of PS steelhead but are not part of the DPS, due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2007).

DIPs can include summer steelhead only, winter steelhead only, or a combination of summer and winter-run timing (e.g., winter-run, summer-run or summer/winter-run). Most DIPs have low viability criteria scores for diversity and spatial structure, largely because of extensive hatchery influence, low breeding population sizes, and freshwater habitat fragmentation or loss (Hard et al. 2007). In the Central and South Puget Sound and Hood Canal and Strait of Juan de Fuca MPGs, nearly all DIPs are not viable (Hard et al. 2015). More information on PS steelhead spatial structure and diversity can be found in NMFS’ technical report (Hard et al. 2015).

Abundance and productivity. Abundance of adult steelhead returning to nearly all Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent 5-year periods (2005 to 2009 and 2010 to 2014), the geometric mean of estimated abundance increased by an average of 5.4 percent. For seven populations in the Northern Cascades MPG, the increase was 3 percent; for five populations in the Central and South Puget Sound MPG, the increase was 10 percent; and for six populations in the Hood Canal and Strait of Juan de Fuca MPG, the increase was 4.5 percent. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that nine of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults. Between the most recent two 5-year periods (2005 to 2009 and 2010 to 2014), several populations showed increases in abundance between 10 and 100 percent, but about half have remained in decline. Long-term (15-year) trends in natural spawners are predominantly negative (Northwest Fisheries Science Center 2015).

There are some signs of modest improvement in steelhead productivity since the 2011 review, at least for some populations, especially in the Hood Canal and Strait of Juan de Fuca MPG. However, these modest changes must be sustained for a longer period (at least two generations) to lend sufficient confidence to any conclusion that productivity is improving over larger scales across the DPS. Moreover, several populations are still showing dismal productivity, especially those in the Central and South Puget Sound MPG (Northwest Fisheries Science Center 2015).

Little or no data are available on summer-run populations to evaluate extinction risk or abundance trends. Because of their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored.

Limiting factors. In our 2013 proposed rule designating critical habitat for this species (U.S. Department of Commerce 2013b), we noted that the following factors for decline for PS steelhead persist as limiting factors:

- The continued destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania)
- Declining diversity in the DPS, including the uncertain but weak status of summer-run fish
- A reduction in spatial structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of LWD
- Increased flood frequency and peak flows during storms and reduced groundwater-driven summer flows, with resultant gravel scour, bank erosion, and sediment deposition, in the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred.
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, increasing the likelihood of gravel scour and dislocation of rearing juveniles

2.2.2 Status of the Critical Habitats

This section examines the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential PBFs throughout the designated areas. These features are essential to the conservation of the listed species because they support one or more 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 HUC_5 scale in terms of the conservation value they provide to each listed species they support.[3] 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 (e.g., 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 PBFs of freshwater spawning and incubation sites include water flow, quality and temperature conditions, and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles (Tables 11 and 12). These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The PBFs 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.

[3] 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. 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, editor, Portland, Oregon..

Table 11. Physical and biological features of critical habitats designated for Endangered Species Act-listed salmon and steelhead species considered in the opinion (except for Snake River [SR] spring/summer-run Chinook salmon and SR fall-run Chinook salmon, which are found in the next table), and corresponding species life history events.

Physical and Biological Features		
Site Type	**Site Attribute**	**Species Life History Event**
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 12. Physical and biological features of critical habitats designated for Snake River (SR) spring/summer-run Chinook salmon and SR fall-run Chinook salmon, and corresponding species life history events.

Physical and Biological Features		**Species Life History Event**
Site	**Site Attribute**	
Spawning and juvenile rearing areas	Cover/shelter Food (juvenile rearing) Riparian vegetation Space (Chinook, coho) Spawning gravel Water quality 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

Critical Habitat Analytical Review Team salmon and steelhead critical habitat assessments. The CHART for each recovery domain assessed biological information pertaining to habitat occupied by listed salmon and steelhead, determined whether those areas contained PBFs 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 CHART assigned a 0 to 3 point score for the PBFs 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
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 PBFs in the HUC_5 watershed; and Factor 3 (quality–potential condition), which considers the likelihood of achieving PBF potential in the HUC_5 watershed, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility.

Puget Sound recovery domain. Critical habitat has been designated in Puget Sound for PS Chinook salmon, HC summer-run chum salmon, LO sockeye salmon, and PS steelhead. Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, Dungeness rivers, and Soos Creek.

Landslides can occur naturally in steep, forested lands, but inappropriate land use practices likely have accelerated their frequency and the amount of sediment delivered to streams. Fine sediment from unpaved roads has also contributed to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and LWD recruitment (Shared Strategy for Puget Sound 2007).

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and LWD. The loss of side channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish, and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water which ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Forest wetlands are estimated to have diminished by one-third in Washington State (Forest Ecosystem Management Assessment Team 1993; Shared Strategy for Puget Sound 2007; Spence et al. 1996).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of turbidity, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (Shared Strategy for Puget Sound 2007).

Peak stream flows have increased over time, due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (Shared Strategy for Puget Sound 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho spawner mortality, likely due to runoff containing contaminants emitted from motor vehicles (Feist et al. 1996).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected PS Chinook salmon populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat (e.g., Elwha River dams block anadromous fish access to 70 miles of potential habitat), changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and LWD to downstream areas (Shared Strategy for Puget Sound 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system (Washington Department of Fish and Wildlife 2009). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (Shared Strategy for Puget Sound 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of PS's tributaries. A railroad runs along large portions of the eastern shoreline of PS, eliminating natural cover along the shore and natural recruitment of beach sand (Shared Strategy for Puget Sound 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late-summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (Hood Canal Coordinating Council 2005; Shared Strategy for Puget Sound 2007).

The Lake Ozette tributary basin covers 77 square miles and includes several large tributaries and numerous smaller tributaries. Currently, land ownership in the watershed is 73 percent private land, 15 percent Olympic National Park, 11 percent Washington State, and 1 percent tribal. Natural disturbance in the watershed was dominated by wind and hydrogeomorphic events, while contemporary disturbance additionally includes logging, road construction and maintenance, residential and agricultural development, stream channelization, and direct and indirect stream wood clearance. These activities alter stream flow patterns and elevate sediment loads and sedimentation. Wood removal has resulted in less hydraulic roughness, reduced instream water depths, and reduced backwater effects on Lake Ozette, which has thus altered the entire hydraulic control on Lake Ozette levels and changed the in-river stage–discharge relationship. More recently, deposition of sediment originating from Coal Creek at the lake outlet has further altered lake and river levels (Haggerty et al. 2009).

Private timber companies own approximately 93 percent of the four largest tributary watersheds to Lake Ozette. Logging accelerated over the period of record, with 8.7 percent of the Lake Ozette basin clear cut by 1953, increasing to 83.6 percent of the basin area clear cut by 2003 (Haggerty et al. 2009). Effects associated with logging depended on stream size, gradient, and time elapsed. In high-energy coast streams, landslides and debris torrents often modify steep slope tributaries and the mainstem of creeks. Bank erosion also alters stream channels on alluvial floodplains. These effects are additive in the system and reduced the quality of spawning and rearing habitat for juvenile salmonids (Hartman et al. 1996). Lower gradient streams typically have an accumulation of sediment. Second-growth logged sections (12 to 35 years after logging), re-shaded by deciduous forest canopy, have lower biomass of trout and fewer predator taxa than old-growth sites (Murphy and Hall 1981). Based on the quantity and quality of the PBFs, the CHART assessed the conservation value of the Lake Ozette HUC_5 watershed (#1710010102) for sockeye salmon to be “high” (NOAA Fisheries 2005).

In summary, critical habitat throughout the Puget Sound basin has been degraded by numerous management activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of LWD, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common limiting factors in areas of critical habitat.

The Puget Sound recovery domain CHART (NOAA Fisheries 2005) determined that only a few watersheds with PBFs for Chinook salmon in the Whidbey Basin (Skagit River/Gorge Lake, Cascade River, Upper Sauk River, and the Tye and Beckler rivers) are in good-to-excellent condition with no potential for improvement. Most HUC_5 watersheds are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or a high potential for improvement (Table 13).

Table 13. Puget Sound Recovery Domain: Current and potential quality of fifth-field hydrologic unit code (HUC_5) watersheds identified as supporting historically independent populations of Endangered Species Act-listed Chinook salmon (CK) and chum salmon (CM) (NOAA Fisheries 2005). Watersheds are ranked primarily by “current quality” and secondly by their “potential for restoration.”

Current PBF Condition	Potential PBF 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
Strait of Georgia and Whidbey Basin #1711000xxx			
Skagit River/Gorge Lake (504), Cascade (506) & Upper Sauk (601) rivers, Tye & Beckler rivers (901)	CK	3	3
Skykomish River Forks (902)	CK	3	1

Current PBF Condition	Potential PBF 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
Skagit River/Diobsud (505), Illabot (507), & Middle Skagit/Finney Creek (701) creeks; & Sultan River (904)	CK	2	3
Skykomish River/Wallace River (903) & Skykomish River/Woods Creek (905)	CK	2	2
Upper (602) & Lower (603) Suiattle rivers, Lower Sauk (604), & South Fork Stillaguamish (802) rivers	CK	2	1
Samish River (202), Upper North (401), Middle (402), South (403), Lower North (404), Nooksack River; Nooksack River (405), Lower Skagit/Nookachamps Creek (702) & North Fork (801) & Lower (803) Stillaguamish River	CK	1	2
Bellingham (201) & Birch (204) bays & Baker River (508)	CK	1	1
Whidbey Basin and Central/South Basin #1711001xxx			
Lower Snoqualmie River (004), Snohomish (102), Upper White (401) & Carbon (403) rivers	CK	2	2
Middle Fork Snoqualmie (003) & Cedar rivers (201), Lake Sammamish (202), Middle Green River (302) & Lowland Nisqually (503)	CK	2	1
Pilchuck (101), Upper Green (301), Lower White (402), & Upper Puyallup River (404) rivers, & Mashel/Ohop(502)	CK	1	2
Lake Washington (203), Sammamish (204) & Lower Green (303) rivers	CK	1	1
Puyallup River (405)	CK	0	2
Hood Canal #1711001xxx			
Dosewallips River (805)	CK/CM	2	1/2
Kitsap–Kennedy/Goldsborough (900)	CK	2	1
Hamma Hamma River (803)	CK/CM	1/2	1/2
Lower West Hood Canal Frontal (802)	CK/CM	0/2	0/1
Skokomish River (701)	CK/CM	1/0	2/1
Duckabush River (804)	CK/CM	1	2
Upper West Hood Canal Frontal (807)	CM	1	2
Big Quilcene River (806)	CK/CM	1	1/2
Deschutes Prairie-1 (601) & Prairie-2 (602)	CK	1	1
West Kitsap (808)	CK/CM	1	1
Kitsap–Prairie-3 (902)	CK	1	1
Port Ludlow/Chimacum Creek (908)	CM	1	1
Kitsap–Puget (901)	CK	0	1
Kitsap–Puget Sound/East Passage (904)	CK	0	0
Strait of Juan de Fuca Olympic #1711002xxx			
Dungeness River (003)	CK/CM	2/1	1/2
Discovery Bay (001) & Sequim Bay (002)	CM	1	2
Elwha River (007)	CK	1	2
Port Angeles Harbor (004)	CK	1	1

PBF = Physical and Biological Feature

Willamette–Lower Columbia recovery domain. Critical habitat was designated in the Willamette–Lower Columbia recovery domain for UWR Chinook salmon, LCR Chinook salmon, LCR coho salmon, LCR steelhead, UWR steelhead, CR chum salmon, southern green sturgeon, and eulachon. 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.

Land management activities have severely degraded stream habitat conditions in the Willamette River mainstem above Willamette Falls and in associated subbasins. In the Willamette River mainstem and lower sub-basin mainstem reaches, high density urban development and widespread agricultural effects have reduced aquatic and riparian habitat quality and complexity, and altered sediment and water quality and quantity, and watershed processes. The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75 percent. In addition, the construction of 37 dams in the basin 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. Logging in the Cascade and Coast Ranges, and agriculture, urbanization, and gravel mining on valley floors have contributed to increased erosion and sediment loads throughout the WLC domain.

The mainstem Willamette River has been channelized and stripped of LWD. 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. 2002b). They noted that the lower reach from the mouth of the river to Newberg [river mile (RM) 50] is confined within a basaltic trench and that, due to this geomorphic constraint, less channel area has been lost than in upstream areas. The middle reach from Newberg to Albany (RM 50 to 120) incurred losses of 12 percent of primary channel area, 16 percent of side channels, 33 percent of alcoves, and 9 percent of island area. Even greater changes occurred in the upper reach, from Albany to Eugene (RM 187). There, approximately 40 percent of both channel length and channel area were lost, along with 21 percent of the primary channel, 41 percent of side channels, 74 percent of alcoves, and 80 percent of island areas.

The banks of the Willamette River have more than 96 miles of revetments; approximately half were constructed by the U.S. Army Corps of Engineers (USACE). Generally, the revetments were placed in the vicinity of roads or on the outside bank of river bends, so that while only 26 percent of the total length is revetted, 65 percent of the meander bends are revetted (Gregory et al. 2002c). 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. 2002c).

Riparian forests have diminished considerably in the lower reaches of the Willamette River (Gregory et al. 2002a). Sedell and Froggatt (1984) noted that agriculture and cutting of streamside trees were major agents of change for riparian vegetation, along with snagging of LWD 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 (Fernald et al. 2001; Wentz et al. 1998). 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 Federal Columbia River Power System (FCRPS), have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; National Marine Fisheries Service 2013; NMFS 2011b). 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; National Marine Fisheries Service 2013; NMFS 2011b). 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 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; National Marine Fisheries Service 2013; NMFS 2011b). Edges of marsh areas provide sheltered habitats for juvenile salmon and steelhead where food, in the form of amphipods or other small invertebrates that 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 percent reduction in emergent vegetation production and a 15 percent 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; National Marine Fisheries Service 2013; NMFS 2011b). Diking and filling have reduced the tidal prism and eliminated 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 toxins 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 dichlorodiphenyltrichloroethane (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 capacity to support salmon, although historical changes in population structure and salmon life histories may prevent salmon from making full use of estuarine habitats.

The CHART for the Willamette Lower Columbia (WLC) recovery domain determined that most HUC_5 watersheds with PBFs 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 14). For Lower Columbia River coho salmon, the CHART rated critical habitat conservation value as medium or high for occupied HUC_5 watersheds, with the exception of Riffe and Yale Reservoirs, which were rated low (NMFS West Coast Region 2015).

Table 14. Willamette–Lower Columbia Recovery Domain: Current and potential quality of fifth field-hydrologic unit code (HUC_5) watersheds identified as supporting historically independent populations of Endangered Species Act-listed Chinook salmon (CK), chum salmon (CM), and steelhead (ST) (NOAA Fisheries 2005). Watersheds are ranked primarily by "current quality" and secondly by their "potential for restoration."

Current PBF Condition	Potential PBF 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
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

Current PBF Condition	Potential PBF 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
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”		
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 Interior Columbia (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, 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 (National Marine Fisheries Service 2009; Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas.

Migratory habitat quality in this area has been severely affected by the development and operation of FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation (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.

Hydroelectric development modified natural flow regimes, resulting in higher water temperatures, changes in fish community structure leading to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juveniles. Physical features of dams such as turbines also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Similarly, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles.

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, 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 Interior Columbia 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.

Many stream reaches designated as critical habitat are listed on the state of 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 IC recovery domain is a very large and diverse area. The CHART determined that few watersheds with PBFs 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 PBFs 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_5 watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (Table 15).

Table 15. Interior Columbia Recovery Domain: Current and potential quality of fifth-field hydrologic unit code (HUC_5) watersheds identified as supporting historically independent populations of ESA-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 PBF Condition	**Potential PBF 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

Current PBF Condition	Potential PBF 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
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 Creek (302); Catherine Creek (405); Lostine River (502); Bear Creek (504); & Upper (706) & Lower (707) Tucannon River	ST	2	3
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

Current PBF Condition	Potential PBF 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/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
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) &	ST	2	2

Current PBF Condition	Potential PBF 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 HUC5 Code(s)	Listed Species	Current Quality	Restoration Potential
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			
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) & 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	ST	3	3
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

Current PBF Condition	Potential PBF 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
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			
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

Current PBF Condition	Potential PBF 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 HUC5 Code(s)	Listed Species	Current Quality	Restoration Potential
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"		

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The proposed WS–Washington program applies across Washington State. Therefore, the action area includes fresh water in Washington State (including the adjacent floodplain) that is either occupied by ESA-listed salmonids or designated as critical habitat.

2.4 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)

2.4.1 Freshwater Habitat

While there has been substantial habitat degradation across Washington, habitat in many headwater stream segments is generally in better condition than in the largely privately-owned lower portions of tributaries (Lee et al. 1997). Much of the salmonid spawning and rearing occurs in tributaries where riparian areas are relatively intact and dominated by mature forests, though some of these areas remain affected by the legacy of poor forest management practices.

Beginning in the early 1800s, stream morphologies and riparian areas in the low elevation rivers were extensively changed by human activities such as logging, mining, livestock grazing, agriculture, beaver removal, dams, and irrigation diversions. Additional factors affecting freshwater habitat include transportation infrastructure, industrialization, urbanization, and other development. Very little of the once-extensive riparian vegetation and wetland habitat remains to maintain water quality and provide habitats for ESA-listed species. Introduced (non-native) plant species pose a risk to some riparian habitat by dominating local habitats and reducing the diversity and abundance of native species. Grazing in riparian areas is another significant threat. The width and age of stream-adjacent vegetation decreases in the middle and lower portions of the watersheds, and today less than 20 percent of the riparian vegetation consists of mature trees.

Dams, diversions, and other water control structures have negatively affected several habitat attributes such as hydrographs, minimum flows, sediment, LWD, nutrient transport, side channel and floodplain connectivity, and temperatures. They have also blocked fish passage to suitable habitat, or entrained fish into unsuitable habitat. Habitat changes due to dams have also improved conditions for predators including marine mammals, birds, and both native and introduced fish.

Many salmon recovery plans discuss habitat loss associated with beaver removals extending back to the 1800s and continuing to the present. The WDFW reports an annual average take of 2,584 nuisance and recreationally trapped beavers from 2014–2017 (https://wdfw.wa.gov/hunting/trapping/beaver/). The WS–Washington removed (i.e., killed) an average of about 485 beavers per year during that period, or about 19 percent of the reported beaver take in Washington. In addition, it is likely that not all lethal beaver removal is reported. There are no data on current beaver population numbers or trends in Washington (Sarah Kindschuh, Small Game and Furbearer Specialist, WDFW, personal communication, September 18, 2018). However, the Washington Natural Heritage Program rates beaver as "Secure" in Washington (i.e., at very low or no risk of extirpation in the state due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats) (https://www.dnr.wa.gov/publications/amp_nh_animals_ranks.pdf?nrdnxkw).

Several groups have been active in beaver conservation and relocation projects in Washington. In response to the need for beaver reintroductions identified in the Upper Columbia River Salmon and Steelhead Recovery Plan, the MBP re-establishes active beaver colonies to streams in the Methow River sub-basin. Through 2015, 30 of 61 (49 percent) of the MBP's beaver release sites were determined successful, though success was not defined (Woodruff 2016). During 2016–17, 10 of 23 (43 percent) of the MBP's release sites were considered successful (Methow Salmon Recovery Foundation et al. 2018). They defined success as the persistence of the beavers for more than a year. Based on site reviews, however, the MBP found that even in the absence of continued beaver presence, the benefits of their initial occupancy persisted, suggesting that their view of success needed to be revised (Methow Salmon Recovery Foundation et al. 2018). The Mid-Columbia Fisheries Enhancement Group (MCFEG) has also successfully relocated beavers into tributaries of the upper Yakima River. The MCFEG classified 16 of the 45 (35 percent) colonies relocated between 2011 and 2014 as successful (Babik and Meyer 2015). They defined relocations as successful when the beavers remained at or near the relocation site for at least 1 year and constructed and maintained beaver-built infrastructure (e.g., dam, lodge, bank den). The [Sky Beaver Project](http://www.beaversnw.org/conservation.html) (http://www.beaversnw.org/conservation.html) is exploring how beavers can be used as restoration tools to increase the health of streams in western Washington, where they relocate nuisance beavers to the Skykomish River watershed.

Currently, there are limited data quantifying how these relocations have improved salmon and steelhead habitat, but, due to the widespread ecological benefits of beaver dams (Pollock et al. 2017), the establishment of new beaver colonies within the range of ESA-listed salmonids is likely to be beneficial to those fish. Babik and Meyer (2015) measured a sample of 11 relocated beaver colonies in the Yakima Basin in 2015. These 11 colonies resulted in 24 new pools, 365 m (1,198 ft.) of increased edge habitat and cover for juvenile fish, reconnected floodplains and side channels, and 24.6 million gallons of water stored. All of these enhanced habitat features would benefit juvenile salmonids, including MCR steelhead in the Yakima Basin. Successful beaver relocations to other drainages occupied by ESA-listed salmonids across the action area are also likely to enhance juvenile salmonid habitat, helping to offset potential habitat loss at beaver removal sites.

2.4.2 Water Quality

Water quality throughout much of the program action area is degraded to various degrees from several sources including aerial deposition, wastewater treatment plant effluents, stormwater runoff, agricultural practices, industrial effluents, and others. The full presence of contaminants throughout the program action area is poorly understood, but the concentration of many increase in downstream reaches (Fuhrer et al. 1996; Johnson et al. 2013; Johnson et al. 2005; Morace 2012). Both the physical and chemical properties of water are affected. For example, the most common increase in 303(d) listings (water bodies that are considered “impaired” under the Clean Water Act) in Washington in the past decade are related to high stream temperatures.

Although the state regulates most activities that affect water quality, the baseline condition includes a legacy of past actions. Johnson et al. (2013) frequently found PCBs and DDT in juvenile salmon and salmon diet samples from the lower Columbia River and estuary. In some cases, concentrations in salmon were above estimated thresholds for effects on growth and survival. These chemicals have not been produced in the United States since the 1970s, but are still present in sediments throughout the action area.

In a typical year in the United States, pesticides are applied at a rate of approximately 5 billion pounds of active ingredients per year (Kiely et al. 2004). Therefore, pesticide contamination in the nation’s freshwater habitats is ubiquitous and pesticides usually occur in the environment as mixtures.

2.4.3 Physical Barriers

ESA-listed species and critical habitat within the action area have been affected by the development and operation of the FCRPS as well as dams that are owned and operated by public utility districts and Reclamation. Storage dams have eliminated spawning and rearing habitat and have altered the natural hydrograph, decreasing spring and summer flows and increasing fall and winter flows. This has virtually reversed the natural hydrograph on rivers such as the Yakima, Snake, and Columbia Rivers. Water storage for flood control and withdrawal for irrigation cause river elevations and flows to fluctuate, affecting fish movement through reservoirs, affecting riparian ecology, and stranding fish in shallow areas. The eight dams in the migration corridor of the Snake and Columbia Rivers alter salmonid smolt emigration and adult immigrations. Dams have also converted the once-swift river into a series of slow-moving reservoirs. Water velocities throughout the migration corridor now depend far more on volume runoff than before construction of the mainstem reservoirs.

Existing road systems affect the environmental baseline condition. Roads that parallel streams have degraded stream bank conditions through rip rap armoring of the banks, have decreased floodplain connectivity through the addition of fill in floodplains, and have impaired water quality through the discharge of untreated or marginally treated stormwater runoff to streams.

Culvert and bridge crossings can act as physical or hydraulic barriers, preventing fish access to spawning or rearing habitat, and contribute to adverse stream morphology changes upstream and downstream of the crossing. Tide gates and water control structures that were installed to drain wetlands and floodplains for farming and development have resulted in the loss of nearly 90 percent of historic estuarine, off-channel, and wetland rearing habitats.

The environmental baseline also includes the anticipated impacts of all federal actions in the action area that have already undergone formal consultation. For example, since implementation of the first USACE Fish Passage and Restoration Programmatic in 2008, the USACE approved 271 salmon habitat restoration and fish passage projects, averaging 45 projects per year. Under the Standard Local Operating Procedures for Endangered Species (SLOPES) IV programmatic consultation, the USACE authorized 229 restoration actions and 223 other actions related to transportation features, over and in-water structures, and streambank stabilization, from 2008 through September 2011 (National Marine Fisheries Service 2008b). The USACE, Bonneville Power Administration, and Reclamation have also consulted on large water management actions, such as operation of the FCRPS, the Umatilla Basin Project, and the Deschutes Project. The USFS consults on federal land management throughout Washington, including restoration actions, timber harvest, livestock grazing, and special use permits. After completing consultation, many ongoing actions, such as water management, have less impact on listed salmon and steelhead, while the restoration actions will improve the environmental baseline over time.

Finally, the Federal Emergency Management Agency consulted with NMFS on implementation of the National Flood Insurance Program (NFIP) in the Puget Sound area in Washington State. NMFS determined the NFIP was likely to jeopardize the continued existence of the PS Chinook salmon, HC summer-run chum salmon, and PS steelhead ESUs. The NMFS also concluded that implementation of the NFIP was likely to destroy or adversely modify designated critical habitats of PS Chinook salmon, and HC summer-run chum salmon (National Marine Fisheries Service 2008a). Therefore, NMFS issued a reasonable and prudent alternative (RPA) for the Federal Emergency Management Agency (FEMA) to implement to avoid jeopardy and adverse modification of critical habitat. Through FEMA's implementation of the RPA, levee vegetation and new levee and floodwall standards will result in enhanced edge shoreline habitat, increasing the value of habitat for juvenile salmonid rearing. In addition, Hazard Mitigation grant funding and the Flood Mitigation Assistance Program will be used for projects that both reduce flood losses and enhance floodplain habitat, which NMFS expects will result in long-term benefits to listed species. Other RPA elements will increase riparian function, enlarge areas of floodplain function, mitigate for stormwater runoff, mitigate for development in floodplains, and enhance floodplain connectivity. NMFS concluded that these mitigation action effects would increase the likelihood of salmonid recovery.

2.5. Effects of the Action

Under the ESA, "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 still are reasonably certain to occur.

2.5.1 Effects to Species

ESA Species Presence in the Action Area

Due to the large geographic area covered under this programmatic consultation, we assume that ESA-listed fish could be present within the area affected by any Aquatic Mammal Damage Management project that occurs within or in close proximity to critical habitat or other habitat occupied by ESA-listed salmonids.

Direct Effects

Direct effects of the proposed action associated with beaver, muskrat, mink, nutria, and river otter will cause little, if any, disturbance to the aquatic environment. If they are exposed to WS–Washington personnel near or in the water, individual fish may be temporarily displaced. Fish on redds will not be disturbed and redds will be avoided. Personnel might also generate minor amounts of suspended sediment during management activities at some sites. Both of these effects will be short-term and not likely to injure, harm, or reduce the fitness of any individual salmon or steelhead or critical habitat.

Indirect Effects

Actions associated with beaver removal have the potential to indirectly affect salmon and steelhead. We discuss these effects below.

Beaver dam effects on stream ecology and salmonid habitat. Pollock et al. (2017); (2003) have completed extensive reviews of how beaver dams can affect the hydrology, water quality, and geomorphology of streams. Beaver dams can play a critical role in replenishing alluvial aquifers by trapping and storing water, redirecting surface water onto adjacent floodplains, and forcing water into the streambed and banks. Beaver dams slow stream flows, holding the water within the stream reach for longer periods, which can increase base flows. Beaver dams create surface pools and ponds, transforming moving-water habitats to a combination of moving- and slow-water habitat and can lead to an expansion of riparian and wetland habitats along streams. Beaver ponds can add habitat complexity, including variation in temperatures, depths, and velocities, as well as potential prey diversity (McDowell and Naiman 1986; Wathen et al. 2018; Weber et al. 2017). In summary, these changes can result in increased and enhanced salmonid habitat.

Beaver dams may also have less obvious positive influences on salmonid habitat, such as by reducing or preventing channel incision. Pollock et al. (2007) suggested beaver trapping and subsequent intensive sheep and cattle grazing in the mid-19th and early 20th centuries as a mechanism for widespread channel incision in the Columbia River basin. Channel incision can lower stream-adjacent water tables, with a subsequent loss of riparian vegetation. The lowered water tables also reduce groundwater inputs to the stream, which can reduce or eliminate base flows, and lead to increased summer stream temperatures. Also, with no access to floodplains, high flows are concentrated within the incised channel, and fish have no access to slow-water refugia during floods. In contrast, numerous studies suggest that when local water tables of incised streams are raised, usually through the construction of beaver dams or small human-made dams, flows increase and intermittent streams become perennial (reviewed by Pollock et al. 2007).

Current information does not universally support beaver ponds as wholly beneficial to salmonids in every situation. One study by Malison et al. (2016) estimated that, if beavers were not present on the Kwethluk River, floodplain habitats would be fully interconnected and theoretically could produce two times the biomass and rear three times the number of salmon compared to the existing condition with beaver dams present. This study was on a large Alaskan river, however, which may not be applicable to many river systems in Washington. Collen and Gibson (2001) report that beaver dams built at culverts could prevent fish passage.

Nevertheless, it is reasonable to conclude that, overall, the published science applicable to the action area documents a predominantly positive effect of beaver dams related to juvenile salmonid rearing, because they can increase suitable habitat area and add habitat complexity to streams.

This assessment is reflected in and reinforced by applicable recovery plans. For example, the Upper Columbia spring Chinook salmon and steelhead recovery plan encourages beaver re-population (Upper Columbia Salmon Recovery Board 2007b). More specifically, the Regional Technical Team's "Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region" calls for beaver recolonization in the middle and upper Methow, lower Chewuch and lower Twisp Rivers (Upper Columbia Regional Technical Team 2017). In the Water Resource Inventory Area (WRIA) 1 salmonid recovery plan, which includes the Nooksack River watershed and Drayton Harbor tributaries, one of the recovery strategies is to reintroduce beavers and/or discourage removal of beavers or destruction of beaver dams (WRIA 1 Salmon Recovery Board 2005). The Lower Columbia River recovery plan lists beaver ponds as one of the key active rearing habitats for coho salmon, and fall and spring Chinook salmon. One of the plan's recovery strategy elements is tributary habitat restoration (particularly overwintering habitat), to the point that each subbasin can support coho salmon at the target status for that population (National Marine Fisheries Service 2013). Thus, beaver reintroduction is not specifically called for, but the importance of beaver-enhanced salmonid habitat is implied.

Beaver removal sites where indirect adverse effects will not occur. Under the proposed action, some beaver removal from ESA-listed salmonid habitat will occur without adverse effects to the fish or their habitat. At sites where the beavers would not build dams due to the geography of the site, i.e., stream channels greater than 33 feet wide (Suzuki and McComb 1998) and in lakes, the proposed action will not impact salmonid habitat, because it is the dams that provide the habitat and, here, there would be none. At sites where there are infrastructure and safety concerns as determined by engineers or road supervisors, beaver dams will be removed regardless of whether the beavers are removed. Even if the beavers were left and re-built the dam, the dam would create the same infrastructure or safety concern as in the first instance and so would get removed again. Thus, the beaver removal does not translate into a loss of salmonid habitat because there's no causal relationship between this element of the proposed action and the loss of dam-related salmonid habitat. At some habitat restoration sites, beavers cut down trees and shrubs that were planted to restore the riparian zone. Beaver removal from these sites will not adversely affect salmonids because the animals are hindering efforts to improve salmonid habitat.

Beaver removal sites where indirect adverse effects will occur. Under the proposed action, some beavers will be removed from sites where their dam would otherwise increase, maintain, or improve salmonid habitat. Under the proposed action, this will include no more than 20 sites over any given 5-year period, and no more than three sites within any given HUC_6 over any given 5-year period. After beaver removal, existing habitat features will degrade, or the development of such features will cease because the beavers will not be there to maintain their existing dams or build new ones (Pollock et al. 2017). This reduction in rearing habitat area will force some juvenile salmonids to move elsewhere to find adequate forage and cover. Some fish will be more susceptible to predation and die. Some fish will expend more energy searching for food or cover, resulting in slower growth. Slower-growing individuals will be more susceptible to predation and have decreased chances for overwinter survival. Thus, some salmonids in the action area will experience harm and potential death, due to the indirect effects of beaver removal.

Indirect adverse effects to Puget Sound, Lower Columbia River, Upper Columbia spring-run, Snake River fall-run, and Snake River spring/summer-run Chinook salmon. Chinook salmon are often referred to as having two main life history types: those that migrate to the ocean during their first spring and summer after hatching ("ocean type"), and those that rear for a year in freshwater before emigrating to the ocean ("stream type"). However, the traditional model describing Chinook salmon life-histories as simply "ocean-type" or "stream-type" is being challenged with descriptions that more fully accommodate the diversity of life-history pathways (Bourret et al. 2016). For the purpose of this analysis, although several different Chinook salmon ESUs along with numerous life-history variations are under consideration, we have no reason to doubt that they all share the potential to rear in habitat that is conducive to enhancement by beaver dams.

Juvenile Chinook salmon have been documented using beaver-enhanced habitat, but possibly to a lesser degree than coho salmon. In the Fish Creek basin, Oregon, on the west slope of the Cascade Range, Everest et al. (1986) found Chinook salmon juveniles in beaver ponds, but in low densities (0.04 fish/m^2). However, they noted that Age-0 Chinook salmon are not abundant in the Fish Creek system because most fry emigrate to the Clackamas River soon after emergence. Malison et al. (2015) found higher densities of Chinook salmon juveniles in beaver-free spring brooks than in early-successional beaver ponds on the Kwethluk River, Alaska floodplain. Murphy et al. (1989) found that Chinook salmon were virtually absent from beaver ponds and upland sloughs in the Taku River, Alaska.

In summary, there is evidence that juvenile Chinook salmon use beaver ponds. If beaver are removed, existing habitat features will degrade, or the development of such features will cease because the beavers will not be there to maintain their existing dams or build new ones (Pollock et al. 2017). This reduction in rearing habitat area will force some juvenile Chinook salmon to move elsewhere to find adequate forage and cover. Some fish will be more susceptible to predation and die. Some fish will expend more energy searching for food or cover, resulting in slower growth. Slower-growing individuals will be more susceptible to predation and have decreased chances for overwinter survival. Thus, some juvenile Chinook salmon in the action area will experience harm and potential death, due to the indirect effects of beaver removal.

Pollock et al. (2004) reported an average beaver pond area for the Stillaguamish River, Washington of 1,405 m^2 (15,123 ft^2), Babik and Meyer (2015) reported an average beaver pond area for the Yakima Basin of 670 m^2 (7,215 ft^2), and Nickelson et al. (1992) reported an average beaver pond area of 450 m^2 (4,844 ft^2) for Oregon coastal river basins. We used an average of these three values (9,061 ft^2) as an estimate of the potential loss of rearing habitat at beaver removal sites.

We are unaware of any empirical data for juvenile Chinook salmon densities in beaver ponds in Washington. Using the age-0 Chinook salmon density of 0.018 fish/ft^2 reported by Mullan et al. (1992), an average fry-to-smolt survival rate of 0.101 (Quinn 2005), and the maximum wild smolt-to-adult survival rate of 0.024 reported by McCann et al. (2017), we estimate that the average beaver pond (9,061 ft^2) would support 17 Chinook salmon smolts, which is 0.40 adult equivalents.

WS–Washington proposes to not remove beavers from more than 20 sites over any given 5-year period, which would be an average of four sites per year (i.e., 20 sites/5 years = four sites/year). Based on the available information on the geographic dispersal of past beaver removal locations, it is extremely unlikely that four (or more) sites will occur within the range of any one ESA-listed salmonid population in any given year. WS–Washington also proposes to not remove beavers from more than three sites within any HUC_6 over any given 5-year period. Based on the geographic dispersal of past beaver removal locations, we believe it is highly unlikely that three removal sites would occur within any HUC_6 within the same year. However, we assume this situation as the worst-case scenario of potential effects to any one population in a year. In this case, if WS–Washington were to remove beavers from three sites within the same HUC_6 in 1 year, this would be 1.2 Chinook salmon adult equivalents, which we believe would be the maximum effect to any one population in any 1 year under the proposed action. These calculations are also based on another worst-case scenario, i.e., we assumed that all juvenile Chinook salmon affected would die. This is highly unlikely because the wetted stream channel portion of the area ponded by a beaver dam would still remain to provide some rearing habitat after the dam is destroyed. In addition, we expect some fish would survive the predation risk and find rearing habitat off site, though possibly of lower quality.

In summary, we calculated our adult equivalent estimates to show the possible magnitude of effects under a worst-case scenario. As we discussed in the previous paragraph, these adult equivalent estimates are likely inflated, though we do not know by how much. In addition, in most cases, WS–Washington removes beavers from sites of recent beaver activity, and not as a result of dams in existence for greater than a year. In cases where beavers are removed from sites where dams have not yet been built, pond habitat would not exist, so there would be no loss of existing habitat, but there would be the lost potential for it.

Indirect adverse effects to Hood Canal summer-run chum salmon. HC summer-run chum salmon typically spawn in the lowest reaches of their natal streams. This characteristic may reflect an adaptation to low flows present during their late summer/early fall spawning ground migration timing (predominately in September and October), which confines spawning to areas with sufficient water volume. Spawning in lower river reaches during low flows, however, confines incubating eggs to center channel areas, exposing the eggs to increased risk of egg pocket scouring during freshets (Washington Department of Fish and Wildlife and Point No Point Treaty Tribes 2000).

Beaver dams can dampen peak flows (Pollock et al. 2003), which could reduce the threat of redd scouring. Historic conversion of the lowland valleys from beaver pond wetlands and forested bogs to pasturelands may have increased the duration and magnitude of peak flows in Chimacum Creek, while channelization and the removal of logjams, debris, and beaver dams resulted in a loss of channel complexity and bed stability in the Tahuya River. These situations have made redds more susceptible to scouring in both of these HC summer-run chum salmon streams (Hood Canal Coordinating Council 2005). Beaver removals and subsequent loss of beaver dams could increase the chances of redd scouring, but we are unaware of any empirical data to support this hypothesis.

Beaver dams can also increase base flows (Pollock et al. 2017; Pollock et al. 2003), which could be beneficial for HC summer-run chum salmon. For example, dryer weather conditions since 1977 have resulted in lower stream flows during the summer chum spawning period and higher flood flows during incubation (October through March) for the Hood Canal and the Strait of Juan de Fuca region (Washington Department of Fish and Wildlife and Point No Point Treaty Tribes 2000). However, we have no evidence that beaver dams are helping increase base flows for HC summer-run chum salmon. In contrast, Lestelle et al. (2018) reported that chronic low-water conditions and extensive beaver dam activity have resulted in years where no summer chum are observed in the Anderson spawning aggregation. This implies that the dams are not increasing base flows, and may be hindering HC summer-run chum salmon from completing their life cycle.

Beaver dams have the potential to obstruct adult HC summer-run chum salmon passage to upstream spawning habitat. For example, a series of dams on the Little Quilcene River is completely blocking upstream passage. On some HC summer-run chum salmon streams (e.g., Snow Creek), beaver dams are notched to provide adult passage. (Cheri Scalf, Scientific Technician, WDFW, personal communication, October 3, 2018).

The life history of chum salmon indicates that juveniles are probably not dependent on beaver-enhanced habitat. Washington Department of Fish and Wildlife and Point No Point Treaty Tribes (2000) reported that when the fry emerge from redds, they immediately commence migration downstream to estuarine areas. However, through fry-trapping studies, WDFW has trapped some relatively larger fry (though a small proportion of the total catch), indicating that some individuals are feeding and growing in the natal stream a short time before they emigrate (Cheri Scalf, Scientific Technician, WDFW, personal communication, October 3, 2018). Therefore, we cannot rule out that a small proportion of HC summer-run chum salmon fry could incidentally use beaver pond habitat for feeding and cover for short periods.

Given the limited and somewhat contradictory information on the potential effects of beaver removal on HC summer-run chum salmon, we are uncertain about the effects of the proposed action. However, we expect very little beaver removal activity in HC summer-run chum salmon streams. WS–Washington could not recall any instances of beaver removals from HC summer-run chum salmon streams on the Olympic Peninsula (Mike Linnell, State Director, WS–

Washington, personal communication, September 26, 2018) and, based on the geographic spread of past trapping efforts, we expect few sites will occur in HC summer-run chum salmon streams. Therefore, if there are adverse effects to HC summer-run chum salmon due to the proposed action, they will be infrequent across the ESU in general, and not concentrated in any one stream.

Indirect adverse effects to Columbia River chum salmon. The pervasive loss of critical spawning, incubation, and rearing habitat is a primary limiting factor for chum salmon throughout the Lower Columbia subdomain. Chum salmon typically spawn in upwelling areas of clean gravel beds in mainstem and side channel portions of low-gradient reaches above tidewater. These habitats have been practically eliminated in most systems through a combination of channel alteration and sedimentation that is attributable largely to past and current land uses (National Marine Fisheries Service 2013). Chum salmon fry emigrate downstream soon after emergence, which typically occurs from March through May. The fry do not typically have substantial freshwater rearing time (Lower Columbia Fish Recovery Board 2010)

Beaver ponds can improve the status of primary limiting factors for this species. For Washington populations, these limiting factors include impaired side channel and wetland conditions, and degraded floodplain habitat (National Marine Fisheries Service 2013). As stated above, beaver dams can help establish side channels and redirect surface water onto adjacent floodplains, while the ponds expand wetland habitats. Sediment conditions are also identified as a primary limiting factor for all Washington populations in the Coast stratum and for the Cowlitz, Kalama, and Washougal populations. For example, in the Coast stratum, the high density of unimproved rural roads throughout the area leads to an abundance of fine sediment in tributary streams that covers spawning gravel and increases turbidity (National Marine Fisheries Service 2013). Beaver dams can mitigate this effect through sediment storage behind the dams (Green and Westbrook 2009; Naiman et al. 1986; Pollock et al. 2007). In addition, beaver dams can cause upwelling downstream of the dam (Pollock et al. 2007; White 1990). Beaver removals and subsequent loss of beaver dams would potentially negatively affect these limiting factors.

In comparison, beaver dams have been identified as salmonid passage barriers in the lower Columbia region (Lower Columbia Fish Recovery Board 2010). Although chum salmon are strong swimmers, they rarely pass river blockages and waterfalls that pose no hindrance to other salmon or steelhead (Oregon Department of Fish and Wildlife 2010). Beaver dams have been identified as impediments to upstream migration by adult chum salmon on the Grays and Skamokawa rivers (Steve West, Lower Columbia Fish Recovery Board, personal communication, October 9, 2018), but the significance of beaver dams in preventing CR chum salmon access to spawning habitat has not been quantified.

Given the limited and somewhat contradictory information on the potential effects of beaver removal on CR chum salmon, we are uncertain about the effects of the proposed action. However, based on the geographic spread of past trapping efforts, and the fact that, on average, only 4 trapping sites are expected in ESA-listed salmonid habitat any given year (20 sites/5 years = four sites/year), if there are adverse effects to CR chum salmon due to the proposed action, they will be infrequent across the ESU in general, and not concentrated in any one stream.

Indirect adverse effects to Lower Columbia River coho salmon. Coho historically utilized almost every accessible stream tributary in the lower Columbia River. Coho particularly favor small, rain-driven, lower-elevation streams characterized by relatively low flows during late summer and early fall, and increased river flows and decreased water temperatures in winter (Lower Columbia Fish Recovery Board 2010). Juveniles typically rear in freshwater for more than a year. After emergence, coho fry move to shallow, low-velocity rearing areas, primarily along the stream edges and in side channels. Key active rearing areas include relatively slow-water habitat types, often near velocity shears, often associated with relatively low-gradient stream channel reaches, including primary pools, backwaters, tailouts, glides, and beaver ponds (National Marine Fisheries Service 2013). Juvenile coho favor pool habitat and often congregate in quiet backwaters, side channels, and small creeks with riparian cover and woody debris. Side channel rearing areas are particularly critical for overwinter survival of coho, which is also a key regulator of freshwater productivity (Lower Columbia Fish Recovery Board 2010).

In small tributary streams in Alaska, Bryant (1983) found more juvenile coho per unit length of stream in beaver ponds than in up- and downstream stream sections, but densities were usually lower in ponds. The ponds, however, dramatically increased the unit area per length of stream. Bryant (1983) observed that the overall effect of beaver ponds is to add another dimension to the stream system and to increase stream habitat heterogeneity. Everest et al. (1986) reported that beaver ponds were the preferred habitat of juvenile coho salmon in the Fish Creek Basin, Oregon, in summer. They determined that beaver ponds, glides, and side channels were the most productive summer rearing habitats in the system for coho salmon, which combined, constituted about 16 percent of total habitat.

Murphy et al. (1989) documented the highest mean densities of coho salmon were in beaver ponds and upland sloughs. They reported that mean fork length of coho salmon was longer in beaver ponds than in other habitats, which they attributed to warmer temperatures in the ponds. In September, young-of-the-year coho salmon in beaver ponds were 10–15 mm (0.4-0.6 in.) longer than those in beaver-influenced and beaver-free spring brooks on the Kwethluk River, Alaska floodplain, but densities were highest in beaver-free spring brooks (Malison et al. 2015).

In two Oregon streams, (Leidholt-Bruner et al. 1992) reported that beaver pools added 7 percent more habitat in Cummins Creek and 14 percent more in Cape Creek, which was 12 percent and 22 percent of the total fall pool volume, respectively. They also noted that coho salmon fry density by area and volume did not differ in beaver ponds and non-beaver pools.

A series of unused beaver ponds on a Vancouver Island stream, which was dry in the summer, was an important overwintering area for coho salmon with a survival rate about twice as high as the 35 percent estimated for the entire stream system (Bustard and Narver 1975). In Oregon coastal streams, beaver ponds supported a higher density of juvenile coho salmon in winter (1.28 fish/m^2) compared to other dammed pools (0.49 fish/m^2) (Nickelson et al. 1992). Pollock et al. (2004) found that the decline in beaver populations and subsequent loss of their dams resulted in a 61 percent reduction of summer coho salmon habitat capacity and an 86 percent reduction in overwintering capacity in the Stillaguamish River basin, Washington.

In summary, there is ample evidence that beaver-enhanced habitat (e.g., ponds, side channels) are important to coho salmon ecology. If beaver are removed, existing habitat features will degrade, or the development of such features will cease because the beavers will not be there to maintain their existing dams or build new ones (Pollock et al. 2017). This reduction in rearing habitat area will force some juvenile coho salmon to move elsewhere to find adequate forage and cover. Some fish will be more susceptible to predation and die. Some fish will expend more energy searching for food or cover, resulting in slower growth. Slower-growing individuals will be more susceptible to predation and have decreased chances for overwinter survival. Thus, some juvenile coho salmon in the action area will experience harm and potential death due to the indirect effects of beaver removal.

We are unaware of any empirical data for coho densities in beaver ponds in Washington. We used an average of the juvenile coho salmon densities in beaver ponds reported by Leidholt-Bruner et al. (1992) ($0.34/m^2$) and Everest et al. (1986) ($1.43/m^2$) for Oregon streams (average density = 0.885 juveniles/m^2 or 0.082 juveniles/ft^2), a fry-to-smolt survival rate of 0.165 (Quinn 2005) and an average smolt to adult return rate of 0.033 for Cowlitz River coho salmon (Zimmerman 2018), to estimate that the average sized-beaver pond (9,061 ft^2) could support 123 coho salmon smolts (4.1 adult equivalents).

WS–Washington proposes to not remove beavers from more than 20 sites over any given 5-year period, which would be an average of four sites per year (i.e., 20 sites/5 years = four sites/year). Based on the available information on the geographic dispersal of past beaver removal locations, it is extremely unlikely that four (or more) sites will occur within the range of any one ESA-listed salmonid population in any given year. WS–Washington also proposes to not remove beavers from more than three sites within any HUC_6 over any given 5-year period. Based on the geographic dispersal of past beaver removal locations, we believe it is highly unlikely that three removal sites would occur within any HUC_6 within the same year. However, we assume this situation as the worst-case scenario of potential effects to any one population in a year. In this case, if WS–Washington were to remove beavers from three sites within the same HUC_6 in 1 year, this would be 12.2 adult coho salmon equivalents, which we believe would be the maximum effect to any one population in any 1 year under the proposed action. These calculations are also based on another worst-case scenario, i.e., we assumed that all juvenile coho salmon affected would die. This is highly unlikely because the wetted stream channel portion of the area ponded by a beaver dam would still remain to provide some rearing habitat after the dam is destroyed. In addition, we expect some fish would survive the predation risk and find rearing habitat off site, though possibly of lower quality.

In summary, we calculated our adult equivalent estimates to show the possible magnitude of effects under a worst-case scenario. As we discussed in the previous paragraph, these adult equivalent estimates are likely inflated, though we do not know by how much. In addition, in most cases, WS–Washington removes beavers from sites of recent beaver activity, and not as a result of dams in existence for greater than a year. In cases where beavers are removed from sites where dams have not yet been built, pond habitat would not exist, so there would be no loss of existing habitat, but there would be the lost potential for it.

Indirect adverse effects to Puget Sound, Lower Columbia River, Middle Columbia River, Upper Columbia River, and Snake River Basin Steelhead. Although there are several different steelhead DPSs considered in this opinion, and steelhead have diverse life history traits, we have no reason to doubt that they all share the potential to rear in habitat that is conducive to enhancement by beaver dams.

There is some evidence that steelhead benefit from beaver-enhanced habitat. Bouwes et al. (2016) built artificial beaver dams (beaver dam analogs (BDAs) in reaches of Bridge Creek, Oregon. The BDAs complemented existing beaver dams and encouraged additional beaver activity. They found that the linear and areal density of juveniles was on average 210 fish/100 m and 27 fish/100 m^2 greater in impounded than un-impounded reaches, suggesting a higher preference by juvenile steelhead for ponded areas. Following the manipulation, juvenile steelhead survival increased by 52 percent in Bridge Creek relative to Murderers Creek (a reference stream) and, 4 years after the manipulation, juvenile production increased 175 percent in Bridge Creek relative to Murderers Creek. Wathen et al (2018) suggested spatial resource partitioning as a potential mechanism for higher steelhead density, survival, and production, due to the increased habitat complexity with beaver-based restoration in Bridge Creek.

In contrast to Bouwes et al. (2016), Everest et al. (1986) found that beaver ponds had the lowest juvenile steelhead densities of the six habitat types they investigated in Fish Creek, Oregon. This discrepancy may be due to habitat partitioning by steelhead and coho where they occur together (Bisson et al. 1988; Hartman 1965). For example, in Fish Creek, steelhead may have avoided beaver ponds occupied by coho salmon, while in Bridge Creek steelhead may have taken advantage of ponded areas because coho salmon do not occupy this stream. Regardless, we assume that steelhead would occupy beaver-enhanced habitat in streams where WS–Washington will remove beavers.

We are unaware of any empirical data for steelhead densities in beaver ponds in Washington. We used a density of 0.399 juvenile steelhead/m^2 (0.037/ft^2) reported by Mullan et al. (1992), and a 0.135 steelhead fry-to-smolt survival rate (Quinn 2005), to estimate that the average-sized beaver pond (9,061 ft^2) would support 45 steelhead smolts. We applied the maximum smolt to adult return rate of 0.047 reported by McCann et al. (2017) to estimate this was 2.1 adult equivalents.

WS–Washington proposes to not remove beavers from more than 20 sites over any given 5-year period, which would be an average of four sites per year (i.e., 20 sites/5 years = four sites/year). Based on the available information on the geographic dispersal of past beaver removal locations, it is extremely unlikely that four (or more) sites will occur within the range of any one ESA-listed salmonid population in any given year. WS–Washington also proposes to not remove beavers from more than three sites within any HUC_6 over any given 5-year period. Based on the geographic dispersal of past beaver removal locations, we believe it is highly unlikely that three removal sites would occur within any HUC_6 within the same year. However, we assume this situation as the worst-case scenario of potential effects to any one population in a year. In this case, if WS–Washington were to remove beavers from three sites within the same HUC_6 in 1 year, this would be 6.3 steelhead adult equivalents, which we believe would be the maximum effect to any one population in any 1 year under the proposed action. These calculations are also based on another worst-case scenario, i.e., we assumed that all juvenile Chinook salmon affected would die. This is highly unlikely because the wetted stream channel portion of the area ponded by a beaver dam would still remain to provide some rearing habitat after the dam is destroyed. In addition, we expect some fish would survive the predation risk and find rearing habitat off site, though possibly of lower quality.

In summary, we calculated our adult equivalent estimates to show the possible magnitude of effects under a worst-case scenario. As we discussed in the previous paragraph, these adult equivalent estimates are likely inflated, though we do not know by how much. In addition, in most cases, WS–Washington removes beavers from sites of recent beaver activity, and not as a result of dams in existence for greater than a year. In cases where beavers are removed from sites where dams have not yet been built, pond habitat would not exist, so there would be no loss of existing habitat, but there would be the lost potential for it.

Potential Beneficial Effects of the Proposed Action

Beaver dam-blocked transportation crossings. Under the proposed action, WS–Washington will remove beavers from sites where beaver dams block culverts or other transportation crossings preventing fish passage. Though the number of these sites cannot be accurately predicted, beaver dam-blocked culverts are one of the main issues that WS–Washington responds to for beaver removal (Laurence Schafer, WS–Washington, personal communication, April 23, 2018). In these cases, removing the beaver decreases the chances that a dam will be rebuilt, and once the culvert blockage is removed, ESA-listed salmonids would benefit by having access to more spawning and rearing habitat. Therefore, beaver removal from these sites would benefit ESA-listed salmonids.

Beaver relocation. To minimize effects of beaver removal, under the proposed action, WS–Washington undertakes to live-trap rather than kill beavers when feasible to provide them to other entities for relocation. Rather than being killed, there is a chance these animals can thrive and enhance salmonid habitat elsewhere. Beaver relocation is one method of promoting recolonization as called for in some salmon recovery plans.

Beaver relocation methods are still being improved, however, with success rates less than ideal. Petro et al. (2015) concluded that beaver relocation options available to landowners in Oregon may not be an effective option for stream restoration in coastal forestlands, due to infrequent dam occurrence and short dam longevity. In the Yakima River drainage (Washington), beaver were relocated with a 35 percent success rate, with success defined as the animals staying and building dams at the release site. Some of the releases considered unsuccessful were beavers that moved to other locations in the release watershed (Melissa Babik, WDFW, personal communication, September 20, 2018). In the Puget Sound area, under a best scenario, a 50 percent success rate might be expected, but success rates of 25 to 40 percent are more typical (Ben Dittbrenner, Beavers Northwest, personal communication, July 24, 2018).

In spite of these lower-than-ideal success rates, there is growing enthusiasm in the beaver relocation concept and in improving success rates (Molly Alves, Tulalip Beaver Project, personal communication, June 28, 2018; Erik White, Wildlife Program Manager, Cowlitz Indian Tribe, personal communication, September 9, 2018). In response to growing interest in relocating “nuisance” beavers rather than killing them, WDFW is facilitating a beaver management working group. The group has been developing protocols for a beaver relocation program and for training certified beaver relocators (who could for example, accept live-trapped beavers from WS–Washington and relocate them) (Melissa Babik, WDFW, personal communication, September 20, 2018). WS–Washington is a participant in this group, showing their commitment to support beaver relocation programs (Mike Linnell, WS-WA, personal communication, September 26, 2018). The WDFW plans to have new State rules implemented by January, 2019 (Sarah Kindschuh, Small Game and Furbearer Specialist, WDFW, personal communication, September 18, 2018). Several groups have expressed interest in working with WS–Washington to help further develop beaver relocation programs (e.g., Cowlitz Indian Tribe, Tulalip Beaver Project, WDFW). However, Washington would need to have expenses covered to assist with relocation. Many of the agreements WS–Washington has are with counties where landowners may request assistance with beaver damage, and beaver relocation costs may not be included in the county-approved work agreement. Because of this uncertainty, we have not factored the expected benefits into our jeopardy analysis.

Summary of Species Effects

In consideration of the minimal number of beaver removal sites in ESA-listed salmonid habitat that will have adverse effects, the expected geographical spread of those sites (i.e., sites will be dispersed across the action area), the minimum number of fish affected for any given ESA-listed salmon or steelhead population, and the potential for increased fish passage at some beaver removal sites, overall there will not be any appreciable impact on Chinook salmon, chum salmon, or coho salmon, or steelhead abundance, productivity, spatial structure or diversity at the independent population level within any ESU or DPS.

Climate change could ultimately play a role in the degree that beaver removals might affect salmonids. Specifically, in some situations, beaver dams could help increase base flows and create pockets of cooler water temperatures in an environment that is expected to get dryer and hotter. The subsequent loss of dams at some beaver removal sites could impair these beneficial effects. However, the limited number of beaver removal sites where these effects could occur (i.e., an average of four per year), spread geographically across the action area, will have a limited influence at any independent population level.

2.5.2 Effects to Critical Habitat

The PBF characteristics (site attributes) that will be affected by the proposed action are substrate, water quality, water quantity, floodplain connectivity, forage, natural cover, and migration obstruction. The effects to PBFs described below apply to all salmon and steelhead considered in this opinion.

The removal of target aquatic mammals other than beavers will not change the functions of any designated critical habitat because those animals’ behavior or presence do not positively affect PBFs. Pollock et al. (2017; 2003) have completed extensive reviews of how beaver dams can affect the hydrology, water quality, and geomorphology of streams. Below we summarize how these effects can enhance critical habitat PBFs and therefore how the proposed action will adversely affect PBFs (with the exception of the migration PBF) by removing beavers, thus precluding the maintenance and building of their dams.[4]

Water Quantity

Ponds created by beaver dams increase the area of aquatic habitat available to salmonids. Water impounded by beaver dams is retained within the stream reach for longer periods and can recharge and elevate the water table (Lowry 1993; Pollock et al. 2003). This water retention may then increase base flows (reviewed in Pollock et al. 2003; Ponce and Lindquist 1990), potentially improving migration conditions or increasing rearing habitat, though we are unaware of empirical data to support this hypothesis. Because there is no end date for this proposed action, and if climate change does result in decreased flow patterns, beaver dams could help mitigate stream flows, as they contribute to both surface water and groundwater storage (reviewed in Pollock et al. 2017). Also, beaver activity within a watershed generally reduces peak flows, reducing erosive energy (Pollock et al. 2017; Pollock et al. 2003). This effect could reduce redd scouring.

Water Quality

Beaver have the ability to improve the water quality of streams by reducing suspended sediments in the water column, moderating stream temperatures, improving nutrient cycling, and removing and storing contaminants. Beaver dams can influence sediment transport rates in a watershed and act as long-term sinks for both suspended and bedload sediments (Green and Westbrook 2009). Cold pockets of water have been found downstream of beaver dams, possibly from the upwelling of groundwater and an increase in hyporheic exchange (Pollock et al. 2007; White 1990). Columbia River chum salmon appear to prefer to spawn at areas of upwelling (National Marine Fisheries Service 2013). Weber et al. (2017) reported that maximum summer stream temperatures were reduced in stream sections with high densities of beaver dams. Such pockets or reaches of cooler water could be important refuges for salmonids when summer water temperatures are high (Wathen et al. 2018).

Floodplain Connectivity

Beaver dams can increase floodplain connectivity by raising the water level onto the floodplain, reconnecting or forming new side channels, creating off-channel salmonid habitat and increasing the amount of riparian area (Bouwes et al. 2016; Pollock et al. 2017; Westbrook et al. 2006), helping to increase the quantity and quality of rearing habitat. Beaver recolonization and construction of beaver dams in the incised channel of Bridge Creek, Oregon, has led to average suspended sediment retention rates of approximately 0.10 m (3.9 in.)/year (Pollock et al. 2007).

---

[4] As indicated above, current information does not universally support beaver ponds as wholly beneficial to salmonids in every situation but, nevertheless, it is reasonable to conclude that, overall, the published science applicable to the action area documents a predominantly positive effect of beaver dams related to juvenile salmonid rearing because they can increase suitable habitat area and add habitat complexity to streams.

Beechie et al. (2008) estimated that, with beaver recolonization and two dams per kilometer of stream on average, the time required for an incised channel to aggrade to the level of its historical floodplain could decrease by 17–33 percent, compared to sites without beavers.

Forage

When beaver modify streams, they create habitat for many aquatic insect populations by increasing the input and storage of organic material and sediment (reviewed in Collen and Gibson 2001) and increasing primary productivity. Primary production increases secondary production, including micro- and macroinvertebrates that form the base of the food web that juvenile salmon and steelhead rely on when rearing and overwintering in beaver ponds (Pollock et al. 2017). The larger riparian zone may also contribute more allochthonous material including terrestrial insects, important salmonid forage.

Natural Cover

Beaver ponds typically provide deep water and other forms of cover, including woody material, overhead cover from riparian vegetation, and, potentially, side channels. Beaver ponds typically have slow current velocities and large edge-to-surface-area ratios, conditions that can provide extensive cover to fish (reviewed in Pollock et al. 2003). In winter, maximum pool depth was positively correlated with juvenile coho salmon density in dammed pools (which included beaver ponds) along with scour and trench pools (Nickelson et al. 1992). Nickelson et al. (1992) hypothesized that in these pool types, depth may be a factor that reduces current velocity and turbulence.

Migration Obstruction

Beaver dam-blocked culverts are one of the main issues that WS–Washington responds to for beaver removal (Laurence Schafer, WS–Washington, personal communication, April 23, 2018). Beaver dam-blocked culverts prevent up- and downstream fish passage. Therefore, removing beavers and their dams from these sites will allow migration to spawning and rearing habitat.

Summary of Critical Habitat Effects

Under the proposed action, WS–Washington will remove beavers from up to 20 sites in ESA-listed salmonid habitat over any given 5-year period (as well as from various other sites in specific situations that, as discussed above, will not have adverse effects on salmonid habitat). Once beavers are removed, they will not be there to maintain existing dams or build new ones (Pollock et al. 2017). As a result, the beaver-enhanced PBFs described above will degrade and ongoing PBF enhancement will cease (with the exception of the migration obstruction PBF). However, beaver removal sites will be dispersed geographically across the action area. Under the proposed action, there will be a maximum of three removal sites in any HUC_6 in any 5-year period. In addition, based on the information from past removals, it is unlikely that effects will be concentrated even within any single HUC_5, the scale at which critical habitat conservation value is determined. For example, designated critical habitat includes 61 different HUC_5s for PS Chinook salmon, 31 different HUC_5s for UCR steelhead, and about 27 HUC_5s in Washington

State for LCR coho salmon. Also, a small amount of habitat will be affected at each site (i.e., an average 9,061 ft^2 of beaver pond at sites where beaver dams exist), relative to the size of any given HUC_5, each of which can include several miles of rearing habitat. Finally, the proposed action also involves beaver removal from some sites where their dams have blocked fish passage through culverts, and the culverts will be re-opened to passage, allowing salmon and steelhead to access spawning and rearing habitat.

In consideration of the small amount of habitat that will potentially be affected at each beaver removal site, the expected dispersion of those sites across the action area, limiting the effects in any given HUC_5, and the potential for increased fish passage at some beaver removal sites, even in the aggregate of removal sites where PBFs could have been enhanced if beavers were left on-site, the proposed action would not preclude or significantly delay the development of those PBFs at the HUC_5 scale.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Many non-federal activities occur on state, tribal, and private lands, including livestock grazing, timber harvest, mining, development, and road-building. Also, the demand for limited water resources, especially in eastern Washington, will likely continue to increase. These activities all affect stream habitat conditions, as described in the Environmental Baseline section, and will continue into the future.

General resource demands continue to expand with population growth and an increasing standard of living. From April 1, 2010 to July 1, 2018, Washington State's population grew by 12.1 percent[5]. This population increase, with associated increases in natural resource consumption, and residential and commercial development, will continue to adversely affect species and their habitat. For example, riparian vegetation is often removed by landowners, decreasing habitat complexity and forage availability for rearing juvenile salmonids, which can decrease growth and survival rates. Stormwater runoff is another by-product of population growth as more ground is paved and traffic increases, resulting in more contaminants reaching streams. Stormwater

[5] https://www.census.gov/quickfacts/fact/table/wa,US/PST045218 (accessed February 22, 2019).

runoff is believed to cause pre-spawn mortality in coho salmon in the Puget Sound area (Feist et al. 2017; McIntyre et al. 2018; Scholz et al. 2011). Projected future sources of cumulative effects (e.g., toxics loadings, riparian habitat loss) are difficult to quantify, but will likely increase commensurate with population growth.

An expanding population also means more people moving into rural environments where conflicts with wildlife, including beavers, are inevitable. There will likely be more pressure to remove so-called nuisance beavers, resulting in the loss of benefits they can provide to salmonid habitat.

Demand for cultural and aesthetic amenities continues to grow with human population, and is reflected in decades of concentrated effort by tribes, states, and local communities to restore an environment that supports flourishing wildlife populations, including populations of species that are now ESA-listed (Columbia River Intertribal Fish Commission 1995; Northwest Power and Conservation Council 2012). This demand has fueled efforts to ensure that resource-based industries adopt improved practices to avoid, minimize, or offset their adverse impacts. Thus, many non-federal actions have become responsive to the recovery needs of ESA-listed species.

Habitat restoration actions carried out by tribes, salmon recovery organizations, and local volunteer groups have improved the availability and quality of estuarine and nearshore habitats, floodplain connectivity, channel structure and complexity, riparian areas and LWD recruitment, stream substrates, stream flow, water quality, and fish passage. In this way, the goal of ESA-species recovery has become institutionalized as a common and accepted part of the state's economic and environmental culture. We expect this habitat restoration trend to continue as awareness of environmental and at-risk species issues increases among the general public.

WDFW-permitted removal (killing) of nuisance beavers and recreational beaver trapping will continue in Washington, as will beaver removals by private landowners. The most recent data do not indicate an increasing trend in the numbers of beavers removed in the state. Also, several groups are, or have been, active in relocating beavers to areas where their dam-building activity can restore more habitat complexity and function without affecting infrastructure or having other negative economic or sociological effects.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Species

The status of salmon and steelhead species addressed by this consultation varies from moderate risk (e.g., MCR steelhead) to high risk (e.g., endangered UCR spring-run Chinook salmon). These species have declined due to numerous factors, but the effects of freshwater habitat degradation have affected all ESA-listed salmon and steelhead. Aquatic and riparian habitat has been degraded by the effects of land and water use, including road construction, forest management, agriculture, mining, urbanization, and water development. Dams and reservoirs have altered river environments and affected fish passage. The operation of water storage projects has altered the natural hydrograph of many rivers. Avian and introduced fish predation on salmonids has been exacerbated by environmental changes associated with river development. This degraded status and environmental baseline is reflective of human development in the Pacific Northwest, and habitat improvement is identified by salmon and steelhead recovery plans as a priority for species recovery.

WS–Washington proposes to remove beavers from up to 20 sites over any given 5-year period where beaver could otherwise positively affect juvenile salmonid habitat. They will not remove beavers from more than three of these sites within any HUC_6 over any given 5-year period. After beaver removal, existing habitat features will degrade, or the development of such features will cease because the beavers will not be there to maintain their existing dams or build new ones. The reduction in rearing habitat area will force some juvenile salmonids to move elsewhere, where they will expend more energy searching for food or cover. Some fish will experience slower growth, decreasing survival. Some fish will be more susceptible to predation. Thus, some salmonids in the action area will experience harm and potential death, due to the indirect effects of beaver removal. By contrast, at other proposed removal sites, e.g., from lakes, built environment sites and habitat restoration sites, no adverse effects are expected.

Based on some assumptions and the best available but limited data, we estimated that about 0.4 Chinook salmon, 4.1 coho salmon, and 2.1 steelhead adult equivalents could be affected by the removal of beaver from any given site. Under a worst-case scenario, if WS–Washington removed beaver from three sites within the same HUC_6 in the same year, this would affect up to 1.2 Chinook salmon, 12.2 coho salmon, and 6.3 steelhead adult equivalents per 6^{th} field HUC. We assume this would be the maximum effect to any individual population because with an average of four removal sites per year in ESA-listed salmonid habitat (i.e., 20 removal sites over any given 5-year period), likely spread across the different ESUs and DPSs in the state, it would be extremely unlikely that more than three sites would occur within the range of any one independent population. In addition, we calculated these numbers assuming that all juvenile salmon and steelhead affected would die. This is highly unlikely because the wetted stream channel portion of the area ponded by a beaver dam would still remain to provide some rearing habitat after the dam is destroyed. In addition, we expect some fish would survive the predation risk and find rearing habitat off site, though possibly of lower quality. Thus, our adult equivalent estimates are likely inflated, though we do not know by how much. In cases where beavers are removed from sites where dams have not yet been built, pond habitat would not exist, so there would be no decrease in the abundance of juveniles currently rearing at the site (and the effects expressed as adult equivalents would be zero); however, this situation still represents an adverse effect, due to the lost opportunity for the future enhancement of juvenile salmonid habitat, which would increase abundance and productivity.

These are low numbers of listed species when considered at the listed unit scale. In addition, our analysis, based on information about past removal site locations, assumes that these sites will not be concentrated geographically. This means that the impacts are likely to be spread across populations and not disproportionately affect one. We also expect beneficial effects from the proposed removal of beavers from sites where beaver dams are blocking fish passage. Finally, because this consultation has no end date, climate change could ultimately play a role in the degree that beaver removals might affect salmonids in the coming decades. Specifically, beaver dams could help increase base flows and create pockets of cooler water temperatures in an environment that is expected to get dryer and hotter. Some beaver removal sites and the subsequent loss of dams could remove these beneficial effects. However, the limited number of beaver removal sites where these effects could occur (i.e., an average of four per year), spread geographically among listed units, will have a limited influence at that scale.

Taking all of these factors together, even in the aggregate of all individual beaver removal sites, the small number of fish affected for any given independent population or MPG will not meaningfully affect the VSP parameters for any of the ESUs or DPSs. With consideration of the impaired status of the populations, the environmental baseline, and expected cumulative effects in the action area, the number of ESA-listed fish that will be affected under the proposed action will not meaningfully affect the survival or recovery of the ESUs or DPSs considered in this opinion.

Rather than kill all of the beavers they remove as they have done in the past, WS–Washington has proposed to make beavers available for relocation where feasible. This action is in line with recovery plans that recommend beaver reintroductions. Several entities are enthusiastic about beaver relocation and have expressed their interest in working with WS–Washington to obtain the animals they need to start or maintain their programs. (e.g., Tulalip Tribes, Cowlitz Tribe, Methow Beaver Project). There is sufficient uncertainty about these relocations such that we have not factored any related benefits into our analysis or ESA conclusions. However, we note that, if relocation programs do take place, beavers provided by WS–Washington will have the opportunity to establish pond habitat elsewhere, resulting in enhanced salmonid habitat, and increased salmonid numbers. This would help offset effects of removing the animals from the original sites.

2.7.2 Critical Habitat

Under the proposed action, WS–Washington will remove beavers from up to 20 critical habitat sites over any given 5-year period (and from no more than three sites within a HUC_6 over any 5-year period), in situations where, if the animals were left alone, they would likely maintain or build dams that would enhance listed fish habitat. Instead, beaver-enhanced PBFs will degrade, and ongoing PBF enhancement will cease at removal sites because beavers will not be there to maintain existing dams or build new ones. Without the presence of a dam, rearing habitat area will decrease by an average of 9,061 ft^2 per site, the size of an average beaver pond. This will result in decreased rearing space (e.g., water quantity), water quality, forage, and cover at the local site scale.

In our critical habitat effects analysis, we concluded that effects would not be concentrated within any one HUC_5 because of the expected geographic spread of beaver removal sites, and that adverse effects would impact a relatively small amount of critical habitat within any given HUC_5. Similarly, because of the expected geographic spread of beaver removal sites throughout the action area, we also expect that critical habitat effects will be distributed at the designation level, i.e., not concentrated within any one ESU or DPS. At other proposed removal sites, e.g., from lakes, built environment sites and habitat restoration sites, no adverse effects are expected. There are some beneficial effects expected from the proposed removal of beavers from sites where beaver dams are blocking fish passage. Accordingly, the conservation value of critical habitat at the designation scale will not be appreciably diminished for any of the ESUs or DPSs considered in this opinion.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon, LCR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, HC summer-run chum salmon, CR chum salmon, LCR coho salmon, PS steelhead, LCR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, or destroy or adversely modify designated critical habitat.

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 T&E 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). NMFS interprets "harass" as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering". 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 ITS.

2.9.1 Amount or Extent of Take

NMFS determined that the proposed action is likely to cause harm and potentially death to salmon and steelhead species considered in this opinion as a result of rearing habitat loss due to beaver removals. However, only juvenile life stages will be adversely affected. Adults could potentially be present at some trapping sites and may move from the immediate area in response to human activity, but they will not be harmed or otherwise adversely affected.

Because of the difficulty in accurately predicting how much beaver-enhanced habitat could exist at any given removal site, and the extent of colonization by ESA-listed salmonids, it is not practicable to quantify how many fish might be harmed or killed. When the specific number of individuals incidentally taken cannot be predicted, NMFS uses a take surrogate, which can be based on the extent of habitat modified. For the proposed action, the best available take surrogate is:

1. Beaver removal at 20 sites statewide over any given 5-year period within critical habitat or other habitat occupied by ESA-listed salmonids, excluding removals in the following situations:

    a. Stream channels greater than 33 feet wide or in lakes;

    b. "Built environment" sites where it has been determined by an engineer or road supervisor that the beaver activity poses a threat to public infrastructure and safety;

    c. Habitat restoration sites, where the beavers are preventing the restoration from succeeding.

    d. Sites where beaver dams have blocked culverts or other transportation crossings to the extent that fish passage is prevented, and/or

2. A maximum of three of these beaver removal sites within any HUC_6 within any given 5-year period.

NMFS will consider the extent of take exceeded if either of these situations occurs—except for the following situations:

1. If beavers removed by WS–Washington are successfully relocated to another site (or sites) within the range of any of the ESUs or DPSs, then the 20 site total (in 1, above) can be credited with the number of those successful relocation sites. A relocation will be considered successful if it meets the post-release success criteria identified by WDFW in their guidelines and permits for CBRs.

2. Likewise, the three-site-per-HUC_6 total in 2 above can be credited with the number of those successful relocation sites that occur within the range of the same independent salmon or steelhead population affected within that HUC_6.

These indicators are connected causally to the amount of take that will occur because an increase in the number of removal sites and/or a geographic clustering of sites translates into a proportional increase in the impact to listed species. The surrogate metrics can also be easily monitored through the spreadsheet that WS–Washington will maintain, where they will document the date and location for all future beaver removal sites as part of the proposed action. This will allow the surrogate to serve its intended role as a clear reinitiation trigger. Although the surrogate is somewhat coextensive with the proposed action, it nevertheless serves as a meaningful reinitiation trigger because there will be monitoring of the surrogate metrics on a periodic basis (e.g., annually and every 5 years), which means that reinitiation could be triggered as frequently as each year.

2.9.2 Effect of the Take

In the opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPMs) are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

Full application of conservation measures included as part of the proposed action, together with use of the RPM and terms and conditions described below, are necessary and appropriate to minimize the likelihood of incidental take of ESA-listed fish due to the proposed action.

The WS–Washington shall minimize incidental take by:

> Conducting monitoring sufficient to document that the proposed program methods are adhered to, that the terms and conditions listed below are implemented, and that the extent of take is not exceeded.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and WS–Washington or any applicant must comply with them in order to implement the RPM (50 CFR 402.14). The WS–Washington or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement the RPM:

    a. WS–Washington shall alert NMFS immediately, if it becomes apparent that a take threshold has been exceeded.

    b. At beaver removal sites subject to the 20-site limit per Section 2.9.1 above, where there are established dams on natural streams, WS–Washington shall visually estimate (to the best of their ability) and record the surface area of the beaver pond.

        i. At sites where there are not established dams, WS–Washington shall record the dam status (i.e., no evidence of a dam, partial dam).

    c. At sites in ESA-listed salmonid habitat where beaver activity poses a threat to public infrastructure and safety, WS–Washington shall report to NMFS, if the dam was not removed following removal of the beavers.

    d. WS–Washington shall report annually with the following information:

i. A summary of beaver removals that occurred in ESA-listed salmonid habitat. This summary shall include:

1. The cumulative (up to and including the past 5 years) number of removal sites subject to the 20-site limit per Section 2.9.1 above, which occurred within the range of each ESU and DPS.

2. Identification of any HUC_6 with more than one removal site (cumulatively, up to and including the past 5 years).

3. The estimated beaver pond surface acres at sites with established beaver dams (per b, above).

4. The number of removal sites within the range of each ESU and DPS where a beaver dam blocked ESA-listed salmonid passage through a transportation crossing, but where passage was subsequently restored following beaver removal.

5. The ultimate disposition of the animal(s) (e.g., transferred for relocation, killed), for each beaver removal site subject to the 20-site limit, per Section 2.9.1 above.

6. The number of successful relocation sites within the range of each independent salmon and steelhead population, for beavers that were initially live-trapped by WS–Washington and transferred to CBRs.

e. After the fifth year of programmatic implementation, and at any time previously, if the facts suggest it is necessary, WS–Washington shall meet with NMFS to discuss if the original assumptions made by both parties were accurate, such that NMFS' analysis of effects is still valid.

Send reports to National Marine Fisheries Service, Columbia Basin Branch, Attention Jody Walters (jody.walters@noaa.gov), 304 South Water Street, Suite 201, Ellensburg, Washington 98926.

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 T&E 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). The following conservation recommendation is a discretionary measure that NMFS believes is consistent with this obligation and therefore should be carried out by WS–Washington:

> Recovery strategies for the middle and upper Methow, lower Chewuch and lower Twisp rivers, and for WRIA 1 (Nooksack River watershed and Drayton Harbor

> tributaries) include beaver reintroductions and conservation of existing beavers and their dams. One of the Lower Columbia River recovery plan strategy elements is tributary habitat restoration, particularly overwintering habitat (which can be provided by beaver ponds). Therefore, WS–Washington should not remove beavers from ESA-listed salmonid habitat in these watersheds, whenever possible. If beavers are removed, WS–Washington should place particular emphasis on providing the animals to CBRs who can relocate the beavers to suitable habitats within the same watersheds, where they will not cause damage.

Please notify NMFS, if WS–Washington carries out this recommendation, so that we will be kept informed of actions that minimize or avoid adverse effects and those that benefit the listed species or their designated critical habitats.

2.11 Reinitiation of Consultation

This concludes formal consultation for WS–Washington Aquatic Mammal Damage Management program. As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained or is authorized by law and if (1) the amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.12 "Not Likely to Adversely Affect" Determinations

2.12.1 Lake Ozette Sockeye Salmon

With the exception of beaver removals, the proposed Aquatic Mammal Damage Management actions will cause little, if any, disturbance to the aquatic environment. If LO sockeye salmon are exposed to WS–Washington personnel near or in the water, individual fish may be temporarily displaced. Personnel might also generate minor amounts of suspended sediment during management activities at some sites. Both of these effects will be short-term and of such a small magnitude that they would not be able to be meaningfully measured, detected, or evaluated—and are therefore insignificant.

LO sockeye salmon fry that originate in tributaries migrate to the lake soon after emergence (Haggerty et al. 2009). Sockeye salmon rear in lakes their first year of life where they feed mainly on zooplankton (Haggerty et al. 2009; Wydoski and Whitney 2003). We have no evidence that LO sockeye salmon rear in beaver ponds (Haggerty et al. 2009). Thus, it is extremely unlikely and therefore discountable that a loss of beaver-enhanced habitat will adversely affect LO sockeye salmon or critical habitat.

2.12.2 Snake River Sockeye Salmon

With the exception of beaver removals, the proposed Aquatic Mammal Damage Management actions will cause little, if any, disturbance to the aquatic environment. If SR sockeye salmon are exposed to WS–Washington personnel near or in the water, individual fish may be temporarily displaced. Personnel might also generate minor amounts of suspended sediment during management activities at some sites. Both of these effects will be short-term and of such a small magnitude that they would not be able to be meaningfully measured, detected, or evaluated—and are therefore insignificant.

Within Washington, SR sockeye salmon are found only in the mainstem Columbia and Snake Rivers. They use these rivers as migration corridors to and from natal habitat in Idaho, and do not rear in Washington streams. Thus, it is extremely unlikely and therefore discountable that a loss of beaver-enhanced habitat will adversely affect SR sockeye salmon or critical habitat.

2.12.3 Upper Willamette River Spring-run Chinook Salmon and Upper Willamette River Steelhead

With the exception of beaver removals, the proposed Aquatic Mammal Damage Management actions will cause little, if any, disturbance to the aquatic environment. If UWR spring-run Chinook salmon and UWR steelhead are exposed to WS–Washington personnel near or in the water, individual fish may be temporarily displaced. Personnel might also generate minor amounts of suspended sediment during management activities at some sites. Both of these effects will be short-term and of such a small magnitude that they would not be able to be meaningfully measured, detected, or evaluated—and are therefore insignificant.

Within Washington, UWR spring-run Chinook salmon and UWR steelhead are found only in the mainstem Columbia River. They use the Columbia River as a migration corridor to and from natal habitat in Oregon, and are not known to rear in Washington streams. Thus, it is extremely unlikely and therefore discountable that a loss of beaver-enhanced habitat will adversely affect UWR spring-run Chinook salmon and UWR steelhead or critical habitat.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by WS–Washington and descriptions of EFH for Pacific Coast salmon contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce (Pacific Fishery Management Council 2014).

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the Introduction to this document. The proposed project action area includes EFH for various life-history stages of Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), and PS pink salmon (*O. gorbuscha*). Habitat areas of particular concern within the action area include complex channel and floodplain habitat, and spawning habitat.

3.2 Adverse Effects on Essential Fish Habitat

Based on information provided in the BA, associated communications, and the analysis of effects presented in the ESA portion of this document, NMFS concludes that the proposed action will adversely affect EFH designated for Chinook and coho salmon as follows:.

> By reducing juvenile Chinook and coho salmon rearing habitat, WS–Washington will remove beavers from locations where their dam would otherwise increase, maintain, or improve salmonid habitat. After beaver removal, existing habitat features will degrade, or the development of such features will cease because the beavers will not be there to maintain their existing dams or build new ones (Pollock et al. 2017).

3.3 Essential Fish Habitat Conservation Recommendations

We provide the following conservation recommendation:

> Recovery strategies for the middle and upper Methow, lower Chewuch and lower Twisp rivers, and for WRIA 1 (Nooksack River watershed and Drayton Harbor tributaries) include beaver reintroductions and conservation of existing beavers and their dams. One of the Lower Columbia River recovery plan strategy elements is tributary habitat restoration, particularly overwintering habitat (which can be provided by beaver ponds). WS–Washington should not remove beavers from Chinook and coho salmon habitat in these watersheds, whenever possible. If beavers are removed, WS–Washington should place particular emphasis on providing the animals to CBRs who can relocate the beavers to suitable habitats within the same watersheds where they will not cause damage.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS’ EFH Conservation Recommendations, unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget (OMB), NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The WS–Washington must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The DQA specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is WS–Washington. Individual copies of this opinion were provided to WS–Washington.. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, "Security of Automated Information Resources," OMB Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 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.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

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.

5. REFERENCES

Abatzoglou, J. T., D. E. Rupp, and P. W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate 27(5):2125–2142.

Babik, M., and W. Meyer. 2015. Yakima Basin beaver reintroduction project 2011–2015 progress report.

Barton, A., B. Hales, G. G. Waldbuster, C. Langdon, and R. Feely. 2012. The Pacific Oyster, *Crassostrea gigas*, shows negative correlation to naturally elevated carbon dioxide levels: implications for near–term ocean acidification effects. Limnology and Oceanography 57(3):698–710.

Beechie, T. J., M. M. Pollock, and S. Baker. 2008. Channel incision, evolution and potential recovery in the Walla Walla and Tucannon River basins, northwestern USA. Earth Surface Processes and Landforms 33(5):784–800.

Bisson, P. A., K. Sullivan, and J. L. Nielsen. 1988. Channel hydraulics, habitat use, and body form of juvenile coho salmon, steelhead, and cutthroat trout in streams. Transactions of the American Fisheries Society 117:262–273.

Bottom, D. L., and coauthors. 2005. Salmon at river's end: The role of the estuary in the decline and recovery of Columbia River salmon. Pages 246 p *in* U.S. Department of Commerce, editor.

Bourret, S. L., C. C. Caudill, and M. L. Keefer. 2016. Diversity of juvenile Chinook salmon life history pathways. Reviews in Fish Biology and Fisheries:1–29.

Bouwes, N., and coauthors. 2016. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (Oncorhynchus mykiss). Pages 1–12 *in* Scientific Reports.

Bryant, M. D. 1983. The role of beaver dams as coho salmon habitat in southeast Alaska streams. Pages 183–192 in J. M. Walton and D. B. Houston, editors. Olympic Wild Fish Conference, Port Angeles, Washington.

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of Fisheries Research Board of Canada 32:667–680.

Collen, P., and R. J. Gibson. 2001. The general ecology of beavers (Castor spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish—a review. Reviews in Fish Biology and Fisheries 10:439–461.

Columbia River Intertribal Fish Commission. 1995. Wy-Kan-Ush-Mi Wa-Kish-Wit: Spirit of the Salmon, the Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes. Two Volumes. Columbia River Inter-tribal Fish Commission and member Tribes, Portland, Oregon.

Crozier, L. G., and coauthors. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications 1(2):252–270.

Crozier, L. G., M. D. Scheuerell, and E. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift toward Earlier Migration Date in Sockeye Salmon. The American Naturalist 178(6):755–773.

Dominguez, F., E. Rivera, D. P. Lettenmaier, and C. L. Castro. 2012. Changes in winter precipitation extremes for the western United States under a warmer climate as simulated by regional climate models. Geophysical Research Letters 39(5).

Doney, S. C., and coauthors. 2012. Climate change impacts on marine ecosystems. Annual Review of Marine Science 4:11–37.

Everest, F. H., and coauthors. 1986. Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement. Annual Report 1985. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Project No. 84–11, Corvallis, Oregon.

Feely, R. A., T. Klinger, J. A. Newton, and M. Chadsey. 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Feist, B. E., J. J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. Fisheries Research Institute Report No. FRI-UW-9603:66 pp.

Feist, B. E., and coauthors. 2017. Roads to ruin: conservation threats to a sentinel species across an urban gradient. Ecological Applications 27(8):2382–2396.

Fernald, A. G., P. J. Wigington, Jr., 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.

Ford, M. J. 2011. Status review update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NWFSC-113, Seattle.

Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: An ecological, economic and social assessment. Report of the Forest Ecosystem Management Assessment Team, Portland, Oregon.

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.

Fuhrer, G. J., D. Q. Tanner, J. L. Morace, S. W. McKenzie, and K. A. Skach. 1996. Water quality of the Lower Columbia River Basin: Analysis of current and historical water-quality data through 1994. U.S. Geological Survey, editor, Reston, Virginia.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon, Seattle.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated status of federally listed ESUs of west coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66.

Goode, J. R., and coauthors. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. Hydrological Processes 27(5):750-765.

Green, K. C., and C. J. Westbrook. 2009. Changes in riparian area structure, channel hydraulics, and sediment yield following loss of beaver dams. BC Journal of Ecosystems and Management 10(1):68–79.

Gregory, S., and coauthors. 2002a. Riparian vegetation. Pages 40–43 *in* D. Hulse, S. Gregory, and J. Baker, editors. Willamette River Basin planning atlas: Trajectories of environmental and ecological change. Oregon State University Press, Corvallis, Oregon.

Gregory, S., L. Ashkenas, D. Oetter, P. Minear, and K. Wildman. 2002b. Historical Willamette River channel change. Pages 18–26 *in* D. Hulse, S. Gregory, and J. Baker, editors. Willamette River basin planning atlas. Oregon State University Press, Corvallis, Oregon.

Gregory, S., and coauthors. 2002c. Revetments. Pages 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.

Haggerty, M. J., A. C. Ritchie, J. G. Shellberg, M. J. Crewson, and J. Jalonen. 2009. Lake Ozette sockeye limiting factors analysis. Prepared for the Makah Indian Tribe and NOAA Fisheries in cooperation with the Lake Ozette Sockeye Steering Committee, Port Angeles, Washington.

Hard, J. J., and coauthors. 2015. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment. Pages 333 p *in* U.S. Department of Commerce, editor.

Hard, J. J., and coauthors. 2007. Status review of Puget Sound steelhead (*Oncorhynchus mykiss*). U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-81, 117 p.

Hartman, G. F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 22(4):1035–1081.

Hartman, G. F., J. C. Scrivener, and M. J. Miles. 1996. Impacts of logging in Carnation Creek, a high-energy coastal stream in British Columbia, and their implication for restoring fish habitat. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1):237–251.

Hood Canal Coordinating Council. 2005. Hood Canal & Eastern Strait of Juan de Fuca summer chum salmon recovery plan. Hood Canal Coordinating Council, editor, Poulsbo, Washington.

Hunter, M. A. 1992. Hydropower flow fluctuations and salmonids: A review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries, editor, Olympia, Washington.

Independent Scientific Advisory Board. 2007a. Climate change impacts on Columbia River Basin fish and wildlife. Independent Scientific Advisory Board, Northwest Power and Conservation Council, Portland, Oregon.

Independent Scientific Advisory Board. 2007b. Human population impacts on Columbia River Basin fish and wildlife, Portland, Oregon.

Intergovernmental Panel on Climate Change. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

Interior Columbia Basin Technical Recovery Team. 2003. Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River domain. Working draft.

Interior Columbia Technical Recovery Team. 2008. Current status reviews: Interior Columbia Basin salmon ESUs and steelhead DPSs. Vol. 2. Upper Columbia spring Chinook salmon ESU and upper Columbia River steelhead DPS.

Isaak, D. J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980–2009 and implications for salmonid fishes. Climatic Change 113(2):499-524.

Jacobsen, R., J. Nott, E. Brown, M. Weeber, and M. Lewis. 2014. Assessment of western Oregon adult winter steelhead–Redd surveys 2014. Oregon Plan for salmon and watersheds. Monitoring Report No. OPSW-ODFW-2014-09:27 p.

Johnson, L., and coauthors. 2013. Persistent organic pollutants in juvenile Chinook salmon in the Columbia River Basin: implications for stock recovery. Transactions of the American Fisheries Society 142(1):21–40.

Johnson, V. G., R. E. Peterson, and K. B. Olsen. 2005. Heavy metal transport and behavior in the lower Columbia River, USA. Environmental Monitoring and Assessment 110:271–289.

Kiely, T., D. Donaldson, and A. Grube. 2004. Pesticides industry sales and usage 2000 and 2001 market estimates. U.S. Environmental Protection Agency, Biological and Economic Analysis Division, editor.

Kondolf, G. M. 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management 21(4):533–551.

Kunkel, K. E., and coauthors. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.

Lawson, P. W., E. A. Logerwell, N. J. Mantua, R. C. Francis, and V. N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences 61(3):360–373.

Lee, D. C., J. R. Sedell, B. E. Rieman, R. F. Thurow, and J. E. Williams. 1997. Broadscale assessment of aquatic species and habitats. U.S. Forest Service, General Technical Report PNW-GTR-405, Volume III, Chapter 4.

Leidholt-Bruner, K., D. E. Hibbs, and W. C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho salmon fry in two coastal Oregon streams. Northwest Science 66(4):218–223.

Lestelle, L., N. Sands, T. Johnson, and M. Downen. 2018. Recovery Goal Review and Updated Guidance for the Hood Canal Summer Chum Salmon ESU. Hood Canal Coordinating Council.

Lower Columbia Fish Recovery Board. 2010. Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan.

Lower Columbia River Estuary Partnership. 2007. Lower Columbia River and estuary ecosystem monitoring: Water quality and salmon sampling report, Portland, Oregon.

Lowry, M. M. 1993. Groundwater elevations and temperature adjacent to a beaver pond in central Oregon. Oregon State University, Oregon State University, Corvallis.

Malison, R. L., L. A. Eby, and J. A. Stanford. 2015. Juvenile salmonid growth, survival, and production in a large river floodplain modified by beavers (Castor canadensis). Canadian Journal of Fisheries and Aquatic Sciences 72:1639–1651.

Malison, R. L., K. V. Kuzishchin, and J. A. Stanford. 2016. Do beaver dams reduce habitat connectivity and salmon productivity in expansive river floodplains? PeerJ 4(e2403).

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change 102(1):187-223.

McCann, J., and coauthors. 2017. Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye 2017 Annual Report. Comparative Survival Study Oversight Committee and Fish Passage Center.

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.

McDowell, D. M., and R. J. Naiman. 1986. Structure and function of a benthic invertebrate stream community as influenced by beaver (*Castor canadensis*). Oecologia 68:481–489.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000a. Viable salmonid populations and the recovery of evolutionarily significant units. Pages 156 *in*. U.S. Department of Congress.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000b. Viable salmonid populations and the recovery of evolutionarily significant units. Pages 156 p *in* U.S. Department of Commerce, editor.

McIntyre, J. K., and coauthors. 2018. Interspecies variation in the susceptibility of adult Pacific salmon to toxic urban stormwater runoff. Environmental Pollution 238:196–203.

McMahon, T. E., and G. F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 46:1551–1557.

Methow Salmon Recovery Foundation, Washington Department of Fish and Wildlife, and U.S. Forest Service–Methow Valley Ranger District. 2018. Methow Beaver Project: Status Report 2016–2017.

Meyer, J. L., M. J. Sale, P. J. Mulholland, and N. L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. Journal of the American Water Resources Association 35(6):1373–1386.

Morace, J. L. 2012. Reconnaissance of contaminants in selected wastewater-treatment-plant effluent and stormwater runoff entering the Columbia River, Columbia River Basin, Washington and Oregon, 2008–10. U.S. Geological Survey, editor, Reston, Virginia.

Mote, P. W., J. T. Abatzglou, and K. E. Kunkel. 2013. Climate: variability and change in the past and the future. In: Climate change in the Northwest: implications for our landscapes, waters, and communities, edited by M. M. Dalton, P. W. Mote, and A. K. Snover, Island Press, Washington, D.C.

Mote, P. W., and coauthors. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States. Geophysical Research Letters 43.

Mote, P. W., and coauthors. 2014. Ch. 21: Northwest. In Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T. C. Richmond, and G. W. Yohe, Eds. U.S. Global Change Research Program.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in Mid-Columbia river tributary streams. U.S. Fish and Wildlife Service.

Murphy, M. L., and J. D. Hall. 1981. Vaired effects of clear-cut logging on predators and their habitat in small streams of the Cascade Mountains, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 38:137–145.

Murphy, M. L., J. Heifetz, J. F. Thedinga, S. W. Johnson, and K. V. Koski. 1989. Habitat Utilization by Juvenile Pacific Salmon (Onchorynchus) in the Glacial Taku River, Southeast Alaska. Canadian Journal of Fisheries and Aquatic Science 46:1677–1685.

Myers, J. M., and coauthors. 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.

Myers, J. M., and coauthors. 2015. Identifying historical populations of steelhead within the Puget Sound distinct population segment U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-128.

Naiman, R. J., J. M. Melillo, and J. E. Hobbie. 1986. Ecosystem Alteration of Boreal Forest Streams by Beaver (Castor Canadensis). Ecology 67(5):1254–1269.

National Marine Fisheries Service. 2006. Final supplement to the Shared Strategy's Puget Sound salmon recovery plan. National Marine Fisheries Service, Northwest Region, Seattle.

National Marine Fisheries Service. 2007. Final Supplement to the recovery plan for the Hood Canal and eastern Strait of Juan de Fuca summer chum salmon (Oncorhynchus keta). National Marine Fisheries Service, Northwest Region, Portland, Oregon.

National Marine Fisheries Service. 2008a. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the on-going National Flood Insurance Program carried out in the Puget Sound area in Washington State. HUC 17110020 Puget Sound. National Marine Fisheries Service, Seattle, WA.

National Marine Fisheries Service. 2008b. Programmatic biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation for revisions to Standard Local Operating Procedures for Endangered Species to administer maintenance or improvement of road, culvert, bridge and utility line actions authorized or carried out by the U.S. Army Corps of Engineers in Oregon (SLOPES IV Roads, Culverts, Bridges and Utility Lines, August 13, 2008), (Refer to NMFS No.:2008/04070), Portland, Oregon.

National Marine Fisheries Service. 2009. Middle Columbia River steelhead distinct population segment ESA recovery plan. National Marine Fisheries Service, Northwest Region, Seattle.

National Marine Fisheries Service. 2013. 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, editor, Seattle.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783–789.

NMFS. 2011a. 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, editor, Portland, Oregon.

NMFS. 2011b. 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, editor, Portland, Oregon.

NMFS. 2011c. 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, editor, Portland, Oregon.

NMFS West Coast Region. 2015. Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead, FINAL Biological Report, Portland, OR.

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, editor, Portland, Oregon.

NOAA Fisheries. 2011. Biennial report to Congress on the recovery program for threatened and endangered species October 1, 2008–September 30, 2010.

NOAA Fisheries. 2017a. ESA recovery plan for Snake River fall Chinook salmon (*Oncorhynchus tshawytscha*). NOAA NMFS West Coast Region, Portland, Oregon.

NOAA Fisheries. 2017b. ESA recovery plan for Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) and Snake River basin steelhead (*Oncorhynchus mykiss*). NOAA NMFS West Coast Region, Portland, Oregon.

Northwest Fisheries Science Center. 2015. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. NOAA, Northwest Fisheries Science Center.

Northwest Power and Conservation Council. 2012. The State of the Columbia River Basin. Northwest Power and Conservation Council, Portland, Oregon.

Oregon Department of Fish and Wildlife. 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. Oregon Department of Fish and Wildlife.

Pacific Fishery Management Council. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18 to the Pacific Coast Salmon Plan: Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. Pacific Fishery Management Council, Portland, Oregon.

Petro, V. M., J. D. Taylor, and D. M. Sanchez. 2015. Evaluating landowner-based beaver relocation as a tool to restore salmon habitat. Global Ecology and Conservation 3:477–486.

Point No Point Treaty Tribes and Washington Department of Fish and Wildlife. 2014. Five-year review of the Summer Chum salmon Conservation Initiative for the period 2005 through 2013: Supplemental Report No. 8, Summer Chum Salmon Conservation Initiative--An implementation plan to recover summer chum salmon in the Hood Canal and Strait of Juan de Fuca region. September 2014. Washington Deptartment of Fish and Wildlife, Olympia, Washington.

Pollock, M., G. Lewallen, K. Woodruff, C. Jordan, and J. Castro. 2017. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.0. United States Fish and Wildlife Service, Portland, Oregon.

Pollock, M. M., T. J. Beechie, and C. E. Jordan. 2007. Geomorphic changes upstream of beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River basin, eastern Oregon. Earth Surface Processes and Landforms 32(8):1174–1185.

Pollock, M. M., M. Heim, and D. Werner. 2003. Hydrologic and Geomorphic Effects of Beaver Dams and Their Influence on Fishes. Pages 213–233 in S. V. Gregory, K. Boyer, and A. Gurnell, editors. American Fisheries Society Symposium 37:1–20.

Pollock, M. M., G. E. Pess, T. J. Beechie, and D. R. Montgomery. 2004. The importance of beaver ponds to Coho salmon production in the Stillaguamish River Basin, Washington, USA. North American Journal of Fisheries Management 24(3):749–760.

Ponce, V. M., and D. S. Lindquist. 1990. Management of baseflow augmentation: A review. Journal of the American Water Resources Association 26(2):259–268.

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Maryland.

Raymondi, R. R., and coauthors. 2013. Water Resources: implications of changes in temperature and precipitation. In: Climate change in the Northwest: implications for our landscapes, waters, and communities, edited by M. M. Dalton, P. W. Mote, and A. K. Snover, Island Press, Washington, D.C.

Reeder, W. S., and coauthors. 2013. Coasts: complex changes affecting the Northwest's diverse shorelines. In: Climate change in the Northwest: implications for our landscapes, waters, and communities, edited by M. M. Dalton, P. W. Mote, and A. K. Snover, Island Press, Washington, D.C.

Ruckelshaus, M., and coauthors. 2002a. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit. Puget Sound Technical Recovery Team. National Marine Fisheries Service, Northwest Fisheries Science Center, editor, Seattle.

Ruckelshaus, M., and coauthors. 2002b. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit. Puget Sound Technical Recovery Team. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle.

Sands, N. J., and coauthors. 2007. Dawgz 'n the hood: The Hood Canal summer chum salmon ESU, Draft. Puget Sound Technical Recovery Team, National Marine Fisheries Service, Northwest Fisheries Science Center, editor, Seattle.

Sands, N. J., and coauthors. 2009. Determination of independent populations and viability criteria for the Hood Canal summer chum salmon evolutionarily significant unit. U.S. Dept. of Commerce, NOAA Technical Memo. NMFS-NWFSC-101.

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.

Scholz, N. L., and coauthors. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urban streams. PLoS ONE 6(12):e28013.

Sedell, J. R., and J. L. Froggatt. 1984. Importnace of streamside forests to large rivers: The isolation of the Willamette River, Oregon, U.S.A., from it floodplain by snagging and streamside forest removal. Verh. Internat. Verein. Limnol. 22:1828–1834.

Shared Strategy for Puget Sound. 2007. Puget Sound salmon recovery plan. Volume 1, recovery plan, Seattle.

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.

Slate, D. A., R. Owens, G. Connolly, and G. Simmons. 1992. Decision making for wildlife damage management, Wenatchee, Washington.

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.

Sunda, W. G., and W. J. Cai. 2012. Eutrophication induced CO_2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric $P\mathrm{co}_2$. Environmental Science & Technology 46(19):10651–10659.

Suzuki, N., and W. C. McComb. 1998. Habitat Classification Models for Beaver (Castor canadensis) in the Streams of the Central Oregon Coast Range. Northwest Science 72(2):102-110.

Tague, C. L., J. S. Choate, and G. E. Grant. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. Hydrology and Earth System Sciences 17(1):341–354.

Takata, T. T. 2011. Oregon Lower Columbia River fall and winter Chinook spawning ground surveys 1952–2010. Oregon Department of Fish and Wildlife, Columbia River Managment.

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation, Reston, Virginia.

U.S. Department of Commerce. 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, Oregon. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Federal Register 78(10):2893–2907.

U.S. Department of Commerce. 2013b. Endangered and threatened species; Designation of critical habitat for Lower Columbia River coho salmon and Puget Sound steelhead; Proposed rule. Federal Register 78(9):2726–2796.

U.S. Department of Commerce. 2014. Endangered and threatened wildlife; Final rule to revise the Code of Federal Regulations for species under the jurisdiction of the National Marine Fisheries Service. Federal Register 79(71):20802–20817.

Upper Columbia Regional Technical Team. 2017. A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region. A draft report to the Upper Columbia Salmon Recovery Board from The Upper Columbia Regional Technical Team, Wenatchee, Washington.

Upper Columbia Salmon Recovery Board. 2007a. Upper Columbia spring Chinook salmon and steelhead recovery plan. Upper Columbia Salmon Recovery Board, editor, Wenatchee, Washington.

Upper Columbia Salmon Recovery Board. 2007b. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352p.

USGCRP. 2009. Global climate change impacts in the United States. U.S. Global Change Research Program, Washington, D.C.

Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. Northwest Science 87(3):219–242.

Washington Department of Fish and Wildlife. 2009. Fish passage and surface water diversion screening assessment and prioritization manual. Washington Department of Fish and Wildlife, editor, Olympia, Washington.

Washington Department of Fish and Wildlife and Point No Point Treaty Tribes. 2000. Summer Chum Salmon Conservation Initiative—An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca Region. Washington Department of Fish and Wildlife, Olympia, Washington.

Wathen, G., and coauthors. 2018. Beaver activity increases habitat complexity and spatial partitioning by steelhead trout. Canadian Journal of Fisheries and Aquatic Sciences.

Weber, N., and coauthors. 2017. Alteration of stream temperature by natural and artificial beaver dams. PLoS ONE.

Wentz, D. A., and coauthors. 1998. Water quality in the Willamette Basin, Oregon 1991–1995. U.S. Geological Survey Circular 1161.

Westbrook, C. J., D. J. Cooper, and B. W. Baker. 2006. Beaver dams and overbank floods influence groundwater–surface water interactions of a Rocky Mountain riparian area. WATER RESOURCES RESEARCH 42:1–12.

White, D. S. 1990. Biological relationships to convective flow patterns within stream beds. Hydrobiologia 196:149–158.

Wildlife Services. 2014. WS Directive 2.201 WS–Decision Model. United States Department of Agriculture, Animal and Plant Health Inspection Service.

Winder, M., and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology 85(8):2100–2106.

Wissmar, R. C., and coauthors. 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.

Woodruff, K. 2016. Methow Beaver Project Accomplishments 2015. http://methowsalmon.org/Documents/Methow_Beaver_Project_Accomplishments_2015_Final.pdf, accessed 2/19/2019.

WRIA 1 Salmon Recovery Board. 2005. WRIA 1 salmonid recovery plan. http://salmonwria1.org/webfm_send/23 accessed 2/19/2019.

Wydoski, R. S., and R. R. Whitney. 2003. Inland Fishes of Washington. University of Washington Press.

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.

Zimmerman, M. S. 2018. 2018 Wild Coho forecasts for Puget Sound, Washington Coast, and Lower Columbia. Washington Department of Fish and Wildlife Science Division, Fish Program.