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

Consultation on effects of the 2018-2027 *U.S. v. Oregon* Management Agreement.

NMFS Consultation Number: WCR-2017-7164

Action Agencies: NOAA's National Marine Fisheries Service
U.S. Fish and Wildlife Service
Bureau of Indian Affairs

Affected Species and NMFS' Determinations:

ESA-Listed Species	**Status**	**Is Action Likely to Adversely Affect Species?**	**Is Action Likely To Jeopardize the Species?**	**Is Action Likely to Adversely Affect Critical Habitat?**	**Is Action Likely To Destroy or Adversely Modify Critical Habitat?**
Lower Columbia River Chinook Salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Upper Columbia River Spring-run Chinook Salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Snake River Spring/Summer-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River Fall-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River Coho Salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Columbia River Chum Salmon (*O. keta*)	Threatened	Yes	No	No	No
Snake River Sockeye Salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

Upper Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River Basin Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Middle Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Upper Willamette River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Sturgeon, green – Southern Distinct Population Segment (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	No*	No	No	No
Pacific Eulachon/Smelt – Southern Distinct Population Segment (*Thaleichthys pacificus*)	Threatened	No*	No	No	No

*Please refer to section 2.11 for the analysis of species or critical habitat that are not likely to be adversely affected.

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	No
Pacific Fishery Management Council's Coastal Pelagic Species	No	No
Pacific Coast Groundfish	No	No
U.S. West Coast Fisheries for Highly Migratory Species	No	No

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

Issued By: FOR ______________________________

Barry A. Thom
Regional Administrator

Date: February 23, 2018

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ABM	Abundance-Based Management
AE	Adult Equivalent
A/P	Abundance and Productivity
BA	Biological Assessment
BIA	Bureau of Indian Affairs
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CI	Confidence Interval
C&S	Ceremonial and Subsistence Fisheries
CFR	Code of Federal Regulations
CHART	Critical Habitat Analytical Review Teams
COE	Core of Engineers
CPS	Coastal Pelagic Species
CR	Columbia River
CRE	Columbia River Estuary
CRFMP	Columbia River Fish Management Plan
CRP	Cooperative Research Program
CSF	Conservation and Sustainable Fisheries
CWA	Clean Water Act
CWT	Coded-Wire Tags
DARRP	Damage Assessment, Remediation, and Restoration Program
DIDSON	Dual Frequency Identification Sonar
DPS	Distinct Population Segment
DQA	Data Quality Act
EDT	Ecosystem Diagnosis and Treatment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFP	Exempted Fishing Permit
EIS	Environmental Impact Statement
ER	Exploitation Rate
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit (a term used by NMFS)
EWEB	Eugene Water & Electric Board
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FMEP	Fisheries Management and Evaluation Plans
FMP	Fishery Management Plan
FR	Federal Register
GSI	Genetic Stock Identification
HMS	Highly Migratory Species
HQI	Habitat Quality Improvements
HR	Harvest Rate
HSRG	Hatchery Scientific Review Group
HUC	Hydrologic Unit Code
IC	Interior Columbia
ICTRT	Interior Columbia Technical Recovery Team
IGF	Insulin Growth Factor
IHNV	Infectious Hematopoietic Necrosis Virus
IMST	Independent Multidisciplinary Science Team
IPC	Idaho Power Company
ISAB	Independent Scientific Advisory Board
ITS	Incidental Take Statement
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
LFH	Lyons Fish Hatchery
LGD	Lower Granite Dam
LRH	Lower River Hatchery
LRW	Lower River Wild
LSRB	Lower Snake River Recovery Board
MCR	Middle Columbia River
MDNs	Marine Derived Nutrients
MF	Middle Fork
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NPEA	Natural Production Emphasis Areas
ODFW	Oregon Department of Fish and Wildlife
OMV	*Oncorhynchus masou* Virus
OSY	Optimum Sustainable Yield
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PBDEs	Polybrominated Diphenyl Ethers
PBFs	Physical or Biological Features
PBT	Parental Based Genetic Tagging
PCD	Predation, Competition, Disease
PCE	Primary Constituent Element
PCSRF	Pacific Coastal Salmon Recovery Fund
PFMC	Pacific Fishery Management Council
PGE	Portland General Electric
pHOS	Proportion of hatchery-origin fish on the spawning grounds
PIT	Passive Integrated Transponder
PNI	Proportionate Natural Influence
pNOB	Proportion of natural-origin fish in the broodstocks
PRP	Proposed Recovery Plan
PST	Pacific Salmon Treaty
PUD	Public Utility District
RBDD	Red Bluff Diversion Dam
RER	Rebuilding Exploitation Rate
RKm	River Kilometer
RM	River Mile
RM&E	Research, Monitoring, and Evaluation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPMs	Reasonable and Prudent Measures
RRS	Relative Reproductive Success
SAFE	Select Area Fisheries Enhancement
SAR	Smolt-to-adult return
SCA	Supplemental Comprehensive Analysis
SEWMU	South East Washington Management Unit
SR	Snake River
SRFB	Salmon Recovery Funding Board
SRKW	Southern Resident Killer Whale
SS/D	Spatial Structure/Diversity
TAC	*U.S. v Oregon* Technical Advisory Committee
TDG	Total Dissolved Gas
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRT	Technical Recovery Team
UCR	Upper Columbia River
UCSRB	Upper Columbia Salmon Recovery Board
URB	Upriver Bright
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VRAP	Viability Risk Assessment Procedure
VSP	Viable Salmonid Populations
WDFW	Washington Department of Fish and Wildlife
WLC	Willamette Lower Columbia

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 USC 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). The document will be available through NMFS' Public Consultation Tracking System: https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at Lacey, Washington.

This opinion considers the effects of the proposed action on fifteen ESA-listed salmonid species (Table 1-1). It also considers the effects on three non-salmonid species: Southern Resident killer whales (SRKW), eulachon, and green sturgeon (Table 1-1).

Table 1-1. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to a listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52706, September 2, 2005	70 FR 37160, June 28, 2005
Upper Columbia River spring-run	Endangered, 70 FR 20816, April 14, 2014	70 FR 52732, September 2, 2005	Issued under ESA Section 9
Snake River spring/summer-run	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005

Species	Listing Status	Critical Habitat	Protective Regulations
Snake River fall-run	Threatened, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Upper Willamette River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52720, September 2, 2005	70 FR 37160, June 28, 2005
Coho salmon *(O. kisutch)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	81 FR 9252, February 24, 2016	70 FR 37160, June 28, 2005
Chum salmon *(O. keta)*			
Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52746, September 2, 2005	70 FR 37160, June 28, 2005
Sockeye salmon *(O. nerka)*			
Snake River	Endangered, 79 FR 20802, April 14, 2014	70 FR 52630, September 2, 2005	Issued under ESA Section 9
Steelhead *(O. mykiss)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52833, September 2, 2005	70 FR 37160, June 28, 2005
Upper Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52630, September 2, 2005	71 FR 5178, February 1, 2006
Snake River Basin	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 37160, June 28, 2005
Middle Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52808, September 2, 2005	70 FR 47160, June 28, 2005

Species	Listing Status	Critical Habitat	Protective Regulations
Upper Willamette River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52848, September 2, 2005	70 FR 37160, June 28, 2005
Killer Whales (*Orcinus orca*)			
Southern Resident DPS	Endangered, 70 FR 69903; November 18, 2005	71 FR 69054; November 29, 2006	Issued under ESA Section 9; 76 FR 20870; April 14, 2011
Green Sturgeon (*Acipenser medirostris*)			
Southern Resident DPS	Threatened, 71 FR 17757; April 7, 2006	74 FR 52300; October 9, 2009	75 FR 30714; June 2, 2010
Pacific Eulachon *(Thaleichthys pacificus)*			
Southern DPS	Threatened, 79 FR 20802, April 14, 2014	76 FR 65324, October 20, 2011	Not yet developed

1.2 Consultation History

Fisheries in the Columbia River are managed subject to provisions of United States v. Oregon (*US v Oregon*) under the continuing jurisdiction of the Federal court. The case now styled *United States v. Oregon* is the outgrowth of the consolidation of two cases filed in 1968, *Sohappy v. Smith*, No. 68-409 (D. Or.), and *United States v. Oregon*, No. 68-513 (D. Or.). These cases were first brought in 1968 to enforce the reserved treaty fishing rights of the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation (collectively, "Columbia River Treaty Tribes"). The United States brought the case to define the Columbia River Treaty Tribes' right to take fish "at all usual and accustomed places" on the Columbia River and its tributaries. At the time the original complaint was filed, the Columbia River Treaty Tribes were limited to approximately 16% of the annual salmon harvest, based on 1960-1968 averages.

In the intervening decades, the courts have established several key principles. First, that the language of the treaties provided that the tribes retain the right to take fish at all usual and accustomed fishing places "in common with the citizens of the United States [or citizens of the territory],” reserved 50% of the harvestable fish destined for the tribes’ traditional fishing places. Second, that the state may only regulate treaty fishing when reasonable and necessary for conservation. The conservation necessity applies when reasonable regulation of non-Indian activities is insufficient to meet the conservation purpose, the regulations are the least restrictive possible, the regulations do not discriminate against Indians, and voluntary tribal measures are not adequate

In the early years of *US v Oregon*, harvest seasons were the subject of litigation and year-to-year court rulings. Since that time, the state and tribal Parties to *US v Oregon*, at the urging of the Federal District Court, have entered into negotiated agreements on allocation and management of upriver salmon runs and provisions related to hatchery production.

Beginning in 1977, the Parties have reached several agreements to meet this goal. Parties to those agreements have included the State of Washington, the State of Oregon, the State of Idaho, the United States (including the NMFS, the U.S. Fish and Wildlife Service (FWS), and the U.S. Bureau of Indian Affairs (BIA)), the Shoshone-Bannock Tribes, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation (collectively, the Parties). In reaching agreement, the Parties have used the 50% treaty share as a measure of the Treaty right for a fair allocation of fish.

In 1988, the Columbia River Fish Management Plan (CRFMP) was agreed to by the Parties and adopted by District Court Order as a partial settlement of *US v Oregon*. In later years, the Federal District Court described the CRFMP as “the seminal document governing in-river harvest activities.” *Pac. Nw. Generating Co-op. v. Brown*, 822 F. Supp. 1479, 1486 (D. Or. 1993). The court noted that the CRFMP was a delicate, but effective structure for allocating and planning harvest activities. *Id.* It further noted that the facts of the case were unique, stemming from “the absolute need for coordinated and centralized management of fish resource management in the Columbia River to protect fish and the balance between treaty Indian and non-treaty Indian fisheries.” *United States v. Oregon*, No. CIV. 68-513-MA, 1992 WL 613238, at *2 (D. Or. Feb. 29, 1992).

In 1991, Snake River sockeye salmon were listed as endangered under the ESA. This was followed by listing of Snake River spring/summer-run Chinook and Snake River fall-run Chinook salmon as threatened in 1992. The Parties had already “greatly curtailed” harvest from historic levels in an effort to protect the fish. Indeed, “[p]reservation and conservation of the species through management, planning and study have been integral components of the CRFMP since its inception.” *Pac. Nw. Generating Co-op*, 822 F. Supp. at 1485 n.13.

Fisheries in the Columbia River Basin were managed subject to provisions of the CRFMP from 1988 through 1998. Following 1998, fisheries were managed subject to provisions of a series of short term agreements among the Parties, the durations of which ranged from several months, covering a single fishing season, to five years.

Annual agreements were implemented for fall Chinook and coho salmon, and summer steelhead during the period 1999 to 2003. A 5-year agreement for harvest was reached for spring Chinook, summer Chinook, and sockeye salmon for the period 2001 through 2005.

In 2005, the Parties negotiated a 3-year (2005 through 2007) Interim Management Agreement (2005 Agreement). Unlike some previous agreements, the 2005 Agreement covered fisheries year round (winter, spring, summer, and fall season fisheries). The 2005 Agreement and associated harvest provisions were the result of ongoing negotiations in *US v Oregon* and the evolution and development of fishery management in response to ESA-listings of Pacific salmon species. The 2005 Agreement expanded the use of abundance-based harvest schedules and served as the model for the next agreement that was completed in 2008. These agreements also gave precedence to the preservation and conservation on the species. As explained in the agreement's preamble, the purpose is:

> to provide a framework within which the Parties may exercise their sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-treaty fisheries.
>
> The primary goals of the Parties are to rebuild weak runs to full productivity and fairly share the harvest of upper river runs between treaty Indian and non-treaty fisheries in the ocean and Columbia River Basin.

In signing the agreement, the sovereign parties voluntarily agree to limit their harvest to levels that meet this purpose and goals thereby mitigating adverse effects on listed species.

To ensure that the agreements provide sufficient curtailment of harvest activities to protect listed species and as directed by the district court, NMFS has consulted under section 7 of the ESA on proposed *US v Oregon* fisheries in the Columbia River Basin since 1992. The commencement of these consultations immediately followed the first listings of salmonids. After the initial consultation, NMFS conducted a series of consultations to consider the effects of proposed fisheries as additional species were listed, as new information became available, and as fishery management provisions evolved to update the agreement where needed and address the needs of ESA-listed species. A list of prior biological opinions related to mainstem fisheries in the Columbia River is shown in the 2008 opinion (NMFS 2008e). More detailed descriptions of the consultation history are provided in the 2001 and 2005 opinions (NMFS 2001b; 2005a).

Most recently, the *US v Oregon* fisheries have been managed subject to the 2008 Agreement (D. Oregon 2008). NMFS completed a biological opinion on the 2008 Agreement on May 5, 2008. Because the 2008 Agreement was due to expire at the end of 2017, the *US v Oregon* parties negotiated a new proposed ten year agreement that is the subject of this consultation.

The Parties to the 2018 Agreement initially requested formal consultation under section 7 of the ESA on June 21, 2017 through submission of a Biological Assessment (BA) assembled by the *US v Oregon* Technical Advisory Committee (TAC). The BA (TAC 2017) assessed the effects of implementing the fishery management framework specified within the 2018 Agreement and an addendum assembled by the *US v Oregon* Production Advisory Committee (PAC) quantified effects associated with hatchery programs referenced in the 2018 Agreement to ESA-listed species. TAC submitted supplemental material on December 7, 2017 clarifying certain aspects of the original BA. This document therefore refers to the original BA with this additional information incorporated into a single reference, both as TAC 2017.

1.3 Proposed Federal Action

Under the ESA, "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). For EFH consultations, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

The proposed action considered in this opinion is for the Federal parties to sign the new 2018 Agreement, as negotiated by the parties to *US v Oregon*, and for NMFS and FWS to issue an associated ITS exempting take of ESA-listed species pursuant to the implementation of the new 2018 Agreement (see Appendix A). This new management agreement would take effect after the current management agreement expires at the end of February 2018[1]. The new management agreement accomplishes two primary objectives. First, it memorializes the harvest policies that the parties have agreed should govern the amount of harvest. Second, it formalizes hatchery program release expectations, developed individually at site specific locations that augment harvest and are important to the conservation of salmon or steelhead runs above Bonneville Dam.

The new management agreement specifies harvest policies for salmon and steelhead stocks bound for upriver areas, for which the BA describes both treaty Indian and non-treaty fisheries that adhere to each harvest policy. A list of hatchery programs with expected production levels in the Columbia River Basin is also included. The new management agreement provides a framework to keep healthy stocks healthy, rebuild weak stocks, and fairly share the harvest of upper river runs between treaty Indian and non-treaty fisheries.

The proposed 2018 Agreement, including the non-treaty and treaty Indian fisheries components, extends from March 1, 2018 to December 31, 2027. The fisheries will operate primarily in the mainstem Columbia River from its mouth (Astoria, Oregon area) upstream to Priest Rapids Dam, and in the Snake River from its confluence with the Columbia River upstream to Lower Granite Dam (described in more detail further below in Section 1.3.1 and 1.3.2). Although not directly specified, the 2018 Agreement states that it covers the mainstem Columbia and "certain tributary fisheries." Fisheries included in the proposed action are described in detail in the biological assessment submitted to NMFS by the TAC (2017), and are summarized below. Tributary fisheries were also identified in the TAC's biological assessment as part of the action and are therefore included in our analysis (and described in more detail further below in Section 1.3.1.2).

[1] The 2008 Agreement was set to originally expire on December 31, 2017. A gap existed between the time the 2008 Agreement and associated biological opinion expired and when the 2018 Agreement and new opinion could be finalized and implemented. As a consequence, the Parties agreed to extend the 2008 Agreement through February 28, 2018. Given the circumstances, NMFS also extended its 2008 biological opinion and associated incidental take statement, and concluded, based on considerations sent to NMFS from the Parties through the TAC, that the activities that would occur during the two month extension were not likely to adversely affect several species and were not likely to jeopardize the continued existence of the remaining species or destroy or adversely modify any designated critical habitat (Wulff 2017).

In describing the proposed action, it is first useful to clarify the distinction between term "stock" and how it is used for management, and "species" as it is used under the ESA. A species of salmon designated for ESA listing is referred to as an Evolutionarily Significant Unit (ESU). ESA-listed steelhead species are referred to as a Distinct Population Segment (DPS). ESUs and DPSs include one or more populations that are reproductively isolated and represent an important part of the evolutionary legacy of the species. We discuss the ESU and DPS concept in more detail in Chapter 2, but it is useful here to highlight and clarify that a biological opinion focuses on the effects of the proposed action on ESA-listed species. However, in fishery management, a stock is commonly used to describe one or more populations that are managed as a group and are exposed to similar fishery related impacts. Stocks generally represent the smallest unit of fish that can be enumerated and monitored in season. Stocks of fish include populations that can be grouped because of similar run timing and spatial distribution. Fisheries managed under the *US v Oregon* Agreement use several stocks that are generally not coincident with the ESA-listed ESUs and DPSs. The 2018 Agreement establishes harvest management policies for fisheries in the action area (described in Section 2.3) directed at Upriver salmon and steelhead stocks. We will further detail this approach in our effects analysis, but introduce the "stock" concept here as the following descriptions of fisheries use the term frequently.

1.3.1 Fishery Framework

This information is summarized from the BA developed by TAC (TAC 2017) as described above in Section 1.2.

Across all of the following fishery descriptions, monitoring and evaluation activities occur throughout the year in the Columbia River to assess the stock status of salmon and steelhead returns and to monitor fishery effort, catch, and impacts to fish listed under the ESA (TAC 2017). Fishery sampling is conducted by the Parties to estimate landed catch and to collect representative and unbiased samples using systematic or stratified sampling methods. The sampling goal is to sample at least 20% of the catch (by fishery / by week, month, etc.) to ensure adequate numbers of coded-wire tags (CWTs) are recovered to profile the stock composition of fish moving upstream and subsequently taken during authorized fisheries. Additionally, the Parties also strive to achieve biological minimum sampling goals for capturing enough fish scales for a 95% confidence interval (+10%) age composition estimate of the catch to use in run reconstruction and subsequent forecasting of fish runs (TAC 2017). Given these monitoring activities result in harvest estimates that are statistically based, they are considered indexes rather than exact point estimates.

Staff from the Parties, including TAC members, meet before every spring, summer, and fall season to review sampling of the various species and fisheries are coordinated, sampling rates and locations set, and deadlines confirmed. Examples of season-specific sampling matrices are contained in the BA submitted (TAC 2017). Creel monitoring along with biological sampling of treaty fisheries follows very similar methods to non-treaty fisheries and is also described in detail in the BA (TAC 2017). As part of the proposed action the Parties expect to review all the sampling and monitoring methods they use for estimation for accuracy and continued pertinence.

1.3.1.1 Management Periods

Fisheries governed by the 2018 Agreement are managed within a winter/spring, summer, and fall season time frame, each referred to as a management period. As specified above, treaty Indian fisheries and non-treaty fisheries are considered in this opinion. Non-treaty fisheries are those that do not have a treaty reserving a fishing right within the action area. These include all state fisheries and certain Indian fisheries operated by tribes that are not party to *US v Oregon*. Non-treaty fisheries consist of both commercial and recreational fisheries. Treaty Indian fisheries are those reserved by one or more treaties. These fisheries include both commercial and ceremonial and subsistence (C&S) fisheries.

The winter/spring season extends from January 1 to June 15 (Table 1-2). During this management period fisheries in the mainstem Columbia River primarily target spring Chinook salmon stocks returning to the upper Columbia, the Willamette River, and lower Columbia River tributaries.

Table 1-2. Fisheries subject to the 2018 Agreement during the winter/spring management period.

Fishery Management Period	Jurisdiction	Fishery Description	Target species	Location
Winter/Spring season (January 1 through June 15)	Non-Treaty	Commercial spring Chinook	Spring Chinook salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Commercial Fisheries in Select Areas	Select Area hatchery-origin Spring Chinook, fall Chinook, and coho salmon	Off-channel areas near the mouth of the Columbia River (upstream of Buoy 10 area)
		Recreational spring Chinook – below BON	Spring Chinook salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Recreational spring Chinook – BON - HWY 395 Bridge	Spring Chinook salmon	Bonneville Dam upstream to Highway 395 Bridge near Pasco, WA
		Recreational spring Chinook – Snake River (WA waters Downstream of LGR)	Spring Chinook salmon	Mouth of the Snake River upstream to Lower Granite Dam
		Recreational spring Chinook – Ringold Area	Spring Chinook salmon	Highway 395 Bridge near Pasco, WA upstream to Priest Rapids Dam
		Wanapum tribal spring Chinook	Spring Chinook salmon	Mainstem Columbia River from Priest Rapids upstream to Wanapum Dam

	Treaty Indian	Ceremonial and Subsistence (C&S)	Spring Chinook salmon	Action Area[1]
		Winter Gillnet (Zone 6)	White Sturgeon	Bonneville Dam to McNary Dam
		Spring gillnet (Zone 6)	Spring Chinook salmon	Bonneville Dam to McNary Dam
		Platform and Hook&Line (Zone 6 + downstream of BON)	Spring Chinook salmon	Buoy 10 to McNary Dam
		Permit Gillnet	Spring Chinook salmon	Action Area[1]
		McNary - HWY 395 Bridge	Spring Chinook salmon	McNary Dam upstream to Highway 395 Bridge near Pasco, WA

Treaty C&S fisheries generally occur in the mainstem Columbia and tributaries except the Snake River.

The summer season extends from June 16 to July 31 (Table 1-3). During this management period, fisheries target primarily Upper Columbia summer Chinook salmon, which is not ESA-listed, and Upriver Columbia sockeye salmon, which includes the ESA-listed Snake River Sockeye Salmon ESU. Snake River sockeye salmon comprise less than one percent of the Upriver sockeye salmon stock. These stocks constrain the summer season fisheries. Summer season fisheries are constrained primarily by the available opportunity for Upper Columbia summer Chinook salmon which includes fish returning to the Okanogan and Wenatchee rivers and fish which also spawn in the mainstem Columbia River, and by specific harvest limits for Snake River sockeye salmon.

Table 1-3. Fisheries subject to the 2018 Agreement during the summer management period.

Fishery Management Period	Jurisdiction	Fishery Description	Target species	Location
Summer season (June 16 through July 31)	Non-Treaty	Recreational – mouth to McNary	Summer Chinook and sockeye salmon and summer steelhead	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Recreational – McNary to I-395	Summer Chinook and sockeye salmon and summer steelhead	McNary Dam upstream to Highway 395 Bridge near Pasco, WA
		Wanapum tribal summer Chinook	Summer Chinook salmon	Mainstem Columbia River from Priest Rapids upstream

				to Wanapum Dam
		Commercial salmon	Summer Chinook salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Select Area commercial	Select Area hatchery-origin spring Chinook and fall Chinook salmon	Off-channel areas near the mouth of the Columbia River (upstream of Buoy 10 area)
	Treaty Indian	Ceremonial and Subsistence (C&S)	Summer Chinook or sockeye salmon	Action Area[1]
		Commercial gillnet (Zone 6)	Summer Chinook and sockeye salmon, shad	Bonneville Dam to McNary Dam
		Platform and Hook&Line (Zone 6 + downstream of BON)	Summer Chinook and sockeye salmon	Buoy 10 to McNary Dam
		Permit Gillnet (Zone 6)	Summer Chinook salmon	Bonneville Dam to McNary Dam
		McNary - HWY 395 Bridge	Summer Chinook and sockeye salmon	McNary Dam upstream to Highway 395 Bridge near Pasco, WA

[1] Treaty C&S fisheries generally occur in the mainstem Columbia and tributaries except the Snake River.

Fall season fisheries begin on August 1 and extend to the end of the calendar year (Table 1-4). During the fall management period fisheries target primarily harvestable hatchery and natural-origin fall Chinook and coho salmon, and hatchery steelhead. Fall season fisheries are constrained by specific ESA related harvest rate limits for listed Snake River fall-run Chinook salmon, and both A-Index and B-Index components of the listed Upper Columbia River (UCR) and Snake River steelhead DPSs (A-Index and B-Index steelhead are stock designations that refer to components of the summer run steelhead DPSs, that have particular life history characteristics. This will be reviewed in further detail in the status section below).

Table 1-4. Fisheries subject to the 2018 Agreement during the fall management period.

Fishery Management Period	Jurisdiction	Fishery Description	Target species	Location
Fall season August 1 through December 31	Non-Treaty	Commercial gillnet	Fall Chinook and coho salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Commercial tangle net	Coho salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Commercial seine	Fall Chinook and coho salmon	Mouth of Columbia (Buoy 10) upstream to Bonneville Dam
		Select Area commercial	Select Area hatchery-origin fall Chinook and coho salmon	Off-channel areas near the mouth of the Columbia River (upstream of Buoy 10 area)
		Recreational Buoy 10	Fall Chinook and coho salmon	Mouth of the Columbia River (Buoy 10/Estuary area)
		Mainstem Recreational – below BON	Fall Chinook, coho salmon, and summer steelhead	Upstream of Buoy 10 to Bonneville Dam
		Recreational – BON - HWY 395 Bridge	Fall Chinook, coho salmon, and summer steelhead	Bonneville Dam upstream to Highway 395 Bridge near Pasco, WA
		Recreational Lower Snake River	Fall Chinook salmon and summer steelhead	Mouth of the Snake River upstream to Lower Granite Dam

		Recreational steelhead (tributary dip-ins Klickitat, Deschutes, John Day)	Fall Chinook, coho salmon, and summer steelhead	Klickitat River, WA Deschutes River, OR John Day River, OR
	Treaty Indian	C&S fisheries	Fall Chinook salmon or steelhead	Action Area[1]
		Commercial gillnet (Zone 6)	Fall Chinook salmon	Bonneville Dam to McNary Dam
		Platform and Hook&Line (Zone 6 + downstream of BON)	Fall Chinook salmon	Buoy 10 to McNary Dam
		Late Fall Commercial gill net	White Sturgeon	Bonneville Dam to McNary Dam
		Permit Gillnet	Fall Chinook salmon	Action Area[1]
		McNary - HWY 395 Bridge	Fall Chinook and coho salmon	McNary Dam upstream to Highway 395 Bridge near Pasco, WA

[1]Treaty C&S fisheries generally occur in the mainstem Columbia and tributaries except the Snake River.

Fisheries in Table 1-2 through Table 1-4 occur during one of the previously described management periods. However, there are a few fisheries that cross the management period time frames (Table 1-5). Additionally, the 2018 Agreement contains treaty tribal tributary fisheries that occur outside of the management periods, which are described in more detail below in Section 1.3.1.2. Additionally, Lamprey fisheries at Willamette Falls and in the Willamette River and any other Columbia tributaries are included. Treaty Indian fisheries directed at Shad, Walleye, and other fish account for incidental impacts of salmon and steelhead and also operate across management periods, but these non-ESA-listed species are also retained during C&S fisheries if caught (Table 1-5).

Table 1-5. Fisheries subject to the 2018 Agreement that span more than one management period.

Jurisdiction	Fishery Description	Target species	Location
Non-Treaty	Mainstem Recreational steelhead	Summer and Winter steelhead	Mouth of Columbia (Buoy 10) upstream to

Jurisdiction	Fishery Description	Target species	Location
			Highway 395 Bridge near Pasco, WA
	Recreational fisheries in Select Areas	Select Area hatchery-origin spring Chinook, fall Chinook, and coho salmon	Off-channel areas near the mouth of the Columbia River (upstream of Buoy 10 area)
Treaty Indian	Ceremonial and Subsistence (C&S)	Salmon and steelhead, and other species[1]	Action Area[2]

[1] Fisheries may retain Shad, Walleye, and other fish may be taken anytime as well, based on their adult availability.
[2] Treaty C&S fisheries generally occur in the mainstem Columbia and tributaries except the Snake River.

1.3.1.2 Treaty Indian Tributary Fisheries

The *US v Oregon* agreement includes a specified set of treaty Indian tributary fisheries (Table 1-6). Catch in some of the tributary fisheries, particularly in the lower reaches and river mouths, are known to catch “dip-in” fish from the overall run moving through the mainstem migration corridor. Catch in these areas is counted against the treaty fishery catch limits. Catch in tributary fisheries further upstream within the tributary itself target local stocks, and occur in areas where fish in the mainstem migration corridor are not likely to enter or occur. These terminal fisheries target non-ESA-listed spring Chinook, fall Chinook, and coho salmon, and hatchery reared steelhead, but still may affect ESA-listed species that are particular to each tributary. The BA (TAC 2017) characterizes expected catch and the expected take of ESA-listed fish for each of the tribal tributary fisheries.

Table 1-6. Treaty Indian tributary fisheries.

Jurisdiction	Fishery Description	Target species	Location
Treaty Indian	Little White Salmon/Drano Tributary	Spring Chinook, fall Chinook, and coho salmon	Drano Lake, WA
	Wind River Tributary	Spring Chinook	Mouth of the Wind River, WA
	White Salmon River Tributary	Spring and fall Chinook salmon	White Salmon River, WA
	Hood River Tributary	Spring Chinook salmon	Hood River, OR

	Klickitat River Tributary	Spring Chinook, fall Chinook, and coho salmon	Klickitat River, WA
	Deschutes River Tributary	Spring and fall Chinook salmon	Deschutes River, OR
	John Day River Tributary	Chinook salmon	John Day River, OR
	Umatilla River Tributary	Spring Chinook, fall Chinook, coho salmon, and steelhead	Umatilla River, OR
	Walla Walla River Tributary	Spring Chinook salmon	Walla Walla River, WA
	Yakima River Tributary	Spring, summer, and fall Chinook salmon	Yakima River, WA
	Icicle Creek Tributary	Spring Chinook salmon	Icicle Creek, WA

1.3.2 Fishery Location and Jurisdiction

1.3.2.1 Treaty Indian Fisheries

Treaty Indian fisheries included in the proposed new *US v Oregon* agreement would be managed subject to the regulation of the tribal signatories to the 2018 Agreement. The fisheries are managed primarily by specifying the time and area for fishery openings, allowable gear types, and monitoring the fisheries to ensure that they achieve catch targets and stay within conservation constraints. Treaty Indian fisheries are generally managed allowing the retention of all fish caught (full retention), but under some circumstances the tribes may choose to implement species selective fisheries. Treaty Indian fisheries generally occur in the mainstem Columbia River between Bonneville Dam and McNary Dam, although some fishing does occur both above McNary and below Bonneville Dam. Impacts associated with these fisheries are accounted for wherever they occur. Reservoirs of water behind each dam are designated separately (upstream of Bonneville Dam is Bonneville Reservoir, Zone 6/61; upstream of The Dalles Dam is Lake Celilo, Zone 6/62; and, upstream of John Day Dam is Lake Umatilla, Zone 6/63). However, they are commonly known collectively as “Zone 6” (Figure 1-1).

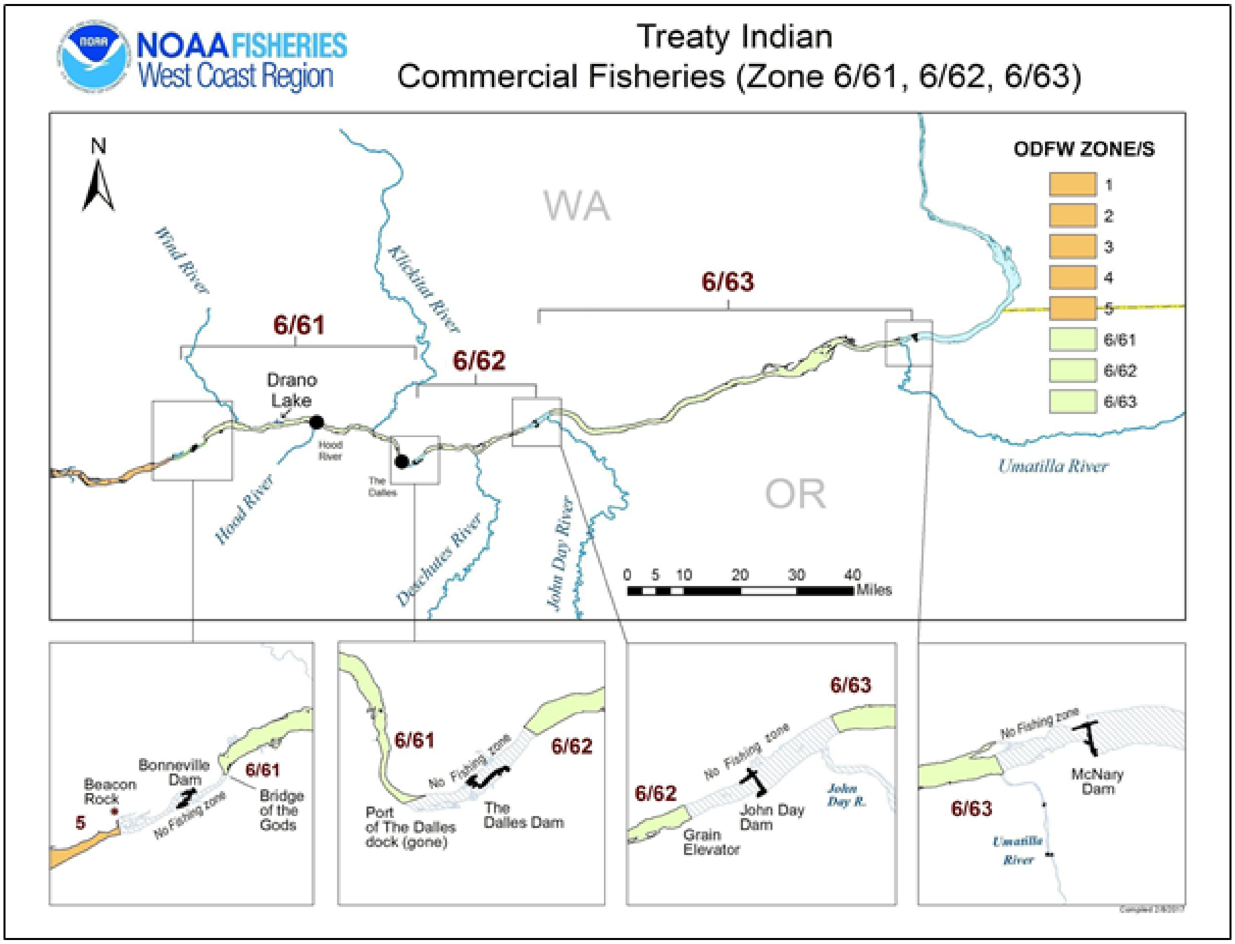


Figure 1-1. Location of mainstem treaty Indian fisheries downstream of McNary Dam, collectively known as Zone 6.

Fisheries implemented in the reservoir upstream of McNary Dam, known as Lake Wallula, up to the mouth of the Snake River are managed under the same mainstem harvest limits as the rest of the mainstem.

The tribes also manage a set of tributary fisheries discussed in further detail in Section 1.3.2.1. These fisheries target spring Chinook, fall Chinook, and coho salmon, or steelhead depending on the status of the stocks returning to each tributary.

1.3.2.2 Non-Treaty Fisheries

Non-treaty fisheries considered in a new *US v Oregon* agreement would be managed under the jurisdiction of the states. Generally, these include mainstem Columbia River commercial and recreational salmonid fisheries between Buoy 10 at the mouth of the Columbia River and Bonneville Dam (commonly known as Zones 1-5, described in more detail below in Section 1.3.3.1), designated off channel Select Area Fishery Enhancement fisheries (SAFE fisheries, described in more detail below in Subsection 1.3.3.2), mainstem recreational fisheries between Bonneville Dam and McNary Dam (commonly known as Zone 6), recreational fisheries between McNary Dam and Highway 395 Bridge in Pasco, Washington, recreational and Wanapum tribal spring Chinook salmon fisheries from McNary Dam to Priest Rapids Dam, and recreational fisheries in the Snake River upstream to the Washington/Idaho state boundary. Catch also occurs in a set of "dip-in" fisheries. These dip-in fisheries are located at mouths and lower reaches of certain tributaries in Zone 6 where migrating fish may hold prior to continuing their upstream migration. The catch of upriver stocks in these dip-in fisheries are included in the catch accounting for upriver stocks. Dip-in fishing areas include Drano Lake at the mouth of the Little White Salmon River, the lower Wind River, the lower Deschutes River (upstream to Shearers Falls), and the John Day River Arm of John Day Reservoir.

1.3.2.2.1 Mainstem Non-Treaty Commercial Fisheries

Commercial fisheries below Bonneville Dam occur in the lower Columbia River in commercial catch Zones 1-5 (Figure 1-2). The majority of commercial harvest occurs in Zones 4 and 5 (Figure 1-2).

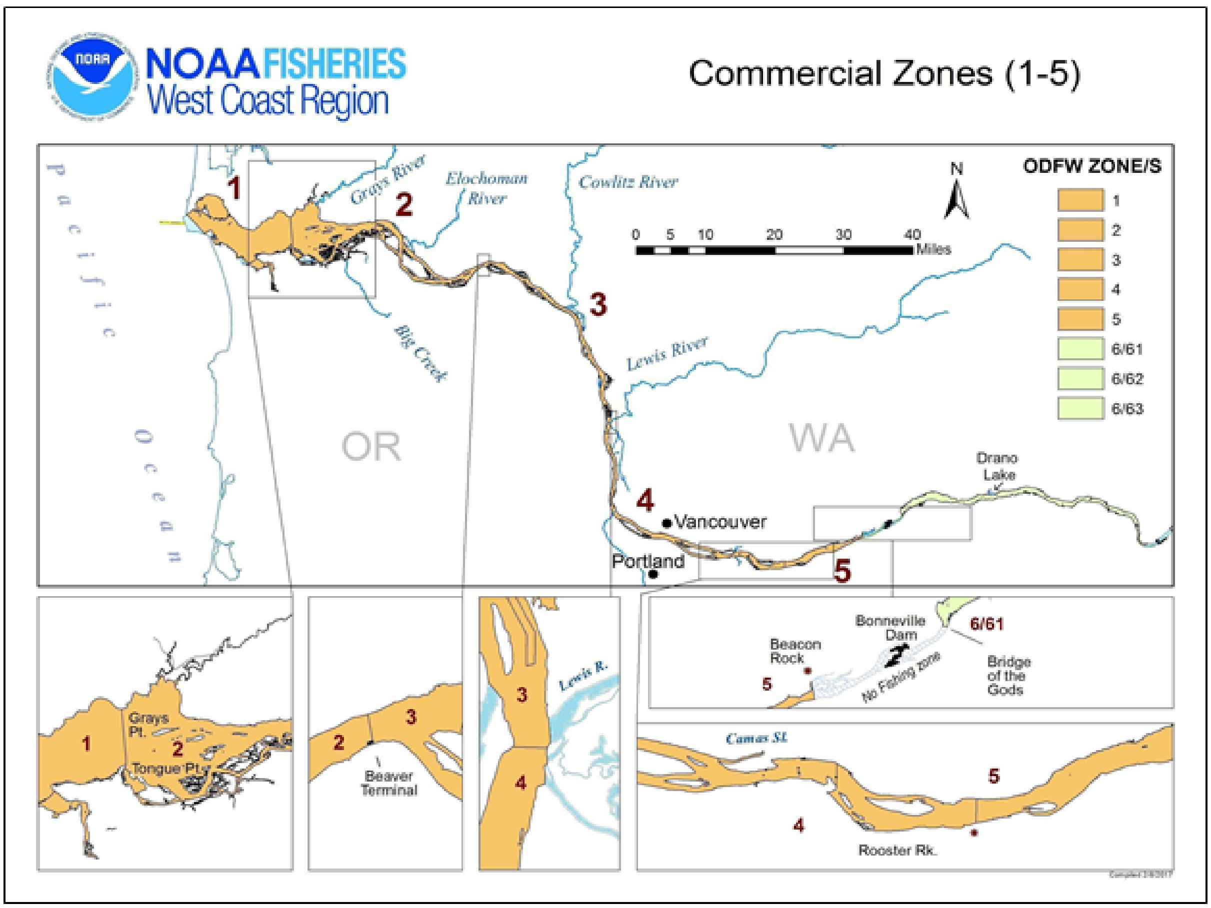


Figure 1-2. Commercial fishing zones downstream of Bonneville Dam.

1.3.2.2.2 Select Area Fisheries Enhancement (SAFE) Commercial Fisheries

SAFE fisheries occur in off-channel areas downstream of Zones 4 and 5 and target hatchery-reared and locally acclimated spring and fall Chinook and coho salmon. The SAFE area fisheries provide opportunity for expanded commercial and recreational fisheries directed at hatchery fish returning to their specific location.

SAFE areas are described as follows (see Figure 1-3):

- *Youngs Bay* is located in Oregon waters adjacent to the city of Astoria and inland of the Highway 101 Bridge. The fishing area extends from the Highway 101 Bridge upstream to Battle Creek Slough below the confluence of the Youngs and Klaskanine rivers.
- *Tongue Point Basin* is just east of the city of Astoria in Columbia River waters bounded by the Oregon shore and Mott and Lois islands. The fishing area includes the South Channel from the mouth of the John Day River upstream to its confluence with the Prairie Channel.
- *Blind Slough* is located near Brownsmead, Oregon and comprises the lower reaches of Gnat Creek. The fishing area also includes Knappa Slough from the mouth of Blind Slough to the east end of Minaker Island.
- *Deep River* is located on the Washington side in the waters of Grays Bay and Deep River.

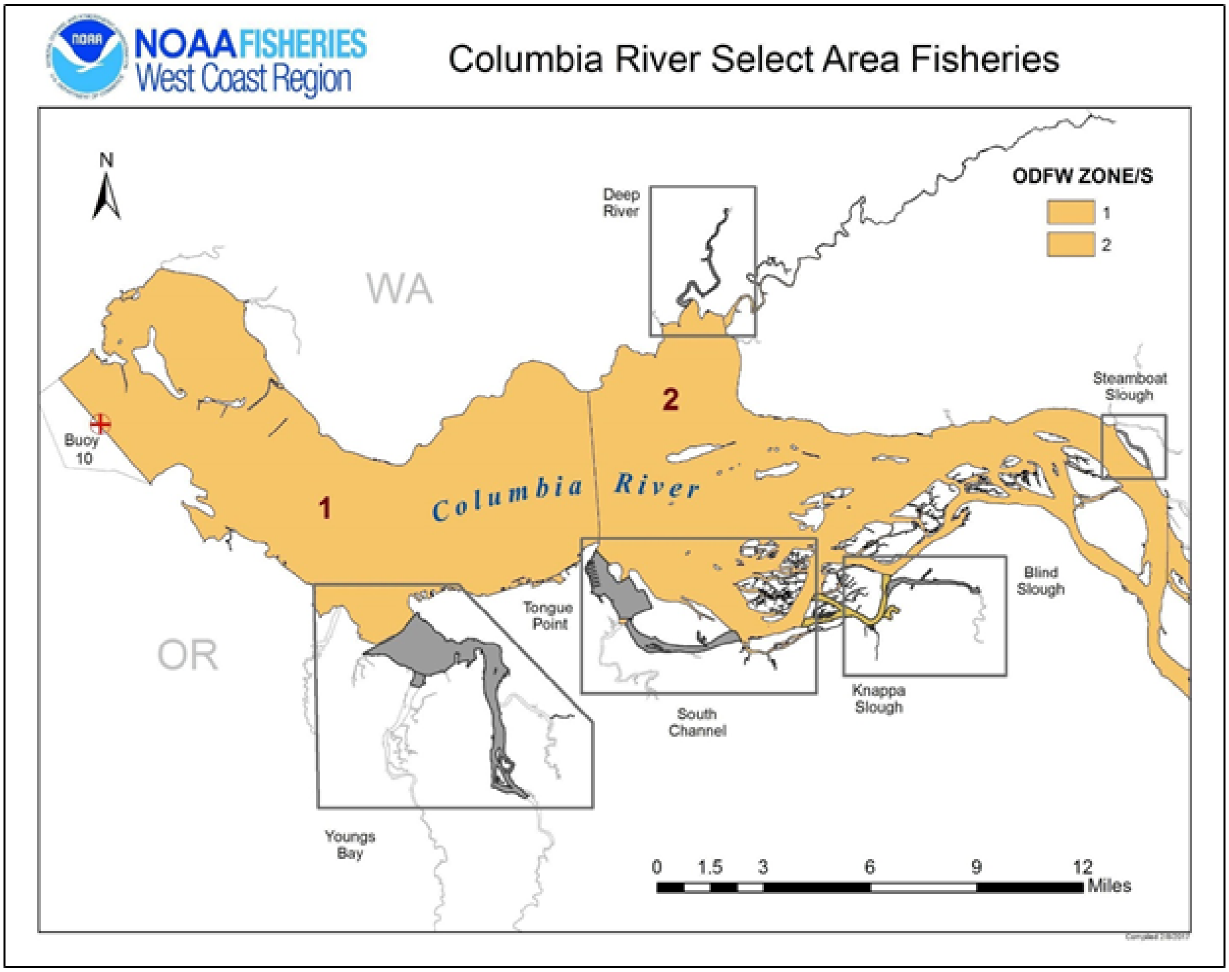


Figure 1-3. Location of SAFE fishery areas near the Columbia River mouth.

1.3.2.2.3 Columbia River Mainstem and Lower Snake River Recreational Non-treaty Fisheries

The states of Washington and Oregon individually set regulations concerning recreational fisheries in the mainstem Columbia River. These fisheries occur in the area from Buoy 10 upstream to Priest Rapids Dam, during the winter/spring, and fall management periods and upstream to Chief Joseph Dam in the summer management period. Fish targeted include hatchery spring Chinook, summer Chinook, fall Chinook, and hatchery coho salmon and hatchery steelhead. Sockeye salmon fishing may occur if run sizes permit. Washington recreational spring Chinook salmon in the Snake River upstream to the Washington/Idaho border near Clarkston are included.

1.3.2.2.4 Non-treaty Tribal Fisheries Included in Non-Treaty Catch

The Wanapum Tribe is a Federally recognized tribe, but do not have treaty fishing rights, and are not a party to *US v Oregon* or the new *US v Oregon* agreement. Catch from Wanapum fisheries are accounted for as part of the non-treaty fisheries under the *U.S. v. Oregon* Agreement. A Washington State statute (RCW 77.12.453; WAC 220-32-055) authorizes the Director of the Washington Department of Fish and Wildlife to issue permits for subsistence fishing to Wanapum tribal members. Seasons have been authorized annually to allow subsistence fishing for spring Chinook, sockeye, and fall Chinook salmon. The tribe is required to provide catch estimates, and Grant County Public Utility District (PUD) has historically acted as a liaison between the tribe and state fishery managers.

Additionally, the Colville Tribe is a Federally recognized tribe that does not have treaty fishing rights and is not party to *US v Oregon* or the new *US v Oregon* agreement. The Colville Tribe fishes for spring Chinook, summer Chinook, sockeye salmon, and steelhead using a variety of gears in both mark selective and full retention fisheries. Their catch of UCR summer Chinook salmon are counted as part of the total allowed non-treaty UCR summer harvest under the *US v Oregon* Agreement.

1.3.3 Hatcheries

This information is summarized from the BA developed by TAC (TAC 2017) as described above in Section 1.2.

As mentioned in Section 1.2, a proposed 2018 Agreement formalizes hatchery programs that produce fish. The agreement describes the number of fish expected to be released, life-history of release, release location, hatchery rearing facilities, purpose of the program, entity(s) that manages the program(s), and the responsible funding entity(s).

These fish are subsequently harvested in the fisheries that fall under the 2018 Agreement's management framework, and are included in the 2018 Agreement both as a measure to formalize the parties' expectations for production of hatchery fish for harvest above Bonneville Dam and to identify hatchery programs that are important to the conservation of salmon or steelhead runs above Bonneville Dam.

While the agreement includes a hatchery production component, the hatchery operations aspect is not solely dependent on the *US v Oregon* agreement and may occur regardless of the outcome of the *US v Oregon* agreement. Separate processes and actions occur outside the *US v Oregon* agreement that review and analyze the hatchery programs at site specific levels. This will be described in more detail in our baseline section.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical 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.

This opinion considers impacts of the proposed action under the ESA on the ESUs and DPSs of ESA-listed species listed in Table 1-1.

NMFS determined the proposed action is not likely to adversely affect SRKW that are part of the southern DPS of the taxonomic species *Orcinus orca* or Pacific eulachon, found in the Columbia River, that are part of the southern DPS of the taxonomic species *Thaleichthys pacificus*; or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations Section Section 2.12.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Under this regulatory definition, the proposed action must result in an appreciable reduction in the likelihood of survival and recovery. While this analysis must consider the action's effects on both the survival and recovery of the species, NMFS does not interpret the statute or its regulations to require the proposed action to improve or increase the likelihood of survival and recovery. Section 7(a)(2) focuses on the "continued existence" of the species, not an improvement in the likelihood of recovery or the attainment of an improved status, which is addressed through Section 4 recovery plans. Nor do the statute or regulations require the development of a tipping point beyond which an action jeopardizes the species or recovery benchmarks to analyze whether there is an appreciable reduction in the likelihood of recovery. section 7(a)(2) provides NMFS with discretion on how it shall determine whether the statutory prohibition is exceeded, and we have interpreted that statutory language as requiring analysis of whether the action reduces "the reproduction, numbers, or distribution of the species."

This biological 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 essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214).

The designations of critical habitat for some listed species use the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). 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 biological 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.* Section 2.2 describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" (VSP) paper (McElhany et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PCEs in some designations) which were identified when the critical habitat was designated.

- *Describe the environmental baseline in the action area.* The environmental baseline (Section 2.4) includes the past and present impacts of Federal, state, or private actions and other human activities in the action area (Section 2.3). It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.

- *Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.* In this step (Section 2.5), NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP and other relevant characteristics. NMFS also evaluates the proposed action's effects on critical habitat features.

- *Describe any cumulative effects in the action area.* Cumulative effects (Section 2.6), as defined in our implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

- *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 (Section 2.7).

- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified*. These conclusions (Section 2.8) flow from the logic and rationale presented in the Integration and Synthesis Section (2.7).

- *If necessary, suggest a RPA to the proposed action.* If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

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 physical or biological features (PBFs) that help to form that conservation value.

2.2.1 Status of Listed Species

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). These "viable salmonid population" (VSP) criteria therefore 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. These attributes are substantially influenced by habitat and other environmental conditions.

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

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

“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 fundamentally on accessibility to the habitat, 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 at single genes to complex life history traits (McElhany et al. 2000).

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe how VSP criteria at the population, major population group (MPG), and species scales (i.e., salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species’ populations and MPGs has been determined, NMFS assesses the status of the entire species. 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 meta-populations (McElhany et al. 2000).

In order to describe a species’ status, it is first necessary to define what the term “species” means in this context. In addition to defining “species” as including an entire taxonomic species or subspecies of animals or plants, the ESA also recognizes listing units that are a subset of the species as a whole. As described above, the ESA allows a DPS (or in the case of salmon, an ESU) of a species to be listed as threatened or endangered. In terms of determining the status of a species, the Willamette Lower Columbia TRT (WLC TRT) developed a hierarchical approach for determining ESU-level viability criteria (Figure 2-1) that represents best available science and is used for the purposes of this opinion.

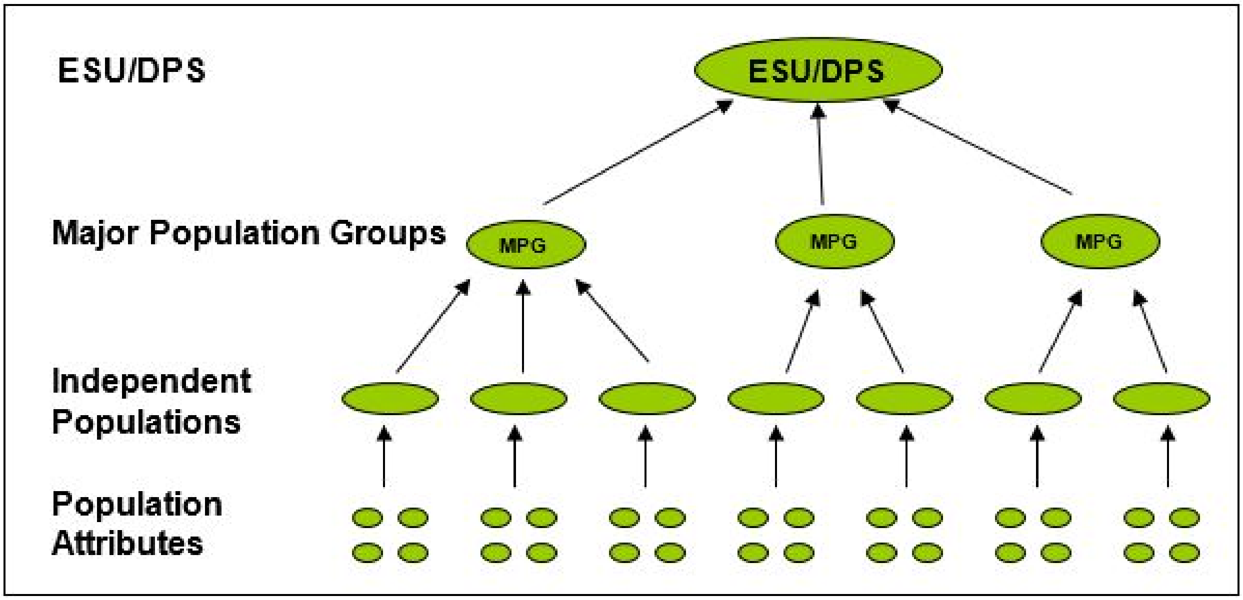


Figure 2-1. Hierarchical approach to ESU viability criteria.

Briefly, an ESU or DPS is divided into natural populations (McElhany et al. 2000). The risk of extinction of each population is evaluated, taking into account population-specific measures of abundance, productivity, spatial structure, and diversity. Natural populations are then grouped into ecologically and geographically similar *strata* (referred to as major population groups (MPG)) which are evaluated on the basis of population status. In order to be considered viable, an MPG generally must have at least half of its historically present natural populations meeting their population-level viability criteria (McElhany et al. 2006). At the MPG-level each of the ESU's MPGs also must be viable. A viable salmonid ESU or DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period.

In assessing status, we start with the information used in its most recent ESA status review for the salmon and steelhead species considered in this opinion, and if applicable consider more recent data, that are relevant to the species' rangewide status. Many times, this information exists in ESA recovery plans. Recent information from recovery plans, where they are developed for a species, is often relevant and is used to supplement the overall review of the species' status. This step of the analysis tells us how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity. It also identifies the causes for the species' decline.

The status review starts with a description of the general life history characteristics and the population structure of the ESU or DPS including the MPGs where they occur. We review VSP information that is available including abundance, productivity and trends (information on trends supplements the assessment of abundance and productivity parameters), and spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of each natural population leading-up to a risk assessment for the ESU or DPS, and the limiting factors and threats. This Section concludes by examining the status of critical habitat.

Recovery plans are an important source of information that describe, among other things, the status of the species and its component populations, limiting factors, recovery goals and actions that are recommended to address limiting factors. Recovery plans are not regulatory documents. Consistency of a proposed action with a recovery plan, therefore, does not by itself provide the basis for determining that an action does not jeopardize the species. However, recovery plans do provide a perspective encompassing all human impacts that is important when assessing the effects of an action. Information from existing recovery plans for each respective ESA-listed salmon and steelhead is discussed where it applies in various sections of this opinion.

2.2.2 Lower River ESUs/DPSs

The LCR is generally considered the area downstream of the former site of Celilo Falls including all the tributaries flowing into the Columbia River and the Columbia River estuary and plume. This is now considered the area downstream of The Dalles Dam. Here we review the species status affected by the proposed action in this geographical stretch of the Columbia River.

2.2.2.1 Life-History and Status of the Lower Columbia River Chinook Salmon ESU

On March 24, 1999, NMFS listed the LCR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on April 14, 2014. Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706).

Within the geographic range of this ESU, 27 hatchery Chinook salmon programs are currently operational. Fourteen of these hatchery programs are included in the ESU (Table 2-1), while the remaining 13 programs are excluded (Jones Jr. 2015). Willamette River Chinook salmon are listed within the Willamette River Chinook Salmon ESU, but they are not listed within the LCR Chinook Salmon ESU. Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. “Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU” (NMFS 2005d). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d).

Table 2-1. LCR Chinook Salmon ESU description and MPGs (NMFS 2013e; Jones Jr. 2015; NWFSC 2015).

ESU Description[1]	
Threatened	Listed under ESA in 1999; updated in 2014.
6 major population groups	32 historical populations
Major Population Group	***Populations***
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, NF Lewis (C), Sandy (C,G)
Gorge Spring	(Big) White Salmon (C), Hood
Coast Fall	Grays/Chinook, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose

Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, EF Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy River early
Gorge Fall	Lower Gorge, Upper Gorge (C), (Big) White Salmon (C), Hood
Cascade Late Fall	North Fork Lewis (C,G), Sandy (C,G)
Artificial production	
Hatchery programs included in ESU (14)	Big Creek Tule Fall Chinook, Astoria High School (STEP), Tule Fall Chinook, Warrenton High School (STEP), Tule Fall Chinook, Cowlitz Tule Fall Chinook Salmon Program, North Fork Toutle Tule Fall Chinook, Kalama Tule Fall Chinook, Washougal River Tule Fall Chinook, Spring Creek National Fish Hatchery (NFH) Tule Chinook, Cowlitz spring Chinook salmon (two programs), Friends of Cowlitz spring Chinook, Kalama River Spring Chinook, Lewis River Spring Chinook, Fish First Spring Chinook, Sandy River Hatchery Spring Chinook salmon (ODFW stock #11)
Hatchery programs not included in ESU (13)	Deep River Net-Pens Spring Chinook, Clatsop County Fisheries (CCF) Select Area Brights Program Fall Chinook, CCF Spring Chinook salmon Program, Carson NFH Spring Chinook salmon Program, Little White Salmon NFH Tule Fall Chinook salmon Program, Bonneville Hatchery Tule Fall Chinook salmon Program, Hood River Spring Chinook salmon Program, Deep River Net Pens Tule Fall Chinook, Klaskanine Hatchery Tule Fall Chinook, Bonneville Hatchery Fall Chinook, Little White Salmon NFH Tule Fall Chinook, Cathlamet Channel Net Pens Spring Chinook, Little White Salmon NFH Spring Chinook

[1] The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively.[2]

Thirty-two historical populations within six MPGs comprise the LCR Chinook Salmon ESU. These are distributed through three ecological zones[3], whereby through a combination of life-history types based on run timing and ecological zones result in the six MPGs, some of which are considered extirpated or nearly so (Table 2-2). The run timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Table 2-2).

Table 2-2. Current status for LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013e).

[2] Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life-history characteristics that are no longer found throughout the ESU (McElhany et al. 2003).

[3] There are a number of methods of classifying freshwater, terrestrial, and climatic regions. The WLC TRT used the term ecological zone as a reference, in combination with an understanding of the ecological features relevant to salmon, to designate four ecological areas in the domain: (1) Coast Range zone, (2) Cascade zone, (3) Columbia Gorge zone, and (4) Willamette zone. This concept provides geographic structure to ESUs in the domain. Maintaining each life-history type across the ecological zones reduces the probability of shared catastrophic risks. Additionally, ecological differences among zones reduce the impact of climate events across entire ESUs (Myers et al. 2003).

Major Population Group	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution[2]	Target Persistence Probability	Abundance Target[3]
Cascade Spring	Upper Cowlitz (WA)	VL	Primary	H+	1,800
	Cispus (WA)	VL	Primary	H+	1,800
	Tilton (WA)	VL	Stabilizing	VL	100
	Toutle (WA)	VL	Contributing	M	1,100
	Kalama (WA)	VL	Contributing	L	300
	North Fork Lewis (WA)	VL	Primary	H	1,500
	Sandy (OR)	M	Primary	H	1,230
Gorge Spring	White Salmon (WA)	VL	Contributing	L+	500
	Hood (OR)	VL	Primary[4]	VH[4]	1,493
Coast Fall	Youngs Bay (OR)	L	Stabilizing	L	505
	Grays/Chinook (WA)	VL	Contributing	M+	1,000
	Big Creek (OR)	VL	Contributing	L	577
	Elochoman/Skamokawa (WA)	VL	Primary	H	1,500
	Clatskanie (OR)	VL	Primary	H	1,277
	Mill/Aber/Germ (WA)	VL	Primary	H	900
	Scappoose (OR)	L	Primary	H	1,222
Cascade Fall	Lower Cowlitz (WA)	VL	Contributing	M+	3,000
	Upper Cowlitz (WA)	VL	Stabilizing	VL	--
	Toutle (WA)	VL	Primary	H+	4,000
	Coweeman (WA)	VL	Primary	H+	900
	Kalama (WA)	VL	Contributing	M	500
	Lewis (WA)	VL	Primary	H+	1,500
	Salmon (WA)	VL	Stabilizing	VL	--
	Clackamas (OR)	VL	Contributing	M	1,551
	Sandy (OR)	VL	Contributing	M	1,031
	Washougal (WA)	VL	Primary	H+	1,200
Gorge Fall	Lower Gorge (WA/OR)	VL	Contributing	M	1,200
	Upper Gorge (WA/OR)	VL	Contributing	M	1,200
	White Salmon (WA)	VL	Contributing	M	500
	Hood (OR)	VL	Primary[4]	H[4]	1,245
Cascade Late Fall	North Fork Lewis (WA)	VH	Primary	VH	7,300
	Sandy (OR)	H	Primary	VH	3,561

[1] (LCFRB 2010) used the late 1990s as a baseline period for evaluating status; ODFW (2010a) assume average environmental conditions of the period 1974-2004. VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan (NMFS 2013e).

[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.

[3] Abundance objectives account for related goals for productivity (NMFS 2013e).

[4] Oregon analysis indicates a low probability of meeting the delisting objectives for these populations.

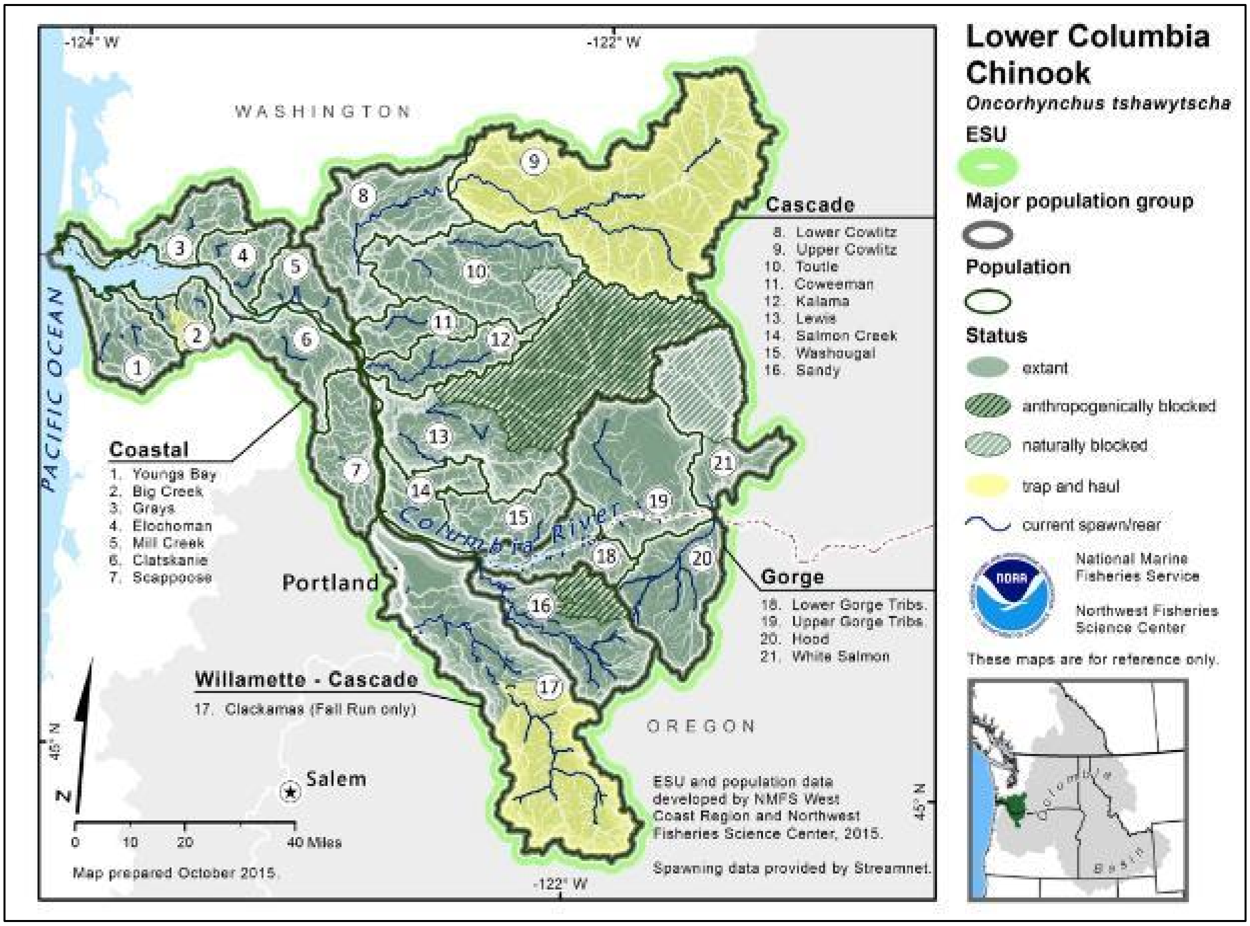


Figure 2-2. Map of the LCR Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs. Several watersheds contain or historically contained both fall and spring runs; only the fall-run populations are illustrated here (NWFSC 2015).

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: "stream-type" and "ocean-type" (Healey 1991; Myers et al. 1998). Ocean-type Chinook salmon reside in coastal ocean waters for three to four years before returning to freshwater and exhibit extensive offshore ocean migrations, compared to stream-type Chinook salmon that spend two to three years in coastal ocean waters. The ocean-type also enter freshwater to return for spawning later (May and June) than the stream-type (February through April). Ocean-type Chinook salmon use different areas in the river – they spawn and rear in lower elevation mainstem rivers, and they typically reside in freshwater for no more than three months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

LCR Chinook salmon are classified into three life-history types including spring runs, early-fall runs ("tules", pronounced (too-lees)), and late-fall runs ("brights") based on when adults return to freshwater (Table 2-3). LCR spring Chinook salmon are stream-type, while LCR early-fall and late-fall Chinook salmon are ocean-type. Other life-history differences among run types include the timing of spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to freshwater. This life-history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia (NMFS 2013e). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, Chinook salmon may rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the north Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. The spawning run typically includes three or more age classes. Adult Chinook salmon are the largest of the salmon species, and LCR fish occasionally reach sizes up to 25 kilograms (55 lbs.). Chinook salmon require clean gravels for spawning and pool and side-channel habitats for rearing. All Chinook salmon die after spawning once (NMFS 2013e).

Table 2-3. Life-history and population characteristics of LCR Chinook salmon.

Characteristic	**Life-History Features**		
	Spring	**Early-fall (tule)**	**Late-fall (bright)**
Number of extant populations	9	21	2
Life-history type	Stream	Ocean	Ocean
River entry timing	March-June	August-September	August-October
Spawn timing	August-September	September-November	November-January
Spawning habitat type	Headwater large tributaries	mainstem large tributaries	mainstem large tributaries
Emergence timing	December-January	January-April	March-May
Duration in freshwater	Usually 12-14 months	1-4 months, a few up to 12 months	1-4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	mainstem, tributaries, sloughs, estuary	mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months
Ocean migration	As far north as Alaska	As far north as Alaska	As far north as Alaska
Age at return	4-5 years	3-5 years	3-5 years
Recent natural spawners	800	6,500	9,000
Recent hatchery adults	12,600 (1999-2000)	37,000 (1991-1995)	NA

All LCR Chinook salmon runs have been designated as part of a LCR Chinook Salmon ESU that includes natural populations in Oregon and Washington from the ocean upstream to and including the White Salmon River in Washington and Hood River in Oregon. Fall Chinook salmon (tules and brights) historically were found throughout the entire range, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries) (NMFS 2013e). Bright Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, bright Chinook salmon mature at an older average age than either LCR spring or tule Chinook salmon, and have a more northerly oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (NWFSC 2015).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Chinook Salmon ESU, is at high risk and remains at threatened status. Each LCR Chinook salmon natural population baseline and target persistence probability level is summarized in Table 2-2, along with target abundance for each population that would be consistent with delisting. Persistence probability is measured over a 100 year time period and ranges from very low (probability < 40%) to very high (probability >99%).

If the recovery scenario in Table 2-2 were achieved, it would exceed the WLC TRT's MPG-level viability criteria for the Coast and Cascade fall MPGs, the Cascade spring MPG, and the Cascade late-fall MPG. However, the recovery scenario for Gorge spring and Gorge fall Chinook salmon does not meet WLC TRT criteria because, within each MPG, the scenario targets only one population (the Hood) for high persistence probability. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook salmon MPG, was intentional on the part of local recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring MPGs. In addition, multiple spring Chinook salmon natural populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems.

NMFS (2013e) commented on the uncertainties and practical limits to achieving high viability for the spring and tule populations in the Gorge MPGs. Recovery opportunities in the Gorge were limited by the small numbers of natural populations and the high uncertainty related to restoration because of Bonneville Dam passage and inundation of historically productive habitats. NMFS also recognized the uncertainty regarding the TRT's MPG delineations between the Gorge and Cascade MPG populations and that several Chinook salmon populations downstream from Bonneville Dam may be quite similar to those upstream of Bonneville Dam. As a result, the recovery plan recommends that additional natural populations in the Coast and Cascade MPGs achieve recovery status to provide a safety factor to offset the anticipated shortcomings for the Gorge MPGs. This was considered a more precautionary approach to recovery than merely assuming that efforts related to the Gorge MPG would be successful.

In 2017 NMFS adopted a Record of Decision ("Mitchell Act ROD") for a policy direction that would be used to guide NMFS' decision on the distribution of funds for hatchery production under the Mitchell Act (16 US CFR 755 757), which NMFS administers. NMFS' continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD was analyzed under the ESA and was found to not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017j). The Mitchell Act ROD directs NMFS to apply stronger performance goals to all Mitchell Act-funded, Columbia River Basin hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs on natural-origin salmon and steelhead populations, including the LCR Chinook Salmon ESU, and primarily to the tule Chinook salmon MPGs. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated. While the following information presented is a review of updated status information available, NMFS expects the prevalence of hatchery-origin tule Chinook salmon spawning contribution to decrease over the course of the 2018 Agreement due to the ITS limits and terms and conditions required by the opinion (NMFS 2017j).

Based on the information provided by the WLC TRT and the management unit recovery planners, NMFS concluded in the recovery plan that the recovery scenario in Table 2-2 represents one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade MPG, coupled with compensation in the other strata for not meeting TRT criteria in the Gorge stratum would provide an ESU no longer likely to become endangered.

Cascade Spring MPG

LCR spring Chinook salmon natural populations occur in both the Gorge and Cascade MPGs (Table 2-1). There are seven LCR spring Chinook salmon populations in the Cascade MPG. The most recent estimates of minimum inriver run size and escapement totals for LCR spring Chinook salmon are provided in Table 2-4. The combined hatchery-origin and natural-origin LCR spring Chinook salmon run sizes for the Cowlitz, Kalama, and Sandy rivers populations have all numbered in the thousands in recent years (Table 2-4). The Cowlitz and Lewis populations are currently managed for hatchery production since most of the historical spawning habitat has been inaccessible due to hydro development in the upper basin (NMFS 2013e). Cowlitz and Kalama river hatcheries' escapement objectives have been met in recent years with few exceptions Table 2-4).

A reintroduction program is now being implemented on the Cowlitz River that involves trap and haul of adults and juveniles. The reintroduction program for the upper Cowlitz and Cispus Rivers above Cowlitz Falls Dam is consistent with the recommendations of the recovery plan and constitutes the initial steps in a more comprehensive recovery strategy. However, the program is currently limited by low collection efficiency of out-migrating juveniles at Cowlitz Falls Dam and by lack of productivity in the Tilton basin because of relatively poor habitat quality. Some unmarked adults, meaning unknown origin (hatchery or natural), return voluntarily to the hatchery intake, but for the time being, the reintroduction program relies primarily on the use of surplus hatchery adults. (Information on the hatchery program and associated Settlement Agreement with Tacoma Power can be found at: https://www.mytpu.org/tacomapower/fish-wildlife-environment/cowlitz-river-project/cowlitz-fisheries-programs/). The reintroduction program facilitates the use of otherwise vacant habitat, but cannot be self-sustaining until low juvenile collection problems are solved, and other limiting factors are addressed. Efforts are underway to improve juvenile collection facilities. Given the current circumstances, first priority is populations are managed to achieve the hatchery escapement goals and thereby preserve the genetic heritage of the population; this preservation of genetic heritage reduces the extinction risk of the population should the passage problems continue, and acts as a safety valve for the eventual recovery of the Cowlitz population.

A reintroduction program is also in place for the Lewis River as described in the Lewis River Hatchery and Supplementation Plan (Jones & Stokes Associates 2009). Out planting of hatchery spring Chinook salmon adults began in 2012 after completion of downstream passage facilities.

While the Cowlitz and Kalama river systems have all met their hatcheries escapement objectives in recent years, with few exceptions based on the goals established in their respective Hatchery Genetic and Management Plan (HGMPs) Table 2-4. Escapements to the Lewis River hatchery have fallen short in recent years, but additional harvest management measures have been taken to help offset the projected shortfalls. This at least ensures that what remains of the genetic legacy of these natural populations is preserved and can be used to advance recovery. The existence of these hatchery programs reduces extinction risk, in the short-term.

The historical significance of the Kalama population to the overall LCR Chinook Salmon ESU was likely limited because habitat there was probably not as productive for spring Chinook salmon compared to the other spring Chinook salmon populations in the ESU (NMFS 2013e). In the recovery scenario, the Kalama spring Chinook salmon population is designated as a contributing population targeted for a relatively lower persistence probability because habitat there was not as productive historically for spring Chinook salmon Table 2-2 (NMFS 2013e).

Legacy effects of the 1980 Mount St. Helens eruption are still a fundamental limiting factor for the Toutle spring Chinook salmon natural population (NMFS 2013e). The North Fork Toutle was the area most affected by the blast and resulting sedimentation from the eruption. Because of the eruption, a sediment retention structure (SRS) was constructed to manage the ongoing input of fine sediments into the lower river. Nonetheless, the SRS is a continuing source of fine sediments and blocks passage to the upper river. A trap and haul system was implemented and operates annually from September to May to transport adult fish above the SRS. The transport program provides access to 50 miles of anadromous fish habitat located above the structure (NMFS 2013e) but that habitat is still in very poor condition. There is relatively little known about current natural spring Chinook salmon production in this basin. The Toutle population has been designated a contributing population targeted for medium persistence probability under the recovery scenario (Table 2-2).

Table 2-4. Total tributary returns for LCR spring Chinook along with hatchery escapement and natural spawning estimates (TAC 2017, Table 2.1.10)*.

Year	Cowlitz			Kalama			Lewis			Sandy		
	Total Tributary Return	Hatchery Escapement (rack return goal: 1,337)[1]	Natural-origin Spawners	Total Tributary Return	Hatchery Escapement (rack return goal: 300)[2]	Natural-origin Spawners	Total Tributary Return	Hatchery Escapement (rack return goal: 1,380)[3]	Natural-origin Spawners	Total Tributary Return	Hatchery Escapement	Natural-origin Spawners
1997	1,877	1,298	437	505	576	39	2,196	2,245	410	4,410	n/a	935
1998	1,055	812	262	407	408	42	1,611	1,148	211	3,577	n/a	700
1999	2,069	1,321	235	977	794	215	1,753	845	241	3,585	n/a	581
2000	2,199	1,408	264	1,418	1,256	33	2,515	776	473	3,641	n/a	564
2001	1,609	1,306	315	1,796	952	555	3,777	1,193	678	5,329	n/a	988
2002	5,152	2,713	781	2,912	1,374	886	3,514	1,865	493	5,905	n/a	1,445
2003	15,954	10,481	2,485	4,556	3,802	766	5,040	3,056	679	5,615	n/a	968
2004	16,511	12,596	2,048	4,286	3,421	352	7,475	4,235	494	12,680	2,950	4,010
2005	9,379	7,503	539	3,367	2,825	380	3,512	2,219	116	7,668	1,830	2,305
2006	6,963	5,379	816	5,458	4,313	292	7,301	4,130	847	4,382	981	2,280
2007	3,975	3,089	144	8,030	4,748	2,146	7,596	3,897	264	2,813	28	1,418
2008	2,986	1,895	484	1,623	940	362	2,215	1,386	25	5,994	163	6,610
2009	6,034	3,604	819	404	170	26	1,493	1,068	58	2,429	261	2,623
2010	8,585	5,920	286	977	467	0	2,347	1,896	157	7,652	652	8,215
2011	5,308	1,992	191	776	275	200	1,310	1,101	90	5,721	635	2,640
2012	12,144	5,589	321	889	285	28	1,895	1,294	190	5,038	424	2,735
2013	8,157	3,762	409	1,014	732	158	1,570	1,785	60	5,700	730	2,413
2014	8,310	4,591	227	1,013	709	187	1,396	1,009	403	5,971	1,016	1,658
2015	23,596	17,600	n/a	3,149	2,642	n/a	1,006	908	147	4,657	365	2,023
2016	22,478	n/a	n/a	3,980	n/a	n/a	473	n/a	n/a	4,151	123	3,590

* Hatchery and natural won't add to total due to sport harvest that is not included.
[1] Cowlitz River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Cowlitz Salmon Hatchery.
[2] Kalama River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Kalama Falls Hatchery.
[3] Lewis River Spring Chinook salmon brood origin hatchery returns are collected at the Merwin Dam Fish Collection Facility, and on-station at the Lewis River Hatchery.

The baseline persistence probability of the Sandy River spring natural population is currently medium. This population is designated as a primary population targeted for high persistence probability and thus is likely to be important to the overall recovery of the ESU (Table 2-2). Marmot Dam in the upper Sandy watershed was used as a counting and sorting site in prior years, but the dam was removed in October 2007. The abundance component of the persistence probability goal for Sandy River spring Chinook salmon is 1,230 natural-origin fish (Table 2-2), and the return of natural-origin fish has exceeded this goal in recent years. The total return of spring Chinook salmon to the Sandy River, including ESA-listed hatchery fish, has averaged more than 5,600 since 2000 (Table 2-4). Although the abundance criterion has been exceeded in recent years, other aspects of the VSP criteria would have to improve for the population to achieve the higher persistence probability level that is targeted.

Gorge Spring MPG

The Hood River and White Salmon natural populations are the only populations in the Gorge Spring MPG. The 2005 BRT described the Hood River spring run as “extirpated or nearly so” (Good et al. 2005), and the 2005 ODFW Native Fish Status report describes the population as extinct (ODFW 2005). NMFS reaffirmed its conclusion that Hood River spring Chinook salmon are in the Gorge Spring MPG in the most recent status review (NWFSC 2015). Additionally, the White Salmon River population is considered extirpated (NMFS 2013e, Appendix C).

Most of the habitat that was historically available to spring Chinook salmon in the Hood River is still accessible. Because of the apparent extirpation of the population, Oregon initiated a reintroduction program using spring Chinook salmon from the Deschutes River. The nearest natural population of spring Chinook salmon is the Deschutes River population, but the population is part of a different ESU, the MCR Chinook Salmon ESU. Although the reintroduction program has been underway since the mid-90s, it has not met its original goals for smolt-to-adult survival rates. Deficiencies are attributed to production practices (ISRP 2008; CTWSR 2009; NMFS 2013e). The delisting persistence probability target is listed as very high, but NMFS (2013e) believes that the prospects for meeting that target are uncertain. The estimates of spring Chinook salmon returning to the Hood River are in Table 2-5.

Table 2-5. Total, hatchery, and natural-origin spring Chinook returns to the Hood River (TAC 2017, Table 2.1.11).

Year	Total Run Size [1]	Clipped Hatchery Run Size	Unclipped Presumed Natural-origin Run Size	Proportion Presumed Natural-origin
2001	602	560	42	7.0%
2002	170	101	69	40.6%
2003	400	338	62	15.5%
2004	242	98	144	59.5%
2005	696	589	107	15.4%
2006	1,236	939	297	24.0%
2007	460	327	133	28.9%
2008	997	936	61	6.1%

2009	1,314	1,248	66	5.0%
2010	635	507	128	20.2%
2011	1,377	1,377	n/a	n/a
2012	1,114	1,114	n/a	n/a
2013	860	820	40	4.7%
2014	1,111	1,086	25	2.3%
2015	2,331	2,223	108	4.6%
2016	1,996	1,846	150	7.5%
5 yr. avg.	1,482	1,418	81	3.8%

[1] Run Size from ODFW. Powerdale dam counts prior to 2010.

The White Salmon River natural population is also considered extirpated. Condit Dam was completed in 1913 with no juvenile or adult fish passage, thus precluding access to all essential habitat. The breaching of Condit Dam in 2011 provided an option for recovery planning in the White Salmon River. The recovery plan calls for monitoring escapement into the basin for four to five years to see if natural recolonization occurs (abundance estimates prior to 2012 reflected fish spawning below Condit Dam during the spring run temporal spawning window) (NWFSC 2015). Sometime during or at the end of the interim monitoring program, a decision will be made about whether to proceed with a reintroduction program using hatchery fish; however, there is not enough data available yet to evaluate that action. The recovery scenario described in the recovery plan identifies the White Salmon spring population as a contributing population with a low plus persistence probability target (Table 2-2).

Coast Fall MPG

There are seven natural populations in the Coast Fall Chinook salmon MPG. None are considered genetic legacy populations. The baseline persistence probability of five of the seven populations in this MPG is listed as very low, whereas the remaining two populations are listed as low (Youngs Bay and Scappoose) (
Table 2-2). All of the populations are targeted for improved persistence probability in the recovery scenario. The Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany (M/A/G), and Scappoose populations are targeted for high persistence, while the Grays River is targeted for medium plus persistence probability. The Big Creek and Youngs Bay populations are targeted for low persistence probability (
Table 2-2).

Populations in this MPG are subject to significant levels of hatchery straying (Beamesderfer et al. 2011). There was a Chinook salmon hatchery on the Grays River, but that program was closed in 1997 with the last hatchery returns to the river in 2002. A temporary weir was installed for the first time on the Grays River in 2008 to quantify escapement and to help control the number of hatchery strays from hatchery programs outside the Grays River. As it turns out, a large number of out-of-ESU Rogue River brights from the Youngs Bay net pen programs were observed at the weir, and by 2010 the weir was functionally able to begin removing hatchery strays. It is worth noting that the escapement data, reported in Table 2-6, have been updated through 2015 relative to those reported in the 2010 status review (Ford 2011).

The Elochoman had an in-basin fall Chinook salmon hatchery production program that released 2,000,000 fingerlings annually. That program was closed in 2009 (NMFS 2013e). The last returns of these hatchery fish were probably in 2014. Closure of the hatchery program is consistent with the overall transition and hatchery reform strategy for tule Chinook salmon. The number of spawners in the Elochoman has ranged from several hundred to several thousand in recent years (Table 2-6) with most being hatchery-origin (Beamesderfer et al. 2011). The M/A/G population does not have an in-basin hatchery program, but still has several hundred hatchery spawners each year; however, numbers have decreased slightly in the most recent years (Table 2-6).

ODFW reported that hatchery strays contributed approximately 90% of the fall Chinook salmon spawners in both the Clatskanie River and Scappoose Creek over the last 30 years (ODFW 2010a). New information was considered when developing the status of the Clatskanie and Scappoose natural populations. Problems with the previous Clatskanie estimates are summarized in Dygert (2011). Escapement estimates for Clatskanie from 1997 to 2016 were based on expanded index counts, meaning if index counts were less than five, they were replaced with values based on averages of neighboring years. This occurred for 11 of the 33 years in the data set. From 2004 to 2006, there was also computational error in the data reported, resulting in estimates that were approximately twice as high as they should have been. Index counts in the Clatskanie since 2006 (i.e., not using the expanded index counts) continue to show few natural spawners.

Surveys were conducted in Scappoose Creek for the first time from 2008 to 2010; two spawning adults were observed in 2008, but none were seen in 2009 or 2010. All of the information above suggests that there are significant problems with the historical time series for the Clatskanie that have been used in the past and that there is currently very little spawning activity in either the Clatskanie River or Scappoose Creek.

Apparent problems with these escapement estimates have implications for earlier analyses that relied on that data. The Clatskanie data was used in life-cycle modeling analysis done by the NWFSC (2010). The Clatskanie data was also used indirectly for the modeling analysis of the Scappoose natural population. Because there were no direct estimates of abundance for the Scappoose, the data from the Clatskanie was rescaled to account for difference in subbasin size and then used in the life-cycle analysis for the Scappoose population. Results from the life-cycle analysis indicated that spawners in both locations were supported largely by hatchery strays and that juvenile survival rates were inexplicably low relative to the generic survival rates used in the analysis. The general conclusion of the life-cycle analysis was that the populations were unproductive and not viable under current conditions. If there are substantive flaws in the escapement data, then results from the life-cycle analysis are also flawed. The general conclusion of the life-cycle analysis is still probably correct – the populations are not viable. But the recent data suggests that there are, in fact, few hatchery strays and little or no natural production in the Clatskanie or Scappoose, and that the natural populations may be extirpated or nearly so. Confirmation of these tentative conclusions will depend on more monitoring.

Table 2-6. Early-fall (tule) Chinook salmon (in Coast MPG) total natural spawner abundance estimates (natural- and hatchery-origin fish combined) and the proportion of hatchery-origin fish (pHOS1) on the spawning grounds for the Coast Fall MPG populations, 1997-2015 (from WDFW SCoRE[2]).

Year	Clatskanie[3]	pHOS	Grays	pHOS	Elochoman[5]	pHOS	M/A/G[5]	pHOS	Youngs Bay[4]	pHOS
1997	7	n/a	12	n/a	2,137	n/a	595	n/a	n/a	n/a
1998	9	n/a	93	n/a	358	n/a	353	n/a	n/a	n/a
1999	10	n/a	303	n/a	957	n/a	575	n/a	n/a	n/a
2000	26	90%	89	n/a	146	n/a	370	n/a	n/a	n/a
2001	26	90%	241	n/a	2,806	n/a	3,860	n/a	n/a	n/a
2002	39	90%	78	n/a	7,893	n/a	3,299	n/a	n/a	n/a
2003	48	90%	373	n/a	7,348	n/a	3,792	n/a	n/a	n/a
2004	11	90%	726	n/a	6,880	n/a	4,611	n/a	n/a	n/a
2005	10	90%	122	n/a	2,699	n/a	2,066	n/a	n/a	n/a
2006	4	90%	383	n/a	324	n/a	622	n/a	n/a	n/a
2007	9	90%	96	n/a	168	n/a	335	n/a	n/a	n/a
2008	9	90%	33	65%	1,320	n/a	780	n/a	n/a	n/a
2009	94	44%	210	62%	1,467	n/a	604	n/a	n/a	n/a
2010	12	88%	70	55%	154	88%	194	93%	1,152	0%
2011	12	100%	70	83%	59	95%	111	93%	1,584	61%
2012	6	92%	43	79%	64	73%	23	88%	170	97%
2013	3	92%	189	91%	187	71%	207	80%	409	95%
2014	7	91%	322	56%	192	78%	65	90%	119	95%
2015	6	91%	156	85%	313	68%	92	91%	382	81%

[1] Proportion of hatchery-origin spawners (pHOS): hatchery fish escaping to the spawning grounds. For example, Clatskanie in 2007 had 9 natural-origin spawners and 90% hatchery spawners. To calculate hatchery-origin numbers multiply (9/ (1-.90))-9 = 81 hatchery-origin spawners.

[2] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook Date Accessed: October 4, 2017

[3] Clatskanie estimates are from: http://odfwrecoverytracker.org/explorer/species/Chinook/run/fall/esu/241/244/ Date Accessed: October 4, 2017

[4] Youngs Bay estimate is from: http://odfw.forestry.oregonstate.edu/spawn/pdf%20files/reports/2012-13LCTuleSummary%20.pdf Date accessed: May 19, 2016

[5] Elochoman and Germany/Abernathy/Mill estimates from 1997-2009 are considered a proportion on the WDFW SCoRE website. Elochoman estimates include the Skamokawa Creek Fall Chinook Spawners (proportion).

The Big Creek and Youngs Bay natural populations are both proximate to large net pen rearing and release programs designed to provide for a localized, terminal fishery in Youngs Bay. ODFW estimates that 90% of the fish that spawn in these areas are hatchery strays (Table 2-6). The number of fish released at the Big Creek hatchery has been reduced with additional changes in hatchery practices to help reduce straying into the Clatskanie and other neighboring systems. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries. The nature and scale of the reform actions were described in more detail in Frazier (2011) and Stahl (2011).

Cascade Fall MPG

There are ten natural populations of fall Chinook salmon in the Cascade MPG. Of these, only the Coweeman and East Fork Lewis are considered genetic legacy populations. The baseline persistence probability of all of these populations is very low (Table 2-2). These determinations were generally based on assessments of status at the time of listing. The Lower Cowlitz, Kalama, Clackamas, and Sandy populations are targeted for medium persistence probability and Toutle, Coweeman, Lewis, and Washougal populations are targeted for high-plus persistence probability in the ESA recovery plan. The target persistence probability for the other two populations is very low: Salmon Creek, a population within a highly urbanized subbasin with limited habitat recovery potential, and Upper Cowlitz, a population with reintroduction of spring Chinook salmon as the main recovery effort (NMFS 2013e) (Table 2-2).

Total escapements (natural-origin and hatchery fish combined) to the Coweeman and East Fork Lewis have averaged 735 and 612, respectively, over the last eighteen years (Table 2-7) The recovery abundance target for the Coweeman is 900 natural-origin fish and 1,500 natural-origin fish for the East Fork Lewis (Table 2-2). The historical contribution of hatchery spawners to the Coweeman and East Fork Lewis populations is relatively low compared to that of other populations (Beamesderfer et al. 2011). The Kalama, Washougal, Toutle, and Lower Cowlitz natural populations are all associated with significant in-basin hatchery production and are subject to large numbers of hatchery strays (Beamesderfer et al. 2011). We have less information on returns to the Clackamas and Sandy Rivers, but ODFW indicated for both that 90% of the spawners are likely hatchery strays from as many as three adjacent hatchery programs (NMFS 2013e, Appendix A).

The Coweeman and Lewis populations do not have in-basin hatchery programs and are generally subject to less straying. Broodstock management practices for hatcheries are being revised to reduce the level of straying and the resulting effects when straying occurs. Weirs are being operated on the Kalama River to assist with broodstock management, and on the Coweeman and Washougal Rivers to further assess and control hatchery straying in each system. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries. The nature and scale of the reform actions were described in more detail in Frazier (2011) and Stahl (2011).

Gorge Fall MPG

There are four natural populations of tule Chinook salmon in the Gorge Fall Chinook salmon MPG: Lower Gorge, Upper Gorge, White Salmon, and Hood. The baseline persistence probability for all of these populations is very low (Table 2-2). The recovery plan targets the White Salmon and Lower and Upper Gorge populations for medium persistence probability, and the Hood River population for high persistence although, as discussed earlier in this subsection, it is unlikely that the high viability objective can be met (Table 2-2). There is some uncertainty regarding the historical role of the Gorge populations in the ESU and whether they truly functioned historically as demographically independent populations (NMFS 2013e). This is accounted for in the recovery scenario presented in the recovery plan.

Natural populations in the Gorge Fall MPG have been subject to the effects of a high incidence of hatchery fish straying and spawning naturally. The White Salmon population, for example, was limited by Condit Dam, as discussed above regarding Gorge Spring MPG, and natural spawning occurred in the river below the dam (NMFS 2013e, Appendix C). The number of fall Chinook salmon spawners in the White Salmon increased from low levels in the early 2000s to an average of 1,086 for the period from 2010 to 2015 (Table 2-8), but spawning is dominated by tule Chinook salmon strays from the neighboring Spring Creek Hatchery and upriver bright Chinook salmon from the production program in the adjoining Little White Salmon River[4]. The Spring Creek Hatchery, which is located immediately downstream from the Little White Salmon River mouth, is the largest tule Chinook salmon production program in the Columbia basin, releasing approximately 10 million smolts annually. The White Salmon River was the original source for the hatchery broodstock, so whatever remains of the genetic heritage of the population is contained in the mix of hatchery and natural spawners. There is relatively little known about current natural-origin fall Chinook salmon production in this basin, but it is presumed to be low.

There is relatively little specific or recent information on the abundance of tule Chinook salmon for the other natural populations in the Gorge Fall MPG (Table 2-8). Stray hatchery fish are presumed to be decreasing contributors towards the spawning populations in these tributaries due to recent reductions in overall Gorge MPG hatchery releases, including the recent discontinuation of tule Chinook salmon releases from the Little White Salmon Hatchery. Hatchery strays still contribute to the escapement to the Lower Gorge, Upper Gorge, and Hood River populations on the Oregon side of the river (NMFS 2013e, Appendix A). These populations are mostly influenced by hatchery strays from the Bonneville Hatchery located immediately below Bonneville Dam, and the Spring Creek Hatchery located just above Bonneville Dam. The natural-origin abundance of returning Chinook salmon on the Washington side of the Lower and Upper Gorge populations has been steadily increasing in recent years (Table 2-8). The tributaries in the Gorge on the Washington side of the river are similarly affected by hatchery strays, which the recent past five years of monitoring show stable pHOS levels (Table 2-8). As a consequence, hatchery-origin fish contribute at varying degrees to spawning levels in all of the Gorge area tributaries, but actual estimates are unknown for areas like Eagle Creek, Tanner Creek and Herman Creek.

[4] These fish are not part of the LCR Chinook Salmon ESU.

Table 2-7. LCR tule Chinook salmon total natural spawner escapement (natural-origin) and the proportion of hatchery-origin fish (pHOS[1]) on the spawning grounds for Cascade Fall MPG populations, 1997-2015 (from WDFW SCoRE[2])*.

Year	Coweeman	pHOS	Washougal	pHOS	Kalama	pHOS	EF Lewis	pHOS	Upper Cowlitz[3]	pHOS	Lower Cowlitz	pHOS	Toutle[4]	pHOS
1997	689	n/a	4,529	n/a	3,539	n/a	307	n/a	27	n/a	2,710	n/a	n/a	n/a
1998	491	n/a	2,971	n/a	4,318	n/a	104	n/a	257	n/a	2,108	n/a	1,353	n/a
1999	299	n/a	3,105	n/a	2,617	n/a	217	n/a	1	n/a	997	n/a	720	n/a
2000	290	n/a	2,078	n/a	1,420	n/a	304	n/a	1	n/a	2,363	n/a	879	n/a
2001	802	n/a	3,836	n/a	3,613	n/a	526	n/a	3,646	n/a	4,652	n/a	4,971	n/a
2002	877	n/a	5,725	n/a	18,809	n/a	1,296	n/a	6,113	n/a	13,514	n/a	7,896	n/a
2003	1,106	n/a	3,440	n/a	24,710	n/a	714	n/a	4,165	n/a	10,048	n/a	13,943	n/a
2004	1,503	n/a	10,404	n/a	6,612	n/a	886	n/a	2,145	n/a	4,466	n/a	4,711	n/a
2005	853	n/a	2,671	n/a	9,168	n/a	598	n/a	2,901	n/a	2,870	n/a	3,303	n/a
2006	566	n/a	2,600	n/a	10,386	n/a	427	n/a	1,782	n/a	2,944	n/a	5,752	n/a
2007	251	n/a	1,528	n/a	3,296	n/a	237	n/a	1,325	n/a	1,847	n/a	1,149	n/a
2008	424	n/a	2,491	n/a	3,734	n/a	379	n/a	1,845	n/a	1,828	n/a	1,725	n/a
2009	783	n/a	2,741	n/a	7,546	n/a	596	n/a	7,491	n/a	2,602	n/a	539	n/a
2010	446	30%	833	86%	832	88%	378	64%	3,700	62%	3,169	29%	275	87%
2011	500	12%	842	82%	599	93%	827	71%	5,029	62%	2,782	25%	338	79%
2012	412	11%	305	72%	517	93%	601	52%	1,951	68%	1,946	29%	259	73%
2013	1,398	31%	3,018	58%	1,037	91%	1,441	85%	3,287	55%	3,593	19%	950	58%
2014	857	4%	1,362	33%	1,029	91%	856	57%	n/a	n/a	n/a	n/a	371	50%
2015	1,430	1%	1,703	57%	3,598	50%	947	50%	n/a	n/a	4,241	n/a	440	39%

[1] proportion of hatchery-origin spawners (pHOS): hatchery fish escaping to the spawning grounds. For example, Coweeman in 2013 had 1,398 natural-origin spawners and 31% hatchery spawners. To calculate hatchery-origin numbers, multiply (1,398/ (1-.31))-1,398 = 628 hatchery-origin spawners.

[2] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook

* Date Accessed: October 4, 2017

[3] Upper Cowlitz includes the Cispus portions of the Cowlitz River. Only natural spawner abundance estimates are shown. No data exists for 2014-2015 as of date of website access.

[4] Toutle River numbers include both the North Fork Toutle (Green River) and South Fork Toutle River fall (tule) Chinook salmon.

Table 2-8. LCR tule Chinook salmon total natural-origin spawner abundance estimates in Gorge Fall Strata populations, 2005-2015.

Year	Upper Gorge (WA estimates only) White Salmon[1,3]		White Salmon[1]		Hood River[2]	
	Natural-Origin Spawners	pHOS[2]	Natural-Origin Spawners	pHOS[2]	Natural-Origin Spawners	pHOS[2]
2005	452	n/a	1,448	n/a	42	14%
2006	235	n/a	755	n/a	49	11%
2007	263	n/a	898	n/a	45	0%
2008	181	n/a	770	n/a	21	22%
2009	343	n/a	964	n/a	57	12%
2010	334	22%	1,097	27%	n/a	n/a
2011	581	68%	335	12%	n/a	n/a
2012	286	68%	517	7%	n/a	n/a
2013	816	72%	829	32%	n/a	n/a
2014	779	71%	1,304	23%	n/a	n/a
2015	1,833	67%	557	52%	n/a	n/a

[1] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook
Date Accessed: October 4, 2017

[2] For example, Hood River in 2005 had 42 natural-origin spawners and 14 % hatchery spawners. To calculate hatchery-origin numbers multiply (42/ (1-.14))-42 = ~7 hatchery-origin spawners. Online at: http://www.odfwrecoverytracker.org/explorer/species/Chinook/run/fall/esu/241/243/

[3] Upper Gorge natural-origin spawner abundance numbers include Little White Salmon and Wind River spawners.

Cascade Late Fall MPG

There are two late fall, “bright,” Chinook salmon natural populations in the LCR Chinook Salmon ESU in the Sandy and Lewis Rivers. Both populations are in the Cascade MPG (Table 2-1). The baseline persistence probability of the Lewis and Sandy populations are very high and high, respectively; both populations are targeted for very high persistence probability under the recovery scenario (Table 2-2).

The TAC designated for the 2018 Agreement provided estimates of the escapement of bright Chinook salmon to the Sandy River (Table 2-9); these are estimates of spawning escapement are estimates of peak redd counts obtained from direct surveys in a 16 km index area that is expanded to estimates of spawning escapement by multiplying by a factor of 2.5 (TAC 2017). The recovery plan includes an appendix that describes how index counts are expanded to estimates of total abundance (ODFW 2010a, Appendix C). There are some minor differences between the values reported in ODFW (2010a, Appendix C) and those shown in Table 2-9 that reflect updates or revisions in prior index area estimates. The abundance target for delisting is 3,747 natural-origin fish (Table 2-2) and escapements have averaged about 728 natural-origin fish since 1995 (Table 2-9).

The Lewis River population is the principal indicator stock for management within the Cascade Late Fall MPG. It is a natural-origin population with little or no hatchery influence. The escapement goal, based on estimates of maximum sustained yield (MSY), is 5,700. The escapement has averaged 9,000 over the last ten years and has generally exceeded the goal by a wide margin since at least 1980. Escapement was below goal from 2006 through 2008 (Table 2-9). The shortfall is consistent with a pattern of low escapements for other far-north migrating stocks in the region and can likely be attributed to poor ocean conditions. Escapement improved in 2009 and has been well above goal since (Table 2-9). NMFS (2013e) identifies an abundance target under the recovery scenario of 7,300 natural-origin fish (Table 2-2), which is 1,600 more fish than the currently managed for escapement goal. The recovery target abundance is estimated from population viability simulations and is assessed as a median abundance over any successive 12 year period. The median escapement over the last 12 years is 8,580, therefore exceeding the abundance objective (Table 2-9). Escapement of spring Chinook salmon to the Lewis River is expected to vary from year to year as it has in the past, but generally remain high relative to the population's escapement objectives, which suggests that the population is near capacity (NWFSC 2015).

Table 2-9. Annual escapement of natural-origin LCR bright Chinook salmon from 1995-2016.*

Year	Lewis River[1, 2]	Sandy River
1995	9,715	1,036
1996	13,077	505
1997	8,168	2,001
1998	5,173	773
1999	2,417	447
2000	8,741	84
2001	11,274	824
2002	13,293	1,275
2003	12,912	619
2004	12,928	601
2005	9,775	770
2006	5,066	1,130
2007	3,708	171
2008	5,485	602
2009	6,283	318
2010	9,294	373
2011	8,205	1,019
2012	8,143	62
2013	15,197	1,253
2014	20,809	436
2015	23,614	1,274
2016	8,957	451

[1] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook. These have been updated and adjusted with the BA (TAC 2017).
[2] Data are total spawner estimates of wild late fall (bright) Chinook salmon.
* Date Accessed: October 4, 2017

Summary

Spatial structure and diversity are VSP attributes that are evaluated for the LCR Chinook Salmon ESU using a mix of qualitative and quantitative metrics. Spatial structure has been substantially reduced in many populations within the ESU (NMFS 2013e). The 2015 VSP status for LCR Chinook salmon populations indicate that a total of 2 of 32 populations are at their recovery viability goals (Table 2-10), although under the recovery plan scenario only one of these populations are at a moderate level of viability (NWFSC 2015). The remaining populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals (NWFSC 2015). The natural populations that did meet their recovery goals were able to do so because the goals were set at status quo levels.

Table 2-10 provides recently updated information about the abundance and productivity (A/P), spatial structure, diversity, and overall persistence probability for each population within the LCR Chinook Salmon ESU. Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (LCFRB 2010; ODFW 2010a).

Out of the 32 populations that make up this ESU, only the two late-fall "bright" runs – the North Fork Lewis and Sandy – are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so) (NMFS 2016h). Five of the six strata fall significantly short of the WLC-TRT criteria for viability; one stratum, Cascade late-fall, meets the WLC TRT criteria (NMFS 2013e; 2016h).

Abundance and productivity (A/P) ratings for LCR Chinook salmon populations are currently low to very low for most populations, except for spring Chinook salmon in the Sandy River (moderate) and late-fall Chinook salmon in North Fork Lewis River and Sandy Rivers (very high for both) (Table 2-10) (NMFS 2013e). For some of these populations with low or very low A/P ratings, low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. For tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (NWFSC 2015).

Table 2-10. LCR Chinook Salmon ESU MPG, ecological sub-regions, run timing, populations, and scores for the key elements (A/P, spatial structure, and diversity) used to determine overall net persistence probability of the population (NWFSC 2015).[1]

MPG		Spawning Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Cascade Range	Spring	Upper Cowlitz River (WA)	VL	L	M	VL
		Cispus River (WA)	VL	L	M	VL
		Tilton River (WA)	VL	VL	VL	VL
		Toutle River (WA)	VL	H	L	VL

		Kalama River (WA)	VL	H	L	VL
		North Fork Lewis (WA)	VL	L	M	VL
		Sandy River (OR)	M	M	M	M
	Fall	Lower Cowlitz River (WA)	VL	H	M	VL
		Upper Cowlitz River (WA)	VL	VL	M	VL
		Toutle River (WA)	VL	H	M	VL
		Coweeman River (WA)	L	H	H	L
		Kalama River (WA)	VL	H	M	VL
		Lewis River (WA)	VL	H	H	VL
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas River (OR)	VL	VH	L	VL
		Sandy River (OR)	VL	M	L	VL
		Washougal River (WA)	VL	H	M	VL
	Late Fall	North Fork Lewis (WA)	VH	H	H	VH
		Sandy River (OR)	VH	M	M	VH
Columbia Gorge	Spring	White Salmon River (WA)	VL	VL	VL	VL
		Hood River (OR)	VL	VH	VL	VL
	Fall	Lower Gorge (WA & OR)	VL	M	L	VL
		Upper Gorge (WA & OR)	VL	M	L	VL
		White Salmon River (WA)	VL	L	L	VL
		Hood River (OR)	VL	VH	L	VL
Coast Range	Fall	Youngs Bay (OR)	L	VH	L	L
		Grays/Chinook rivers (WA)	VL	H	VL	VL
		Big Creek (OR)	VL	H	L	VL
		Elochoman/ Skamokawa creeks (WA)	VL	H	L	VL
		Clatskanie River (OR)	VL	VH	L	VL
		Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
		Scappoose River (OR)	L	H	L	L

[1] Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

Figure 2-5 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for natural populations of LCR Chinook salmon in Oregon (Ford 2011). The results indicate low to moderate spatial structure risk for most populations, but high diversity risk for all but two populations; the Sandy River bright and spring Chinook salmon populations. The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR Chinook salmon natural populations in Oregon. Risk is characterized as high or very high for all populations except the Sandy River late fall and spring populations (Figure 2-5). Relative to baseline VSP levels identified in the recovery plan (NMFS 2013e) there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals (NWFSC 2015).

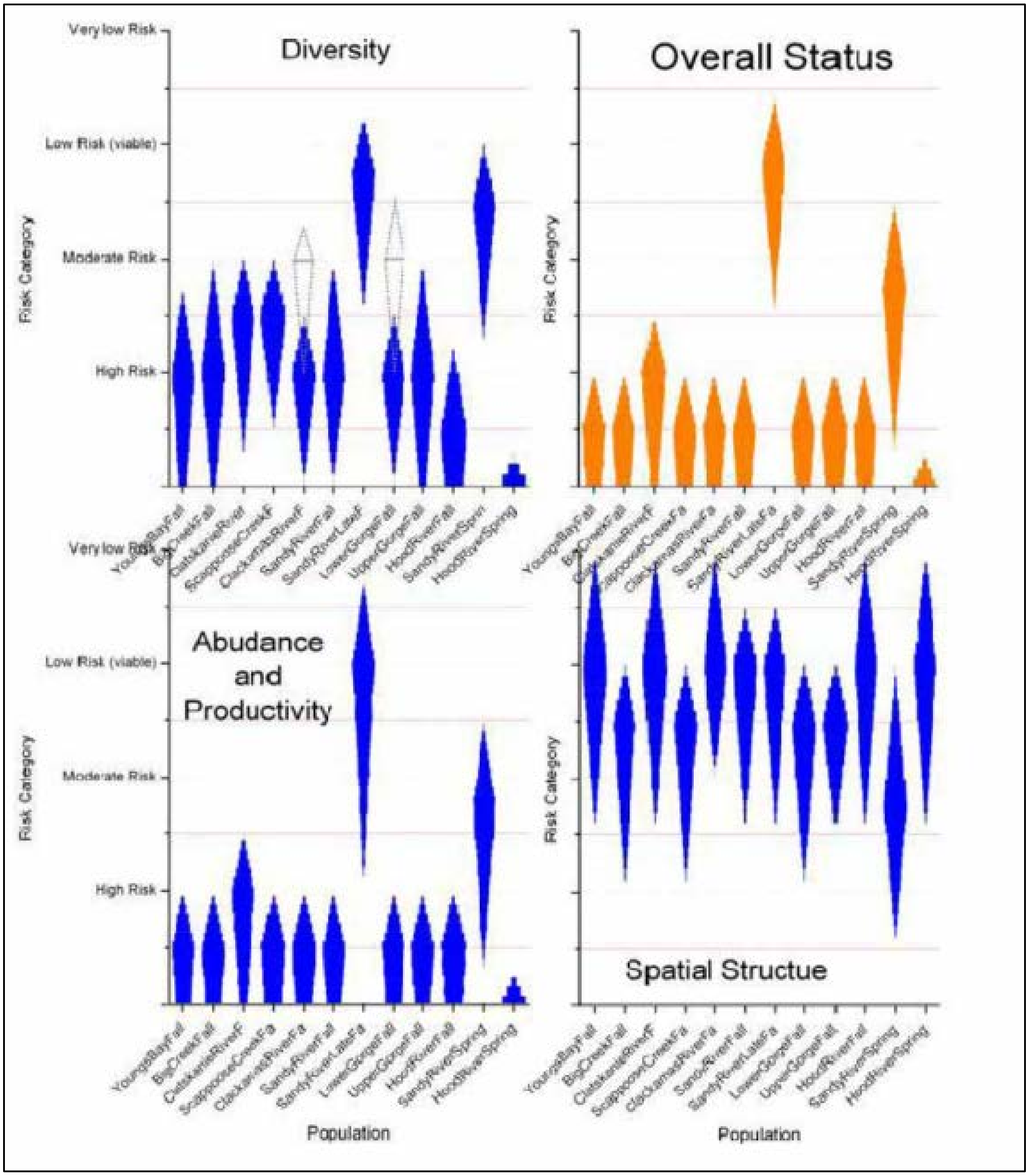


Figure 2-3. Extinction risk ratings for LCR Chinook salmon natural populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combine the three attributes (Ford 2011).

The recent status review (NWFSC 2015) concluded that there has been little change since the last status review (Ford 2011) in the biological status of Chinook salmon natural populations in the LCR Chinook Salmon ESU, though there are some positive trends. For example, increases in abundance were observed in about 70% of the fall-run populations, and decreases in the hatchery contribution were noted for several populations. The improved fall-run VSP scores reflect both changes in biological status and improved monitoring. However, the majority of the populations in this ESU remain at high risk, with low natural-origin abundance levels, especially the spring-run Chinook population in this ESU (NWFSC 2015). Hatchery contributions remain high for a number of populations, especially in the Coast Fall MPG, and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, which contributes to the high risk. Moreover, hatchery produced fish still represent a majority of fish returning to the ESU even though hatchery production has been reduced (NWFSC 2015). Because spring-run Chinook salmon populations have generally low abundance levels from hydroelectric dams cutting off access to essential spawning habitat, it is unlikely that there will be significant improvements in the status of the ESU until efforts to improve juvenile passage systems are in place and proven successful (NWFSC 2015).

Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Chinook Salmon ESU. Understanding the factors that limit the ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. LCR Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given these changing habitat conditions. Human impacts and limiting factors come from multiple sources including hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The recovery plan consolidates available information regarding limiting factors and threats for the LCR Chinook Salmon ESU (NMFS 2013e).

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the recovery plan (NMFS 2013e) describes limiting factors on a regional scale and how they apply to the four ESA-listed species from the LCR considered in the plan, including the LCR Chinook Salmon ESU. Chapter 4 (NMFS 2013e) includes details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Chapter 7 of the recovery plan discusses the limiting factors that pertain to LCR Chinook salmon spring, fall, and late fall natural populations and the MPGs in which they reside. The discussion of limiting factors in Chapter 7 (NMFS 2013e) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

As mentioned above, high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g. for reintroduction purposes in the Hood, Cowlitz, and Lewis subbasins, and will continue, but the recent opinion on the majority of hatchery production affecting this ESU (NMFS 2017j) expects Federal funding guideline requirements to reduce limiting factors relative to hatchery effects over the course of the next decade.

2.2.2.2 Life-History and Status of the Lower Columbia River Coho Salmon ESU

On June 28, 2005, NMFS listed the listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014. Critical Habitat was originally proposed January 14, 2013 and was finalized on January 24, 2016 (81 FR 9252).

Inside the geographic range of the ESU, 24 hatchery coho salmon programs are currently operational (Table 2-11). Up through 2008, 25 hatchery programs produced coho salmon considered to be part of the ESU. Genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see (NMFS 2005d). In 2009, the Elochoman Type-S and Type-N programs were discontinued. Table 2-11 lists the 23 hatchery programs currently included in the ESU and the one excluded program (Jones Jr. 2015). LCR coho salmon are primarily limited to the tributaries downstream of Bonneville Dam (Figure 2-4). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160).

Table 2-11. LCR Coho Salmon ESU description and MPGs (NMFS 2013e; Jones Jr. 2015).[5]

ESU Description	
Threatened	Listed under ESA in 2005; updated in 2014.
3 major population groups	24 historical populations
Major Population Group	***Population***
Coast	Youngs Bay, Grays/Chinook, Big Creek, Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, South Fork Toutle, North Fork Toutle, Coweeman, Kalama, North Fork Lewis, East Fork Lewis, Salmon Creek, Clackamas, Sandy, Washougal
Gorge	Lower Gorge, Upper Gorge/White Salmon, Upper Gorge/Hood
Artificial production	
Hatchery programs included in ESU (23)	Grays River (Type-S), Sea Resources (Type-S), Peterson Coho Salmon Project (Type-S), Big Creek Hatchery (ODFW stock #13), Astoria High School (STEP) Coho Salmon Program, Warrenton High School (STEP) Coho Salmon Program, Cathlamet High School FFA Type-N Coho Salmon Program, Cowlitz Type-N Coho Salmon Program, Cowlitz Game and Anglers Coho Salmon Program, Friends of the Cowlitz Coho Salmon Program, North Fork Toutle River Hatchery (type-S), Kalama River Type -N Coho Salmon Program, Kalama River Type-S Coho Salmon Program,

[5] Because NMFS had not yet listed this ESU in 2003 when the WLC TRT designated core and genetic legacy populations for other ESUs, there are no such designations for LCR coho salmon.

	Lewis River Type-N Coho Salmon Program, Lewis River Type-S Coho Salmon Program, Fish First Wild Coho Salmon Program, Fish First Type-N Coho Salmon Program, Syverson Project Type-N Coho Salmon Program, Washougal River Type-N Coho Salmon Program, Eagle Creek NFH, Sandy Hatchery (ODFW stock #11), Bonneville/Cascade/Oxbow Complex (ODFW stock #14)
Hatchery programs not included in ESU (1)	CCF Coho Salmon Program (Klaskanine River origin) *The Elochoman Type-S and Type-N coho salmon hatchery programs have been discontinued and NMFS has recommended removed them from the ESU (Jones 2015)

Twenty four historical populations within three MPGs comprise the LCR Coho Salmon ESU with generally low baseline persistence probabilities (Table 2-12). The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia River up to and including the White Salmon and Hood Rivers (Figure 2-4).

Table 2-12. Current status for LCR coho salmon populations and recommended status under the recovery scenario (NMFS 2013e).

Major Population Group	**Population (State)**	**Status Assessment**		**Recovery Scenario**	
		Baseline Persistence Probability[1]	**Contribution[2]**	**Target Persistence Probability**	**Abundance Target[3]**
Coast	Youngs Bay (OR) - *Late*	VL	Stabilizing	VL	7
	Grays/Chinook (WA) - *Late*	VL	Primary	H	2,400
	Big Creek (OR) - *Late*	VL	Stabilizing	VL	12
	Elochoman/Skamokawa (WA) – *Late*	VL	Primary	H	2,400
	Clatskanie (OR) - *Late*	L	Primary	H	3,201
	Mill/Aber/Germ (WA) - *Late*	VL	Contributing	M	1,800
	Scappoose (OR) - *Late*	M	Primary	VH	3,208
Cascade	Lower Cowlitz (WA) - *Late*	VL	Primary	H	3,700
	Upper Cowlitz (WA) - *Early, late*	VL	Primary	H	2,000
	Cispus (WA) - *Early, late*	VL	Primary	H	2,000
	Tilton (WA) - *Early, late*	VL	Stabilizing	VL	--
	South Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900
	North Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900
	Coweeman (WA) - *Late*	VL	Primary	H	1,200
	Kalama (WA) - *Late*	VL	Contributing	L	500
	North Fork Lewis (WA) - *Early, late*	VL	Contributing	L	500
	East Fork Lewis (WA) - *Early, late*	VL	primary	H	2,000
	Salmon Creek (WA) - *Late*	VL	Stabilizing	VL	--
	Clackamas (OR) - *Early, late*	M	Primary	VH	11,232
	Sandy (OR) - *Early, late*	VL	Primary	H	5,685

	Washougal (WA) - *Late*	VL	Contributing	M+	1,500
Gorge	Lower Gorge (WA/OR) - *Late*	VL	Primary	H	1,900
	Upper Gorge/White Salmon (WA) - *Late*	VL	Primary	H	1,900
	Upper Gorge/Hood (OR) - *Early*	VL	Primary	H*	5,162

[1] VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan

[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.

[3] Abundance objectives account for related goals for productivity.

* Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

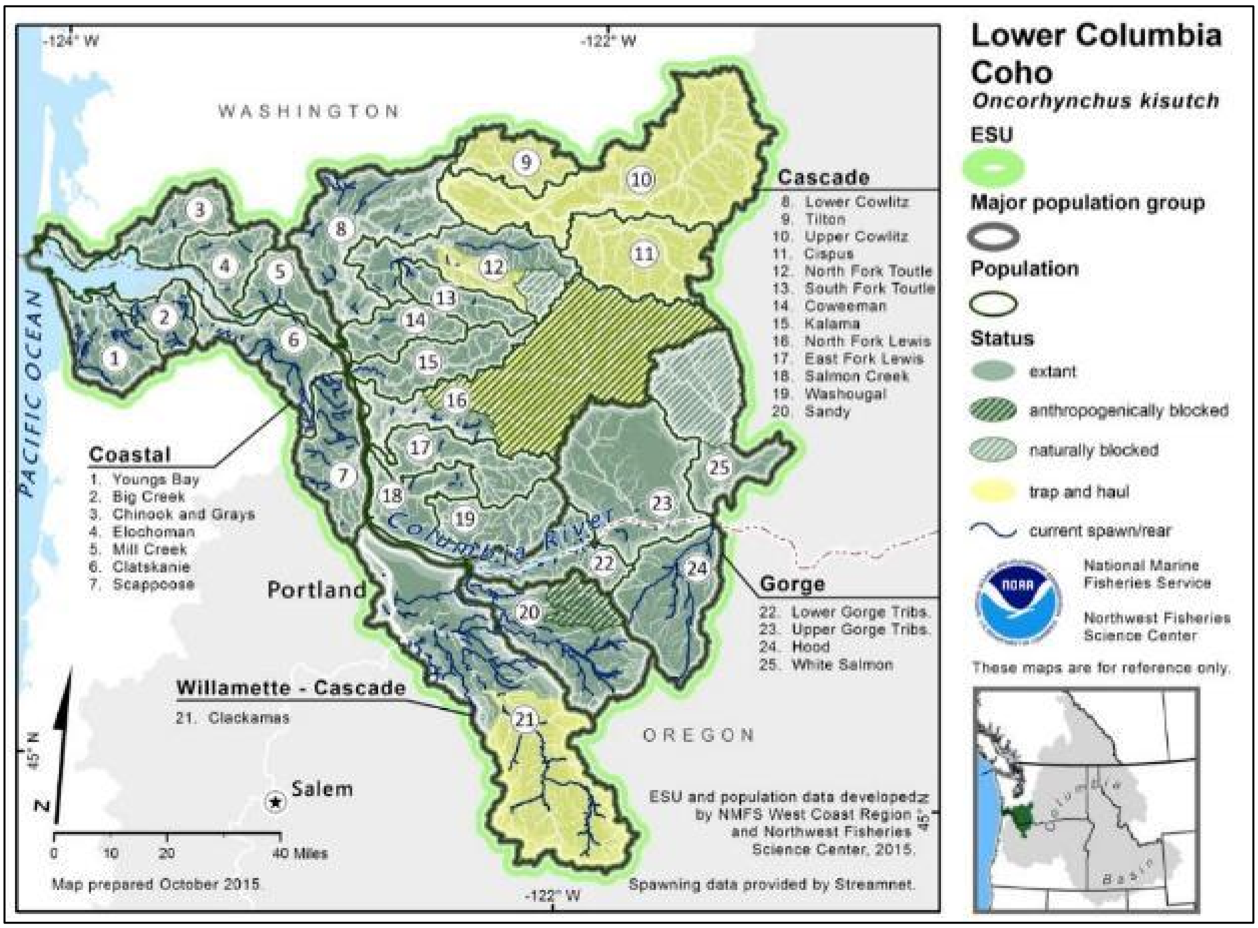


Figure 2-4. Map of the LCR Coho Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Although run time variation is considered inherent to overall coho salmon life- history, LCR coho salmon typically display one of two major life-history types, either early or late returning freshwater entry. Freshwater entry timing for this ESU is also associated with ocean migration patterns (Table 2-12) based on the recovery of CWT hatchery fish north or south of the Columbia River (Myers et al. 2006). Early returning (Type-S) coho salmon generally migrate south of the Columbia River once they reach the ocean, returning to freshwater in mid-August and to the spawning tributaries in early September. Spawning peaks from mid-October to early November. Late returning (Type-N) coho salmon have a northern distribution in the ocean, returning to the LCR from late September through December and enter the tributaries from October through January. Most of the spawning for Type-N occurs from November through January, but some spawning occurs in February and as late as March (NMFS 2013e). In general, early returning fish (Type-S) spawn further upstream than later migrating fish (Type-N), although Type-N fish enter rivers in a more advanced state of sexual maturity (Table 2-13) (Sandercock 1991).

Table 2-13. Life-History and population characteristics of LCR coho salmon.

Characteristic	Life-History Features	
	Early-returning (Type-S)	Late-returning (Type-N)
Number of extant population	10	23
Life-history type	Stream	Stream
River entry timing	August-September	September-December
Spawn timing	October-November	November-January
Spawning habitat type	Higher tributaries	Lower tributaries
Emergence timing	January-April	January-April
Duration in freshwater	Usually 12-15 months	Usually 12-15 months
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	Smaller tributaries, river edges, sloughs, off-channel ponds
Estuarine use	A few days to weeks	A few days to weeks
Ocean migration	South of the Columbia River, as far south as northern California	North of the Columbia River, as far north as British Columbia
Age at return	2-3 years	2-3 years
Recent natural spawners	6,000	
Recent hatchery adults	5,000 – 90,000	12,000 – 180,000

In contrast to Chinook salmon and steelhead, LCR coho salmon run timing was not used to establish differences between MPGs. Some tributaries historically supported spawning by both run types; therefore Myers et al. (2006) indicated that, regardless of whether run timing is an element of diversity on a subpopulation or population level, the run timing was a factor that needed consideration in recovery planning for LCR coho salmon. NMFS' recovery plan took this into consideration by identifying each LCR coho salmon population's proposed life-history component(s).

Regardless of adult freshwater entry timing, coho salmon fry move to shallow, low velocity rearing areas after emergence, primarily along the stream edges and in side channels. All coho salmon juveniles remain in freshwater rearing areas for a full year after emerging from the gravel. Most juvenile coho salmon migrate seaward as one year smolts from April to June. Salmon with stream-type life-histories, like coho salmon, typically do not linger for extended periods in the Columbia River estuary, but the estuary is critical habitat used for foraging during the physiological adjustment to the marine environment (NMFS 2013e). Coho salmon typically spend 18 months in the ocean before returning to freshwater to spawn. Jacks (i.e., precocial males) spend five to seven months in the ocean before returning to freshwater to spawn.

In 2017 NMFS adopted a Record of Decision ("Mitchell Act ROD") for a policy direction that would be used to guide NMFS' decision on the distribution of funds for hatchery production under the Mitchell Act (16 US CFR 755 757), which NMFS administers. NMFS' continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD was analyzed under the ESA and was found to not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017j). The Mitchell Act ROD directs NMFS to apply stronger performance goals to all Mitchell Act-funded, Columbia River Basin hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs on natural-origin salmon and steelhead populations, including the LCR Coho Salmon ESU. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated. While the following information presented is a review of updated status information available, NMFS expects the prevalence of hatchery-origin coho salmon spawning contribution to decrease over the course of the 2018 Agreement due to the ITS limits and terms and conditions required by the opinion (NMFS 2017j).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Coho Salmon ESU, is at high risk and remains at threatened status. Each population's baseline and target persistence probabilities are summarized in Table 2-12, along with target abundance for each population that would be consistent with delisting the species. Persistence probability is measured over a 100 year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

NMFS conducted status reviews of the LCR Coho Salmon ESU in 1996 (NMFS 1996a), in 2001 (NMFS 2001d), in 2005 (Good et al. 2005), in 2011 (Ford 2011), and most recently in 2015 (NWFSC 2015). In 1996, the BRT concluded that they could not identify any remaining natural populations of coho salmon in the LCR (excluding the Clackamas River) or along the Washington coast south of Point Grenville that warrant protection under the ESA, although this conclusion would warrant reconsideration if new information becomes available. In the 2001 review, the BRT was concerned that the vast majority (more than 90%) of the historical natural populations in the ESU were either extirpated or nearly so. The two populations with any significant production (Sandy and Clackamas River populations) were at appreciable risk because of low abundance, declining trends, and failure of the populations to improve after a dramatic reduction in harvest. The large number of hatchery coho salmon in the ESU was also considered an important risk factor. The majority of BRT members in 2001 believed that the species was 'at risk of extinction', with a small number of members believing that the species was 'likely to become endangered'. An updated status evaluation was conducted in 2005, also with a majority of BRT votes for 'at risk of extinction' and a substantial minority for 'likely to become endangered'.

Five evaluations of LCR coho salmon status, all based on WLC-TRT criteria, have been conducted since the last BRT status update in 2005 (McElhany et al. 2007; LCFRB 2010; ODFW 2010a; Ford 2011). McElhany et al. (2007) concluded that the ESU is currently at high risk of extinction. ODFW (2010a) concluded that the Oregon portion of the ESU is currently at very high risk. The (LCFRB 2010) does not provide a statement on ESU-level status, but describes the high fraction of populations in the ESU that are at high or very high risk. According to Ford (2011), of the 27 historical populations in the ESU, 24 are considered at very high risk. The latest status review (NWFSC 2015) relied on data available through 2014. According to the NWFSC, the status of a number of coho salmon populations have changed since previous reviews, mostly due to the improved level of monitoring (and subsequent understanding of status) in Washington tributaries, rather than a true change in status over time. Furthermore, the NWFSC (2015) determined that while recovery efforts have likely improved the status of a number of coho salmon populations, abundance is still at low levels and the majority of DIPs remain at moderate or high risk.

For LCR coho salmon, poor data quality prevented precise quantification of abundance and productivity. Data quality has been poor because of inadequate spawning surveys and, until recently, the presence of unmarked hatchery-origin spawners. Mass marking of hatchery-origin LCR coho salmon began in 1999 (LCFRB 2010) which generally allows assessment of what portion of escapement consists of hatchery-origin spawners and greatly improves the ability to assess the status of populations.

Hatchery production dominates the Washington side of this ESU and no populations are thought to be naturally self-sustaining because the majority of spawners are believed to be hatchery strays. Washington did not collect adult escapement estimates until recently. The state’s monitoring strategy has instead relied primarily on a smolt monitoring program. Similar to the Washington populations, natural productivity on the Oregon side of the LCR Coho Salmon ESU is also believed to have decreased due to legacy effects of hatchery fish. While total hatchery production has been reduced from a peak in the 1980s most populations are still believed to have very low abundance of natural-origin spawners (NMFS 2013e; NWFSC 2015)[6].

In general, hatchery-origin fish comprise the large majority of LCR coho salmon annual adult returns (Table 2-14 and Table 2-15). Numbers can vary substantially from year-to-year because coho salmon encounter and are affected by the widely-varying conditions for marine survival related to environmental conditions particularly in the coastal upwelling zone. Until recently, no population was thought to be naturally self-sustaining, with the majority of spawners believed to be hatchery strays. Moreover, it is likely that hatchery effects have also decreased population productivity. New and added hatchery releases of coho salmon in areas upstream of the LCR may be impacting natural-origin LCR coho salmon through straying, competition, and predation in the lower mainstem and estuary.

[6] An average of approximately 10-17 million hatchery coho salmon since 2005 have continued to be released annually in the LCR.

Information that has recently become available indicates that the frequency of hatchery fish straying onto natural spawning grounds is actually quite low for several natural coho salmon populations, which are thought to be self-sustaining. Table 2-15 presents escapement of LCR coho salmon in selected Oregon tributaries (2002- 2015). Table 2-15 presents escapement of LCR coho salmon in selected Washington tributaries (2002 - 2015). New information about escapement of LCR coho salmon in Oregon and Washington that was not available in prior status reviews (Table 2-14 and Table 2-15) suggests that there has been an increase in the wild fraction of natural-origin coho salmon in their relative abundances. Additionally, hatchery-fish straying into Oregon populations within the LCR Coho Salmon ESU has decreased while pockets of natural production, such as with the Scappoose and Clackamas populations, are also now increasing in their contribution to the overall Oregon coho salmon abundance.

Table 2-14 and Table 2-15 provide estimates of escapement for tributaries on the Oregon and Washington sides of the lower Gorge population, respectively. It is unclear how comprehensive the surveys are or if the estimates are intended to be expanded estimates for the population as a whole. On the Washington side, the estimates are characterized as cumulative fish per mile index counts. This information, although limited, indicates there are several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are actually relatively low.

Table 2-14. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS[1]) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015*.

Major Population Group	Oregon Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Youngs Bay	Natural	411	113	149	79	74	21	82	26	68	161	129	n/a	n/a	n/a
		pHOS	86%	86%	86%	75%	84%	40%	22%	92%	61%	66%	46%	n/a	n/a	n/a
	Big Creek	Natural	98	435	112	219	225	212	360	792	279	160	409	n/a	n/a	n/a
		pHOS	90%	40%	70%	36%	50%	15%	54%	30%	52%	21%	18%	n/a	n/a	n/a
	Clatskanie	Natural	167	563	398	494	421	927	995	1,195	1,686	1,546	619	611	3,246	240
		pHOS	22%	0%	0%	1%	10%	4%	0%	1%	3%	1%	11%	11%	4%	4%
	Scappoose	Natural	502	336	755	348	719	375	292	778	1,960	298	210	979	1,587	487
		pHOS	0%	10%	8%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cascade	Clackamas	Natural	1,981	2,507	2,874	1,301	3,464	3,608	1,694	7,982	1,757	2,254	1,580	3,202	10,670	1,784
		pHOS	57%	10%	16%	28%	76%	14%	45%	27%	57%	10%	10%	2%	14%	11%
	Sandy	Natural	382	1,348	1,213	856	923	687	1,277	1,493	901	3,494	1,165	667	5,942	443
		pHOS	57%	0%	9%	0%	n/a	9%	0%	10%	12%	8%	3%	12%	3%	5%
Gorge	Lower Gorge	Natural	338	n/a	n/a	263	226	126	223	468	920	216	96	151	362	30
		pHOS	17%	n/a	n/a	85%	70%	67%	46%	29%	7%	54%	56%	6%	51%	38%
	Upper Gorge/ Hood	Natural	147	41	126	1,262	373	170	69	65	223	232	169	561	42	4
		pHOS	60%	n/a	n/a	45%	48%	45%	29%	0%	85%	69%	78%	65%	76%	64%

[1] For example, Clatskanie in 2007 had 927 natural-origin spawners and 4% hatchery spawners. To calculate hatchery-origin numbers multiply (927/(1-.04))-583 = 39 hatchery-origin spawners.

*http://www.odfwrecoverytracker.org/summary/#/species=1&run=2&esu=159/esu=159&metric=1&level=3/filter=160&start_year=1992&end_year=2017 Date accessed: October 4, 2017.

Table 2-15. Natural-origin spawning escapement numbers and the proportion of all natural spawners composed of hatchery-origin fish (pHOS1) on the spawning grounds for LCR coho salmon populations in Washington from 2002 through 2015 (https://fortress.wa.gov/dfw/score/score/species/coho.jsp?species=Coho)*.

Major Population Group	Washington Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Gray's/Chinook	Natural	-	-	-	-	-	-	-	-	388	152	795	1,212	3,700	86
		pHOS	-	-	-	-	-	-	-	-	81%	97%	22%	65%	32%	80%
	Elochoman / Skamokawa	Natural	-	-	-	-	-	-	-	-	834	851	505	721	4,158	168
		pHOS	-	-	-	-	-	-	-	-	73%	56%	29%	43%	34%	50%
	Mill Creek	Natural	-	-	-	-	-	-	-	-	859	576	207	101	932	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Abernathy	Natural	-	-	-	-	-	-	-	-	490	183	256	384	832	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Germany	Natural	-	-	-	-	-	-	-	-	322	48	122	149	475	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
Cascade	Lower Cowlitz	Natural	-	-	-	-	-	-	-	-	6,274	3,394	-	1,565	12,661	5,132
		pHOS	-	-	-	-	-	-	-	-	15%	8%	-	-	5%	8%
	Upper Cowlitz/Cispus	Natural	54,188	20,695	28,665	22,329	25,574	5,691	13,805	16,162	18,905	7,326	2,397	7,941	25,147	1,012
		pHOS	13%	28%	14%	21%	18%	40%	26%	26%	13%	51%	40%	0%	22%	-
	Tilton	Natural	1,732	601	722	1,332	738	827	1,006	1,305	929	2,025	1,301	2,744	9,074	-
		pHOS	91%	92%	95%	85%	69%	66%	64%	70%	80%	75%	79%	67%	39%	-
	SF Toutle	Natural	-	-	-	-	-	-	-	-	1,518	490	2,063	3,349	10,960	1,537
		pHOS	-	-	-	-	-	-	-	-	21%	22%	14%	-	19%	53%
	NF Toutle[2]	Natural	-	-	-	-	-	-	-	-	1,454	365	1,425	3,497	6,597	868
		pHOS	-	-	-	-	-	-	-	-	60%	30%	24%	-	32%	65%
	Coweeman	Natural	-	-	-	-	-	-	-	-	3,528	2,436	2,964	4,047	5,021	767
		pHOS	-	-	-	-	-	-	-	-	10%	6%	5%	-	17%	25%
	Kalama	Natural	-	-	-	-	-	-	-	-	5	-	69	64	99	18

		pHOS	-	-	-	-	-	-	-	-	99%	-	78%	-	91%	90%
	NF Lewis[3]	Natural	-	-	-	-	-	-	-	-	700	604	827	-	-	-
		pHOS	-	-	-	-	-	-	-	-	1%	3%	11%	-	100%	75%
	EF Lewis	Natural	-	-	-	-	-	-	-	-	1,363	1,025	3,681	3,251	2,531	389
		pHOS	-	-	-	-	-	-	-	-	32%	6%	9%	-	20%	17%
	Salmon Creek	Natural	-	-	-	-	-	-	-	-	-	1,248	1,897	2,693	4,257	1,348
		pHOS	-	-	-	-	-	-	-	-	-	20%	22%	-	0%	0%
	Washougal	Natural	-	-	-	-	-	-	-	-	795	562	531	604	737	101
		pHOS	-	-	-	-	-	-	-	-	44%	8%	13%	-	65%	67%
Gorge	Lower Gorge	Natural	-	-	-	-	28	-	-	-	385	504	524	1,125	704	650
		pHOS	-	-	-	-	0%	-	-	-	29%	13%	20%	-	35%	11%
	Upper Gorge/ Hood	Natural	147	41	126	1,262	373	170	69	65	223	232	169	561	42	4
		pHOS	-	-	-	-	-	-	-	-	-	-	-	-	23%	24%

[1] For example, Mill Creek in 2010 had 859 natural-origin spawners and 12 % hatchery spawners. To calculate hatchery-origin numbers multiply (859/(1-.12))-859 = 117 hatchery-origin spawners.
[2] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Green River (NF Toutle) coho salmon, the North Fork Toutle River coho salmon, and trap count data.
[3] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Cedar Creek (NF Lewis) coho salmon and the North Fork Lewis River Mainstem coho salmon.
* Date accessed: October 4, 2017.

Any changes from the previous status review in VSP score for coho salmon populations in Table 2-16 reflect improvements in abundance, spatial structure, and diversity, as well as in monitoring (NWFSC 2015). Table 2-17 shows an overall summary of the abundance, productivity, spatial structure, and diversity ratings for each natural population within this ESU. Previous status reviews lacked adequate quantitative data on abundance and hatchery contribution for a number of populations whereas recent surveys provide a more accurate understanding of the status of these populations. However, with only two or three years of data, it is not possible to determine whether there has been a true improvement in status, though it is evident that the contribution of natural-origin fish is much higher than previously thought (NWFSC 2015).

Table 2-16. Summary of VSP scores and recovery goals for LCR coho salmon populations (NWFSC 2015).*

Strata	State	Population	Total VSP Score	Recovery Goal
Coast	OR	Youngs Bay	0	0
	WA	Grays/Chinook	0.5	2.75
	OR	Big Creek	0	0
	WA	Eloc/Skamo	0.5	2.75
	WA	Mill/Abern/Ger	0.5	1.75
	OR	Clatskanie	1	3.5
	OR	Scappoose	2	3.5
Cascade	WA	Lower Cowlitz	0.5	2.75
	WA	Upper Cowlitz	0.5	2.75
	WA	Cispus	0.5	2.75
	WA	Tilton	0.5	.5
	WA	SF Toutle	0.5	2.75
	WA	NF Toutle	0.5	2.75
	WA	Coweeman	0.5	2.75
	WA	Kalama	0.5	.85
	WA	NF Lewis	0.5	.85
	WA	EF Lewis	0.5	2.75
	WA	Salmon	0.5	.5
	OR	Clackamas	2	3.5
	OR	Sandy	0	2.75
	WA	Washougal	0.5	2.25
Gorge	WA	Lower Gorge	0.5	2.25
	WA	Upper Gorge	0.5	2.25

*Summaries taken directly from Figure 69 in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006).

Table 2-17. LCR Coho Salmon ESU populations and scores for the key elements (abundance/productivity (A/P), spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013e)[1].

Ecological Subregions	Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Coast Range	Youngs Bay (OR)	VL	VH	VL	VL
	Grays/Chinook rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L
	Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
	Scappoose River (OR)	M	H	M	M
Cascade Range	Lower Cowlitz River (WA)	VL	M	M	VL
	Upper Cowlitz River (WA)	VL	M	L	VL
	Cispus River (WA)	VL	M	L	VL
	Tilton River (WA)	VL	M	L	VL
	South Fork Toutle River (WA)	VL	H	M	VL
	North Fork Toutle River (WA)	VL	M	L	VL
	Coweeman River (WA)	VL	H	M	VL
	Kalama River (WA)	VL	H	L	VL
	North Fork Lewis River (WA)	VL	L	L	VL
	East Fork Lewis River (WA)	VL	H	M	VL
	Salmon Creek (WA)	VL	M	VL	VL
	Clackamas River (OR)	M	VH	H	M
	Sandy River (OR)	VL	H	M	VL
	Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Lower Gorge Tributaries (WA & OR)	VL	M	VL	VL
	Upper Gorge/White Salmon (WA)[7]	VL	M	VL	VL
	Upper Gorge Tributaries/Hood (OR)	VL	VH	L	VL

[1] Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

Figure 2-5 displays the extinction risk ratings for all four VSP parameters for Oregon natural populations (ODFW 2010a). This figure was updated in 2010 using data available through 2008. The results indicate low to moderate extinction risk for spatial structure for most LCR coho salmon populations in Oregon, but high risk for diversity for all but two populations (the Sandy and Clackamas River populations). The assessments of spatial structure are combined with those of abundance and productivity to give an assessment of the overall status of LCR populations in Oregon. Extinction risk is rated as high or very high in overall status for all populations except the Scappoose and Clackamas river populations (Figure 2-5). In Figure 2-5 where updated ratings differ from those of McElhany et al. (2007) assessment the older rating is shown as an open diamond with a dashed outline (ODFW 2010a).

[7] The White Salmon population was limited by Condit Dam, as discussed above regarding Gorge Fall Run Lower Columbia River Chinook salmon. This population is re-establishing itself following removal of Condit Dam in 2011.

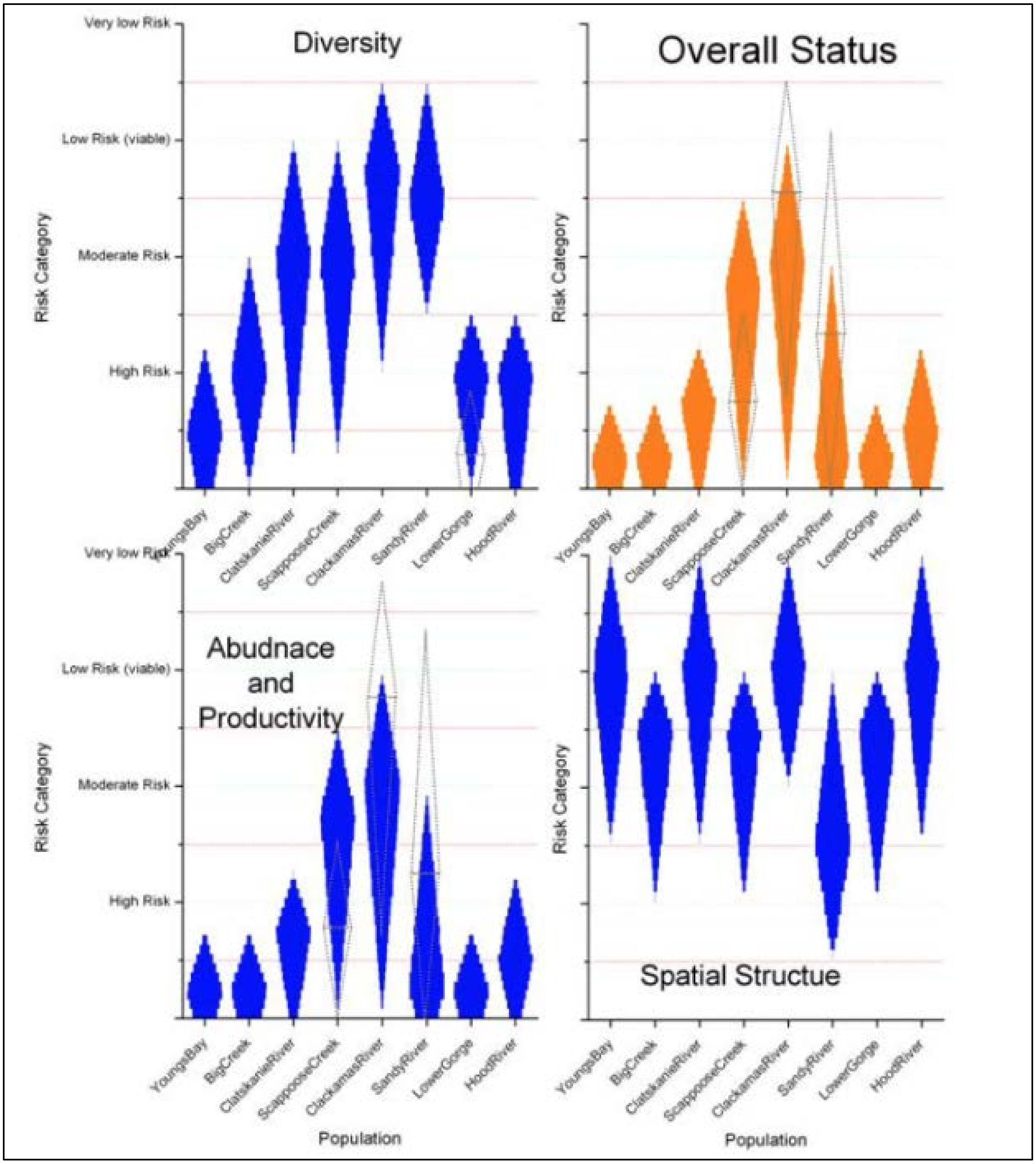


Figure 2-5. Extinction risk ratings for LCR coho salmon populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as an overall rating for populations that combines the three attribute (adapted from McElhany et al. 2007).

The lack of data, as well as poor data quality, has made it difficult to assess spatial structure and diversity VSP attributes for LCR coho salmon. Low abundance, past hatchery stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations (LCFRB 2010; ODFW 2010a). The low persistence probability and risk category for the majority of LCR coho salmon populations reported above is related to the loss of spatial structure and reduced diversity. Spatial structure of some coho salmon populations is constrained by migration barriers (i.e., tributary dams) and development of lowland areas (NMFS 2013e). Inadequate spawning survey coverage, along with the presence of unmarked hatchery-origin coho salmon mixing with natural-origin spawners, also has made it difficult to ascertain the spatial structure of natural-origin populations. The mass marking of hatchery-origin fish and more extensive spawning surveys have provided better information regarding species status recently (NWFSC 2015).

In summary, the 2015 status review (NWFSC 2015) concluded that the LCR Coho Salmon ESU is still at very high risk. A total of 6 of the 23 populations in the ESU are at or near their recovery viability goals (Figure 69 in NWFSC 2015), although under the recovery plan scenario these populations had recovery goals only greater than 2.0 (moderate risk). The remaining populations require a higher level of viability (NWFSC 2015) and therefore still require substantial improvements. Best available information indicates that the LCR Coho Salmon ESU is at high risk and remains at threatened status.

Limiting Factors

Understanding the limiting factors and threats that affect the LCR Coho Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. LCR coho salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable given these changing habitat conditions. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Coho Salmon ESU. Factors that limit the ESU have been, and continue to be hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery operations, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The ESU-level recovery plan consolidates the information regarding limiting factors and threats for the LCR Coho Salmon ESU available from various sources (NMFS 2013e).

The LCR recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 (NMFS 2013e) of the recovery plan describes limiting factors on a regional scale and those factors apply to the four listed species from the LCR considered in the plan, including LCR coho salmon. Chapter 6 of the recovery plan discusses the limiting factors that pertain to the MPGs that compose the LCR Coho Salmon ESU. The discussion of limiting factors in Chapter 6 (NMFS 2013e) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Chapter 4 (NMFS 2013e) includes additional details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Rather than repeating this extensive discussion from the roll-up recovery plan, it is incorporated here by reference.

Harvest-related mortality is identified as a primary limiting factor for all natural populations within the ESU and occurs as a result of direct and incidental mortality of natural-origin fish in ocean fisheries, Columbia River recreational fisheries, and commercial gillnet fisheries. The LCR recovery plan envisions refinements in coho salmon harvest through (1) replacement or refinement of the existing harvest matrix to ensure that it adequately accounts for weaker components of the ESU, (2) continued use of mark-selective recreational fisheries, and (3) management of mainstem commercial fisheries to minimize impacts to natural-origin coho salmon (NMFS 2013e). The recent refinement of the harvest matrix ensured that harvest management is consistent with maintaining trajectories in populations where increasing natural production is beginning to be observed (e.g., the Clatskanie and Scappoose populations), with the assumption that additional refinements will be evaluated as natural production is documented in additional populations. Managing coho salmon harvest to minimize impacts to natural-origin fish has been complicated by uncertainties regarding annual natural-origin spawner abundance and actual harvest impacts on natural-origin fish (in both ocean and mainstem Columbia fisheries). The recovery plan notes these uncertainties and highlight the need for improved monitoring of harvest mortality and natural-origin spawner abundance.

Closely spaced releases of hatchery fish from all Columbia Basin hatcheries could lead to increased competition with natural-origin fish for food and habitat space in the estuary (NMFS 2013e). NMFS (2011b) and LCFRB (2010) identified quantifying levels of competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. As stream-type fish, coho salmon spend less time in the Columbia River estuary and plume than do ocean-type salmon, such as fall Chinook, yet possible ecological interactions in this geographic area likely play a role. ODFW (2010a) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. NMFS is working to better define and describe the scientific uncertainty associated with ecological interaction between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats (NMFS 2013e).

As mentioned above, high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g. for reintroduction purposes in the Upper Cowlitz and Lewis subbasins, and will continue, but the recent opinion on the majority of hatchery production affecting this ESU (NMFS 2017j) expects Federal funding guideline requirements to reduce limiting factors relative to hatchery effects over the course of the next decade.

2.2.2.3 Life-History and Status of the Upper Willamette River Chinook Salmon ESU

On March 24, 1999, NMFS listed the UWR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802). Critical habitat was designated on June 28, 2005 (70 FR 37160).

The ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River, and its tributaries, above Willamette Falls, Oregon, as well as several artificial propagation programs (Figure 2-6). Genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS (2005d) evaluates and determines whether to include hatchery fish in an ESU or DPS, (NMFS 2005d). The ESU contains seven historical populations, within a single MPG (western Cascade Range, Table 2-18).

Table 2-18. UWR Chinook Salmon ESU description and MPG (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014.
1 major population group	7 historical populations
Major Population Group	***Populations***
Western Cascade Range	Clackamas River, Molalla River, North Santiam River, South Santiam River, Calapooia River, McKenzie River, MF Willamette River
Artificial production	
Hatchery programs included in ESU (6)	McKenzie River spring, North Santiam spring, Molalla spring, South Santiam spring, MF Willamette spring, Clackamas spring
Hatchery programs not included in ESU (0)	n/a

UWR Chinook salmon’s genetics have been shown to be strongly differentiated from nearby populations, and are considered one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin (Waples et al. 2004; Beacham et al. 2006). For adult Chinook salmon, Willamette Falls historically acted as an intermittent physical barrier to upstream migration into the UWR basin, where adult fish could only ascend the falls at high spring flows. It has been proposed that the falls served as an zoogeographic isolating mechanism for a considerable period of time (Waples et al. 2004), and has led to, among other attributes, the unique early run timing of these populations relative to other LCR spring-run populations. Historically, the peak migration of adult salmon over the falls occurred in late May. Low flows during the summer and autumn months prevented fall-run salmon and coho salmon from reaching the UWR basin (NMFS and ODFW 2011).

The generalized life history traits of UWR Chinook salmon are summarized in Table 2-19. Today, adult UWR Chinook salmon begin appearing in the lower Willamette River in January, with fish entering the Clackamas River as early as March. The majority of the run ascends Willamette Falls from late April through May, with the run extending into mid-August (Myers et al. 2006).

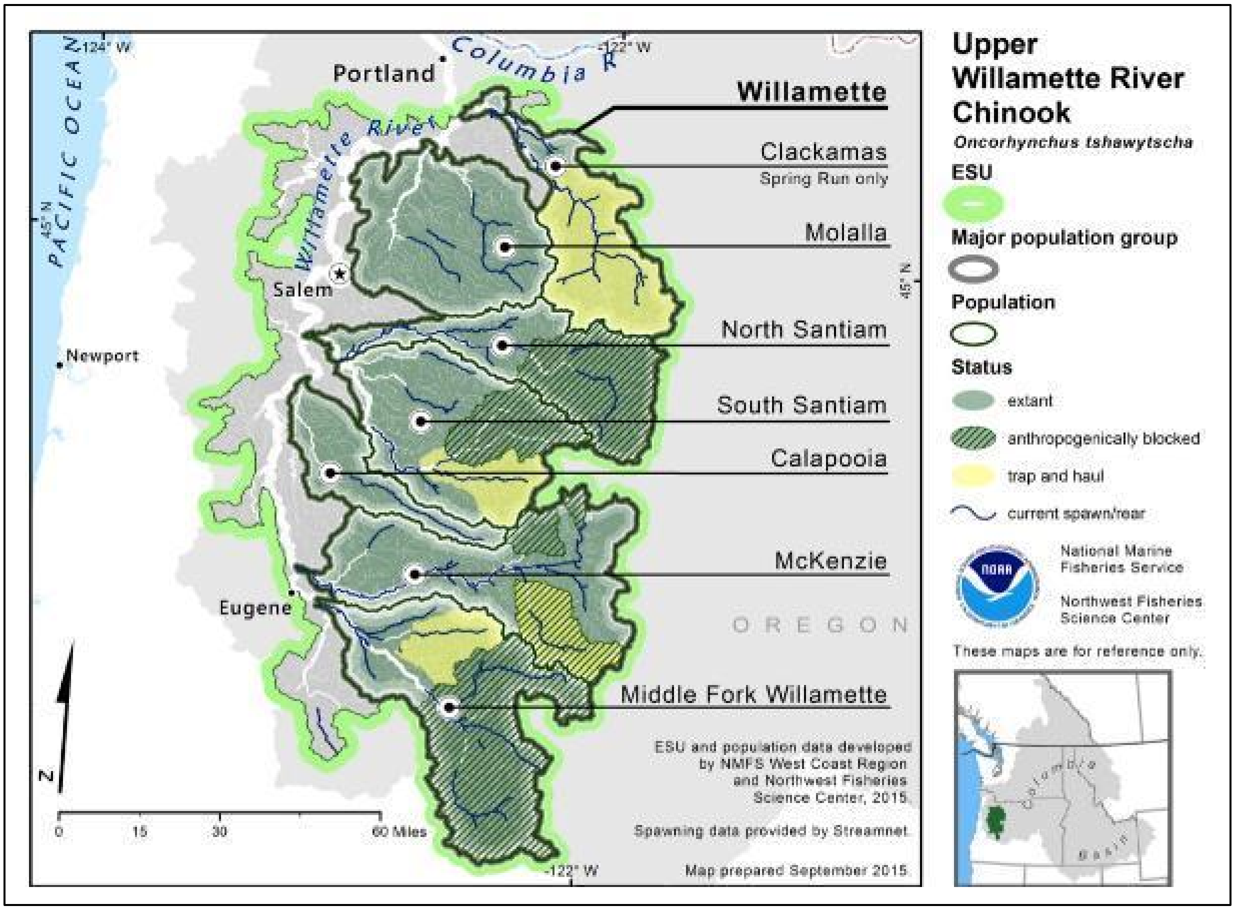


Figure 2-6. Map of the UWR Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Chinook salmon migration past the falls generally coincides with a rise in river temperatures above 50°F (Mattson 1948; Howell et al. 1985; Nicholas 1995). Historically, passage over the falls may have been marginal in June because of diminishing flows, and only larger fish would have been able to ascend. Mattson (1963) discusses a late spring Chinook salmon run that once ascended the falls in June. The disappearance of the June run in the 1920s and 1930s was associated with the dramatic decline in water quality in the lower Willamette River (Mattson 1963). This was also the period of heaviest dredging activity in the lower Willamette River. Dredge material was not only used to increase the size of Swan Island, but to fill floodplain areas like Guild's Lake. These activities were thought to heavily influence the water quality at the time. Chinook salmon now ascend the falls via a fish ladder at Willamette Falls.

Table 2-19. A summary of the general life-history characteristics and timing of UWR Chinook salmon[1].

Life-History Trait	Characteristic
Willamette River entry timing	January-April; ascending Willamette Falls April-August
Spawn timing	August-October, peaking in September
Spawning habitat type	Larger headwater streams
Emergence timing	December-March

Rearing habitat	Rears in larger tributaries and mainstem Willamette
Duration in freshwater	12-14 months; rarely 2-5 months
Estuarine use	Days to several weeks
Life-history type	Stream
Ocean migration	Predominantly north, as far as southeast Alaska
Age at return	3-6 years, primarily 4-5 years

[1] Data are from numerous sources (NMFS and ODFW 2011).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UWR Chinook Salmon ESU, is at moderate to high risk and remains at threatened status. The Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), and Willamette Falls likely served as a physical barrier for reproductive isolation of Chinook salmon populations. This isolation had the potential to produce local adaptation relative to other Columbia River populations (Myers et al. 2006). Fish ladders were constructed at the falls in 1872 and again in 1971, but it is not clear what role they may have played up to the present day in reducing localized adaptations in UWR fish populations. Little information exists on the life-history characteristics of the historical UWR Chinook salmon populations, especially since early fishery exploitation (starting in the mid-1880s), habitat degradation in the lower Willamette Valley (starting in the early 1800s), and pollution in the lower Willamette River (by early 1900s) likely altered life-history diversity before data collections began in the mid-1900s. Nevertheless, there is ample reason to believe that UWR Chinook salmon still contain a unique set of genetic resources compared to other Chinook salmon stocks in the WLC Domain (NMFS and ODFW 2011).

According to the most recent status review (NWFSC 2015), abundance levels for five of the seven natural populations in this ESU remain well below their recovery goals. Of these, the Calapooia River population may be functionally extinct, and the Molalla River population remains critically low (although perhaps only marginally better than the 0 VSP score estimated in the Recovery Plan). Abundances, in terms of adult returns, in the North and South Santiam Rivers have risen since the last review (Ford 2011), but still range only in the high hundreds of fish. Improvements in the status of the MF Willamette River population relates solely to the return of natural-origin adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the MF Willamette River individual population. The status review incorporates valuable information from the Fall Creek program that is relevant to the use of reservoir drawdowns as a method of juvenile downstream passage. The proportion of natural-origin spawners has improved in the North and South Santiam Basins, but is still below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production there. Additionally, the Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but both individual populations have experienced declines in abundance[8] (NWFSC 2015).

All seven historical natural populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the Western Cascade Range. Within the range and ESU, the Clackamas and McKenzie River populations had the best overall extinction risk ratings within the ESU, as well as for A/P, spatial structure, and diversity, as of 2016 (Table 2-20).

Table 2-20. Scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall viability risk for UWR Chinook salmon (NMFS and ODFW 2011; NWFSC 2015)[1].

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

[1] All populations are in the Western Cascade Range ecological subregion. Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). All populations originate in the action area (NWFSC 2015).

Data collected since the BRT status update in 2005 highlight the substantial risks associated with pre-spawning mortality. A recovery plan was finalized for this species on August 5, 2011 (NMFS and ODFW 2011). Although recovery plans are targeting key limiting factors for future actions, there have been no significant on-the-ground-actions since the 2011 status review to resolve the lack of access to historical habitat above dams nor substantial actions removing hatchery fish from the spawning grounds (NWFSC 2015). Furthermore, limited data are available for natural-origin spawner abundance for UWR Chinook salmon populations. Table 2-21 includes the most up-to-date available data for natural-origin Chinook salmon spawner estimates from UWR subbasins. The McKenzie subbasin has the largest amounts of natural-origin Chinook salmon spawners compared to the other surveyed subbasins.

Table 2-21. Estimated number of natural-origin spring Chinook salmon spawners in surveyed subbasins of the UWR from 2005 through 2015 (ODFW 2015)[1].

Run Year	North Santiam	South Santiam	McKenzie	Middle Fork Willamette
2005	247	268	2,135	139

[8] Spring-run Chinook salmon counts on the Clackamas River are taken at North Fork Dam, where only unmarked fish are passed above the Dam presently. A small percentage of these unmarked fish are of hatchery-origin. While there is some spawning below the Dam, it is not clear whether any progeny from the downstream redds contribute to escapement.

2006	201	209	2,049	664
2007	309	245	2,562	69
2008	412	323	1,387	368
2009	358	913	1,193	110
2010	292	376	1,266	189
2011	553	756	2,511	181
2012	348	544	1,769	175
2013	405	631	1,202	59
2014	566	886	1,031	90
2015	431	629	1,571	139
2008 – 2015 average	421	632	1,491	161
Recent 5 year average	461	689	1,617	129

[1] The data are a combination of estimates from spawning ground surveys (N. Santiam, S. Santiam, Lower McKenzie, and Middle Fork) and video counts (upper McKenzie). Estimates include natural-origin spawners transported above dams.

Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. The overview above for UWR Chinook salmon populations suggests that there has been relatively little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk (Table 2-22) (NWFSC 2015).

Table 2-22. Summary of VSP scores and recovery goals for UWR Chinook salmon populations (NWFSC 2015).

MPG	State	Population	Total VSP Score	Recovery Goal
Western Cascade Range	OR	Clackamas River	2	4
	OR	Molalla River	0	1
	OR	North Santiam River	0	3
	OR	South Santiam River	0	2
	OR	Calapooia River	0	1
	OR	McKenzie River	3	4
	OR	MF Willamette River	0	3

Limiting Factors

Understanding the limiting factors and threats that affect the UWR Chinook Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. UWR Chinook salmon are harvested in ocean fisheries, primarily in Canada and Alaska, but they are also taken in lower mainstem Columbia River commercial gillnet fisheries, and in recreational fisheries in the mainstem Columbia and Willamette Rivers, and tributary terminal areas. These fisheries in the Columbia and Willamette Rivers are now directed at hatchery-origin fish. However, hatchery fish could not be discriminated from natural-origin fish historically, and natural-origin fish were also retained in past fisheries. In the late 1990s, ODFW began mass-marking of the hatchery-origin fish, and recreational fisheries within the Willamette River started to retain marked fish only (i.e., hatchery-origin fish), with mandatory release of unmarked natural-origin fish. Overall exploitation rates (ERs) reflect this change in fisheries, with the rates dropping from the 50-60% range in the 1980s and early 1990s to around 30% since 2000, with difference observed in both ocean and freshwater fisheries. Post-release mortality from hooking are generally estimated at 10% in the Willamette River, although river temperatures likely influence this rate. Illegal take of unmarked fish is thought to be low (NWFSC 2015).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, dams that block access to major production areas, loss and degradation of accessible spawning and rearing habitat, and degraded water quality and increased water temperatures; together, these factors have affected the populations of this ESU (NWFSC 2015).

The recovery plan for UWR Chinook salmon (NMFS and ODFW 2011) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them (Chapter 5 in NMFS and ODFW 2011). Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

Additionally, NWFSC (2015) outlines additional limiting factors for the UWR Chinook Salmon ESU which include:

- Significantly reduced access to spawning and rearing habitat because of tributary dams,
- Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development,
- Degraded water quality and altered water temperatures as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development,
- Hatchery-related effects,
- Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon, and
- Ocean harvest rates of approximately 30%.

Although there has likely been an overall decrease in population VSP scores since the last review for the Middle Fork Willamette population, the magnitude of this change in not sufficient to suggest a change in risk category for the ESU as the other three populations have seen slight improvements in abundance during the last five years (Table 2-21). Given current climatic conditions and the prospect of long-term climatic change, the inability of many populations to access historical headwater spawning and rearing areas may put this ESU at greater risk in the near future (NWFSC 2015).

2.2.2.4 Life-History and Status of the Upper Willamette River Steelhead DPS

On March 25, 1999, NMFS listed the UWR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52848).

The UWR Steelhead DPS includes all naturally spawned anadromous winter-run steelhead originating below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (NWFSC 2015). One MPG, composed of four historical populations, comprises the UWR Steelhead DPS. Inside the geographic range of the DPS, 1 hatchery program is currently operational, though it is not included in the DPS (Table 2-23, Figure 2-7) (Jones Jr. 2015). Hatchery summer-run steelhead also occur in the Willamette River Basin but are an out-of-basin stock that is not included as part of this DPS (NMFS 2011a). As explained above NMFS (2005d), genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

The DPS/ESU Boundaries Review Group considered new genetic information relating to the relationship between the Clackamas River winter steelhead and steelhead native to the LCR and UWR DPSs. The Review Group concluded that there was sufficient information available for considering reassigning the Clackamas River winter steelhead population to the UWR River Steelhead DPS. The most recent status review concluded that further review is necessary before there can be any consideration of redefining the DPS; therefore, the most recent status review evaluation was conducted based on existing DPS boundaries (Figure 2-7) (NWFSC 2015).

Table 2-23. UWR Steelhead DPS description and MPGs[1].

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014.
1 major population group	4 historical populations
Major Population Group	***Populations***
Willamette	South Santiam River (C,G), North Santiam River (C,G), Molalla River, Calapooia River
Artificial production	
Hatchery programs included in DPS (0)	n/a
Hatchery programs not included in DPS (1)	Upper Willamette summer (in South Santiam River, North Santiam, McKenzie, MF Willamette)

[1] The designations "(C)" and "(G)" identify core and genetic legacy populations, respectively (McElhany et al. 2003; Jones Jr. 2015; NWFSC 2015).

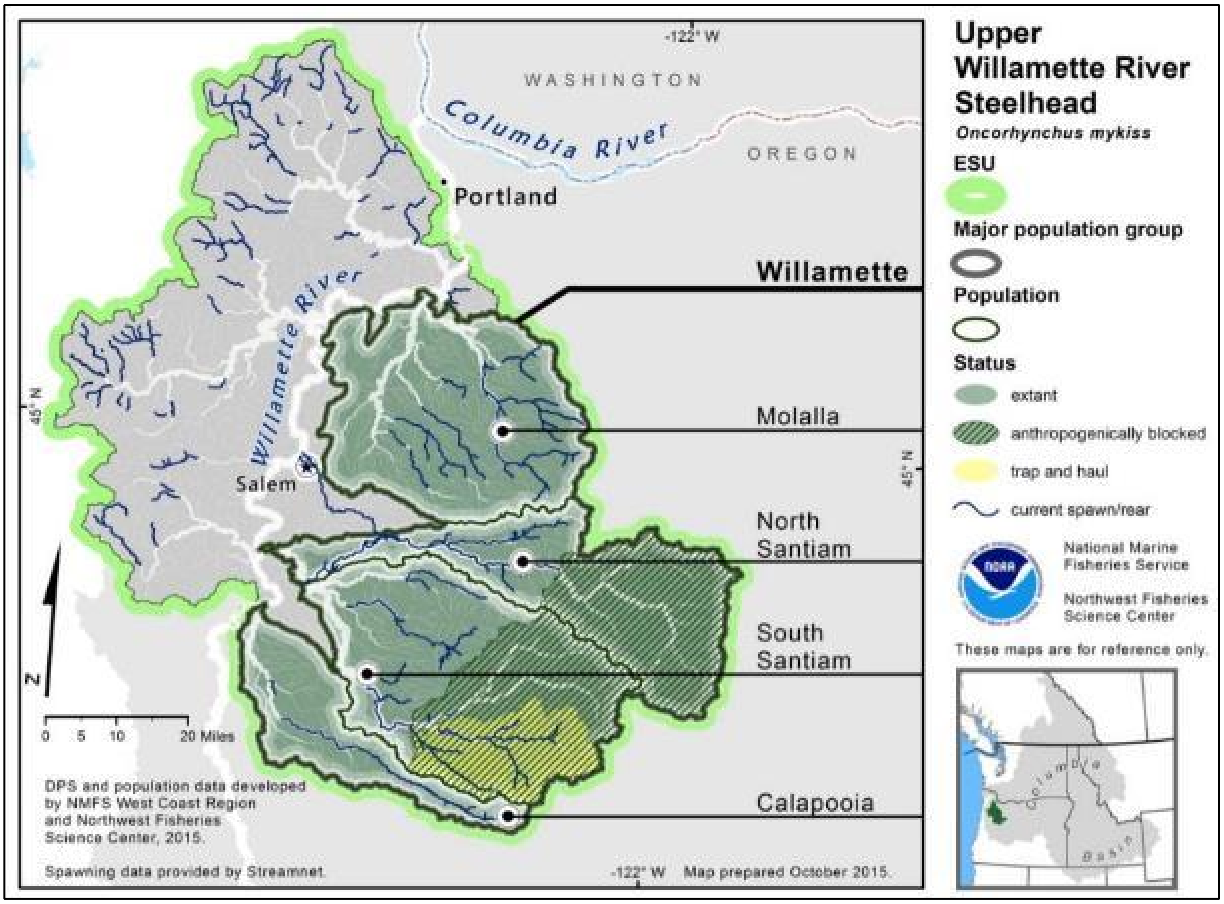


Figure 2-7. UWR Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

Before the construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. Presently, the majority of the UWR winter steelhead run return to freshwater from January through April, pass Willamette Falls from mid-February to mid-May, and spawn from March through June (with peak spawning in late April and early May). UWR steelhead currently exhibit a stream-type life-history with individuals exhibiting yearling life-history strategy. Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins from one to four years (average of two years), then as smoltification occurs in April through May, they migrate downstream through the mainstem Willamette and Columbia River estuaries and into the ocean. The downstream migration speed depends on factors including river flow, temperature, turbidity, and others, with the quickest migration occurring with high river flows. UWR steelhead can forage in the ocean for one to two years (average of two years) and during this time period, are thought to migrate north to waters off Canada and Alaska and into the North Pacific including the Alaska Gyre (Myers et al. 2006; ODFW 2010b).

Table 2-24 summarizes the general life history traits for UWR steelhead. This species may spawn more than once; however, the frequency of repeat spawning is relatively low. The repeat spawners are typically females that spend more than one year post spawning in the ocean and spawn again the following spring (ODFW 2010b).

Table 2-24. A summary of the general life history characteristics and timing of UWR winter steelhead (ODFW 2010b).

Life-History Trait	Characteristic
Willamette River entry timing	February-March
Spawn timing	March-June
Spawning habitat type	Headwater streams
Emergence timing	8-9 weeks after spawning, June-August
Rearing habitat	Headwater streams
Duration in freshwater	1-4 years (mostly 2), smolt in April-May
Estuarine use	Briefly in the spring, peak use in May
Ocean migration	North to Canada and Alaska, and into the North Pacific
Age at return	3-6 years, primarily 4 years

There is no directed fishery for winter steelhead in the UWR, and they are the only life-history displayed by natural steelhead in this area. Due to differences in return timing between native winter steelhead, introduced hatchery-origin summer steelhead, and hatchery-origin spring Chinook salmon, the encounter rates for winter steelhead in the recreational fishery are thought to be low. Sport fishery mortality rates were estimated at 0 to 3% (Ford 2011). There is additional incidental mortality in the commercial net fisheries for hatchery Chinook salmon and steelhead in the LCR. Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UWR Steelhead DPS, is at moderate risk and remains at threatened status. The most recent status update (NWFSC 2015) determined that there has been no change in the biological risk category since the last reviews of these populations. Although new data was available and analyzed for each of the populations in the most recent review, there is still uncertainty in the underlying causes of the long-term declines in spawner abundances that these populations have experienced. Although the recent magnitude of these declines is relatively moderate, continued declines would be a cause for concern (NWFSC 2015).

Estimation of steelhead abundance for this DPS were based on redd counts in the North and South Santiam Basins. Adult counts were also available from observations at Willamette Falls, Bennett Dam, the Minto Fish Facility (North Santiam River), and Foster Dam (South Santiam River). In addition, results from tracking studies of radio-tagged winter steelhead were expanded to estimate spawner abundance in specific individual populations. Steelhead arriving at Willamette Falls were also sampled for genetic analysis to determine the relative proportions of native (late winter steelhead) and out-of-DPS (early winter, or summer/winter hybrid steelhead) genotypes represented in the run (NWFSC 2015).

Winter steelhead hatchery programs were terminated in the late 1990s. Currently, the only steelhead programs in the UWR release Skamania Hatchery-origin summer steelhead, though this program is not part of the DPS. Annual total releases have been relatively stable at around 600,000 from 2009 to 2014, although the distribution has changed, with fewer fish being released in the North Santiam River and corresponding increases in the South Santiam and MF Willamette Rivers to maintain the release level of about 600,000 fish. However, there has been some concern regarding the effect of introduced summer steelhead on native late-winter steelhead. There is some overlap in the spawn timing for summer- and late-winter steelhead, and genetic analysis has identified approximately 10% of the juvenile steelhead sampled at Willamette Falls and in the Santiam Basin (Johnson et al. 2013; NWFSC 2015) as hybrids of summer and winter steelhead.

The presence of hatchery-reared and feral hatchery-origin fish in the UWR Basin may also affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined, by dams, below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.

In the Molalla River and associated tributaries (Pudding River, Abiqua Creek), population abundance estimates based on spawner (redd) surveys are only available through 2006. Recent estimates, based on the proportional migration of winter steelhead tagged at Willamette Falls (Jepson et al. 2013; Jepson et al. 2014) indicate that a significantly smaller portion of the steelhead arriving at Willamette Falls are destined for the Molalla River. Estimated declines in the Molalla River are based on correlations with observed trends in the North and South Santiam Rivers. Given that the Molalla River has no major migration barriers, limiting factors in the Molalla River are likely related to habitat degradation; abundance is likely relatively stable but at a depressed level (NWFSC 2015).

Currently, the best measure of steelhead abundance is the count of returning winter-run adults to the Upper and Lower Bennett Dams for the North Santiam River population. Recent passage improvements at the dams and an upgraded video counting system have contributed to a higher level of certainty in adult estimates. The Bennett Dam counts may also approximate spawner counts, given that post-dam prespawning mortality is thought to be low for winter steelhead. Unfortunately, steelhead were not counted at Bennett Dam from 2006 to 2010, due to budget constraints. The most recent average count for unmarked (presumed native) winter steelhead (2010-2014) is 1,195 ± 194. Longer term trends 1999-2014 are negative, -5 ±3% (NWFSC 2015).

Survey data (index redd counts) is available for a number of tributaries to the South Santiam River; in addition, live counts are available for winter steelhead transported above Foster Dam. Temporal differences in the index reaches surveyed and the conditions under which surveys were undertaken make the standardization of data among tributaries very difficult. For the Foster Dam time series, the most recent 5-year average (2010-2014) has been 304 fish, with a negative trend in abundance over those years (recognizing that the 2010 return reflected good ocean conditions). In addition to steelhead spawning in the mainstem South Santiam River, annual spawning surveys of tributaries below Foster Dam (Thomas, Crabtree, and Wiley Creeks) indicate the consistent presence of low numbers of spawning steelhead (NWFSC 2015).

The Calapooia River DPS has a nearly consistent and complete time series for index reach redd counts dating back to 1985. While there is not an expansion available from index reach to population spawner abundance, the trend in redds per mile is generally negative, although this is due in part to the time series beginning with the time of good ocean conditions. Abundance is thought to be rather low, with population estimates based on radio tagged winter steelhead for 2012, 2013, and 2014 are 127, 204, and 126 respectively (Jepson et al. 2013; Jepson et al. 2014; Jepson et al. 2015). These numbers would suggest that abundances have been fairly stable, albeit at a depressed level (NWFSC 2015).

The available data on natural-origin spawner abundances for the four populations in the MPG are summarized below in Table 2-25.

Table 2-25. UWR Steelhead DPS natural-origin spawner abundance estimates for the four populations in the MPG [1*, 2].

Year	Molalla River	North Santiam River	South Santiam River	Calapooia River
1997	525	1,919	979	253
1998	1,256	1,970	1,043	358
1999	1,079	2,211	1,748	264
2000	1,898	2,437	1,608	225
2001	1,654	3,375	3,268	446
2002	2,476	3,227	2,282	351
2003	1,707	4,013	2,033	458
2004	1,987	3,863	3,546	684
2005	1,388	1,650	1,519	140
2006	1,433	2,965	1,805	257
2007	1,341	2,863	1,535	245
2008	1,273	2,789	1,534	236
2009	**846**	**351**	192	**36**
2010	**2,120**	1,164	426	**143**
2011	**1,560**	1,418	315	**180**
2012	**1,779**	1,894	327	**278**
2013	**944**	727	286	**95**
2014	**1,126**	1,072	215	**267**
2015	**1,107**	**412**	**828**	**219**
2016	**1,427**	**587**	**949**	**331**

[1] Non-bold data available at: http://odfwrecoverytracker.org/explorer/
*Date Accessed: October 4, 2017
[2] Bold data from Falcy (2017) available at: http://people.oregonstate.edu/~falcym/WillametteSteelhead.html

Since the 2005 status review, UWR steelhead initially increased in abundance but subsequently declined and current abundance is at the levels observed in the late-1990s, which is down from the levels observed in the early 2000s. Current information on the natural-origin abundance for each population is currently not finalized. While the current available information is reported in Table 2-25, a recent ODFW paper (Falcy 2017) updated abundances for all populations. Falcy (2017) used radio-telemetry data to apportion the Willamette Falls counts into the respective four populations to estimate population abundances from 1985 through 2016. The information in Table 2-25 is updated to reflect this approach where data was previously unavailable. While this information was not available for use in the recent status review, it follows the similar pattern observed in the total counts reported by ODFW for total winter steelhead counts at Willamette Falls, which saw a decline from 2005 through 2009, but then observed increases in counts that stabilized at current levels remaining constant since 2010 to now.

The DPS appears to be at lower risk than the UWR Chinook Salmon ESU, but continues to demonstrate the overall low abundance pattern that was of concern during the 2005 status review (Table 2-26). The elimination of winter steelhead hatchery releases in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity. In 2011 and 2015, a 5-year review for the UWR steelhead concluded that the species should maintain its threatened listing classification (Ford 2011; NWFSC 2015).

Table 2-26. Scores for the key elements (abundance/productivity (A/P), diversity, and spatial structure) used to determine current overall viability risk for UWR steelhead populations (NMFS and ODFW 2011)[1].

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

[1] All populations are in the Western Cascade Range MPG. Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

Recovery strategies outlined in the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (recovery plan) (ODFW 2010b) are targeted on achieving viability criteria identified by the WLC-TRT (McElhany et al. 2003), which are used as the foundation for biological delisting criteria. Though the viability criteria relate to the biological delisting criteria, they are not identical (ODFW 2010b). The most recent status review (NWFSC 2015) determined that none of the populations are meeting their recovery goal (Table 2-27).

Table 2-27. Summary of VSP scores and recovery goals for UWR steelhead populations (NWFSC 2015).*

MPG	Population	Total VSP Score	Recovery Goal
Willamette	Molalla River	3	4
	North Santiam River	3	4

	South Santiam River	3	4
	Calapooia River	2	2

*Summaries taken directly from Figure 98 in (NWFSC 2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. VSP scores represent a combined assessment of population abundance and productivity, spatial structure, and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

Limiting Factors

Understanding the limiting factors and threats that affect the UWR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. The populations in this DPS have experienced long-term declines in spawner abundances, but the underlying cause(s) of these declines is not well understood (NWFSC 2015). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the abundance, productivity, spatial structure, and diversity of the populations in this DPS (NWFSC 2015).

The recovery plan (ODFW 2010b) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 5 of the recovery plan describes the limiting factors on a regional scale and how those factors affect the populations of the UWR Steelhead DPS (ODFW 2010b). Chapter 7 of the recovery plan addresses the recovery strategy and actions for the entire DPS. The recovery plan addresses the topics of:

- Flood control/hydropower management,
- Land management,
- Harvest-related effects,
- Hatchery-related effects,
- Habitat access,
- Impaired productivity and diversity,
- Effects of predation, competition, and disease,
- Impaired growth and survival,
- Physical habitat quality, and
- Water quality.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

In summary, the new information in the 2015 status review (NWFSC 2015) does not indicate a change in the biological risk category of this DPS since the previous reviews in 2011. Although direct biological performance measures for this DPS indicate some progress to date toward meeting its recovery criteria, there is no new information to indicate that its extinction risk has been reduced significantly. The DPS continues to demonstrate a stable overall low abundance pattern. More definitive genetic monitoring of steelhead ascending Willamette Falls in tandem with radio tagging work needs to be undertaken to estimate the total abundance of this DPS (NMFS 2011a; NWFSC 2015).

The release of non-native summer steelhead continues to be a concern. Genetic analysis suggests that there is some level of introgression among native late-winter steelhead and summer steelhead (Friesen and Ward 1999). Accessibility to historical spawning habitat is still limited, especially in the North Santiam River. Much of the accessible habitat in the Molalla River, Calapooia River, and lower reaches of North and South Santiam Rivers is degraded and under continued development pressure. Although habitat restoration efforts are underway, the time scale for restoring functional habitat is considerable (NWFSC 2015).

2.2.2.5 Life-History and Status of the Lower Columbia River Steelhead DPS

On March 19, 1998, NMFS listed the LCR Steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834) and most recently on April 14, 2014 (79 FR 20802). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833).

The DPS includes all naturally spawned anadromous 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 (NWFSC 2015). As explained in NMFS 2005c, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d).

Inside the geographic range of the DPS, 29 hatchery programs are currently operational, of which only 7 are considered part of the ESA-listed DPS description (Table 2-28). In recent years, there were several programs discontinued within the boundary of the DPS, such as the Cowlitz Trout Hatchery Late Winter Steelhead plant in the Tilton and the Hood River Summer Steelhead (Skamania Stock) programs in 2009, the Hood River Summer (ODFW stock #50) Steelhead program in 2011, and the Cowlitz Trout Hatchery Late Winter plants in the Upper Cowlitz and Cispus Rivers in 2012. Most recently, in 2014 the Cowlitz Early Winter Steelhead program was discontinued (Jones Jr. 2015), as well as the East Fork Lewis River (EFLR) Hatchery Summer Steelhead program, the North Toutle Hatchery Summer Steelhead program, the EFLR Skamania Hatchery Winter Steelhead Outplant program (LeFleur 2014). Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, Oregon, and from the Little and Big White Salmon Rivers, Washington.

The LCR Steelhead DPS is composed of 23 historical populations, distributed through two ecological zones, split by summer or winter life history resulting in four MPGs (Table 2-28). There are six summer populations and seventeen winter populations (Figure 2-8).

Table 2-28. LCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA in 1998; updated in 2014.

4 major population groups	23 historical populations
Major Population Group	***Populations***
Cascade summer	Kalama (C), North Fork Lewis, East Fork Lewis (G), Washougal (C)
Gorge summer	Wind (C), Hood
Cascade winter	Lower Cowlitz, Upper Cowlitz (C, G), Cispus (C, G), Tilton, South Fork Toutle, North Fork Toutle (C), Coweeman, Kalama, North Fork Lewis (C), East Fork Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge winter	Lower Gorge, Upper Gorge, Hood (C, G)
Artificial production	
Hatchery programs included in DPS (7)	Kalama River Wild Winter, Kalama River Wild Summer, Hood River Winter (ODFW stock # 50), Cowlitz Trout Hatchery Late Winter, Clackamas Hatchery Late Winter (ODFW stock # 122), Sandy Hatchery Late Winter (ODFW stock # 11), Lewis River Wild Late Winter.
Hatchery programs not included in ESU (22)	Upper Cowlitz River Wild Late Winter, Tilton River Wild Late Winter, Cowlitz Summer, Friends of the Cowlitz Summer, Cowlitz Game and Anglers Summer, North Toutle Summer, Kalama River Summer, Merwin Summer, Fish First Summer, Speelyai Bay Net-Pen Summer, EF Lewis Summer, Skamania Summer, Kalama River Winter, Cowlitz Early Winter, Merwin Winter, Coweeman Ponds Winter, EF Lewis Winter, Skamania Winter, Klineline Ponds Winter, Eagle Creek NFH Winter, Clackamas Summer, Sandy River Summer.

[1] The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (NMFS 2013e).

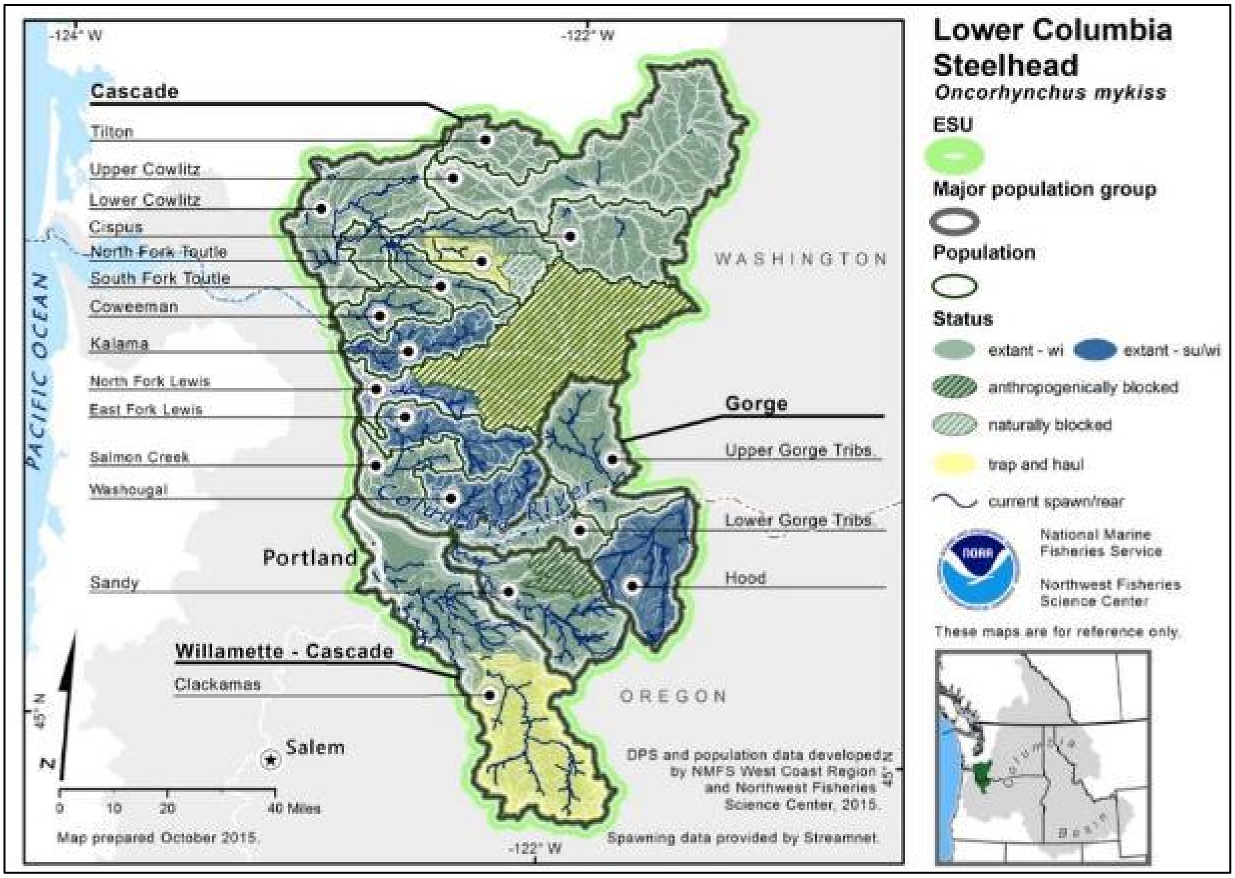


Figure 2-8. Map of populations in the LCR Steelhead DPS (NWFSC 2015).

LCR steelhead exhibit a complex life history. Steelhead are rainbow trout (*O. mykiss*) that migrate to and from the ocean (i.e., anadromous). Resident and anadromous life-history patterns are often represented in the same populations, with either life-history pattern yielding offspring of the opposite form. Steelhead are iteroparous, meaning they can spawn more than once. Repeat spawners are called “kelts” (NMFS 2013e).

LCR basin populations include summer and winter steelhead (Table 2-29). The two life-history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013e). Generally, summer steelhead enter freshwater from May to October in a sexually immature condition, and require several months in freshwater to reach sexual maturity and spawn between late February and early April. Winter steelhead enter freshwater from November to April in a sexually mature condition and spawn in late April and early May. Iteroparity (repeat spawning) rates for Columbia Basin steelhead have been reported as high as 2% to 6% for summer steelhead and 8% to 17% for winter steelhead (Leider et al. 1986; Busby et al. 1996; Hulett et al. 1996).

Historically, winter steelhead were likely excluded from Interior Columbia River subbasins by Celilo Falls. Winter steelhead favor lower elevation and coastal streams. Winter steelhead were historically present in all LCR subbasins and also return to other Columbia River tributaries as far upriver as Oregon’s Fifteenmile Creek.

Table 2-29. Life history and population characteristics of LCR steelhead.

Characteristic	Life-History Features	
	Summer	**Winter**
Number of extant population	10	23
Life history type	Stream	Stream
River entry timing	May-November	November-April
Spawn timing	late February-May	late April-June
Spawning habitat type	Upper watersheds, streams	Rivers and tributaries
Emergence timing	March-July	March-July
Duration in freshwater	1-3 years (mostly 2)	1-3 years (mostly 2)
Rearing habitat	River and tributary main channels	River and tributary main channels
Estuarine use	Briefly in the spring, peak abundance in May	Briefly in the spring, peak abundance in May
Ocean migration	North to Canada and Alaska, and into the N Pacific	North to Canada and Alaska, and into the N Pacific
Age at return	3-5, occasionally 6 years	3-5, occasionally 6 years
Recent natural spawners	1,500	3,500
Recent hatchery adults	2,000	9,000

Steelhead spawn in a wide range of conditions ranging from large streams and rivers to small streams and side channels (Myers et al. 2006). Productive steelhead habitat is characterized by suitable gravel size, depth, and water velocity, and also by complexity that is primarily added in the form of large and small wood (Barnhart 1986). Steelhead may enter streams and arrive at spawning grounds weeks or even months before spawning and therefore are vulnerable to disturbance and predation. They need cover in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects (e.g., logs, rocks), floating debris, deep water, turbulence, and turbidity (Geiger 1973). Their spawn timing must optimize avoiding risks from gravel-bed scour during high stream flows and increasing water temperatures that can become lethal to eggs. Spawning generally occurs earlier in areas of lower elevation, where water temperature is warmer, than in areas of higher elevation, with cooler water temperature.

Depending on water temperature, steelhead eggs may incubate for 35 to 50 days before hatching, and the alevins remain in the gravel 2 to 3 weeks thereafter, until the yolk-sac is absorbed. Generally, fry emergence occurs from March into July, with peak emergence time in April and May. Emergence timing is principally determined by the time of egg deposition and the water temperature during the incubation period. In the LCR, emergence timing differs slightly between winter and summer life-history types and among subbasins (NMFS 2013e). These differences may be a function of spawning location (and hence water temperature) or of genetic differences between life-history types.

Following emergence, fry usually move into shallow and slow-moving margins of the stream. As they grow, they inhabit areas with deeper water, with a wider range of velocities, and larger substrate, and they may move downstream to rear in large tributaries or mainstem rivers. Young steelhead typically rear in streams for some time before migrating to the ocean as smolts.

Steelhead smolts generally migrate at ages ranging from 1 to 4 years with most smolting after 2 years in freshwater (Busby et al. 1996). Smoltification for steelhead has been described by Thorpe (1994) as a ‘‘developmental conflict’’ whereby juvenile steelhead are faced with three distinct possibilities every year: 1) undergo smoltification, followed by migration to the ocean; 2) begin maturation and attempt to spawn as a resident fish in the following winter (precocial residuals); and 3) remain in freshwater (natal streams, other tributaries, or the main channel of large rivers such as the Columbia River, etc.) and revisit these options in the following year (residuals, collectively). These possibilities represent a case of developmental plasticity where adoption of one of these three life-history strategies is initiated through the interplay of phenotypic expression with environmental and biological cues. In the LCR, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May (NMFS 2013e).

Sampling data suggest that juvenile steelhead migrate directly offshore during their first summer, rather than migrating nearer to the coast. Maturing Columbia River steelhead are found off the coast of Northern British Columbia and west into the North Pacific Ocean (Busby et al. 1996). Fin-mark and CWT data suggest that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992). Most steelhead spend 2 years in the ocean (ranging from 1 to 4 years) before migrating back to their natal streams (Shapovalov and Taft 1954; Narver 1969; Ward and Slaney 1988). Once in the river, adult steelhead rarely eat and grow little, if at all.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Steelhead DPS, is at moderate risk and remains at threatened status. Each natural population's baseline and target persistence probabilities are summarized in Table 2-30, along with target abundance for each population that would be consistent with delisting. Persistence probability is measured over a 100 year time period and ranges from very low (probability < 40%) to very high (probability >99%).

Table 2-30. Current status for LCR steelhead populations and recovery scenario targets (NMFS 2013e).

MPG	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution[2]	Target Persistence Probability	Abundance Target[3]
Cascade summer	Kalama (WA)	M	Primary	H	500
	North Fork Lewis (WA)	VL	Stabilizing	VL	--
	EF Lewis (WA)	VL	Primary	H	500
	Washougal (WA)	M	Primary	H	500
Gorge summer	Wind (WA)	H	Primary	VH	1,000
	Hood (OR)	VL	Primary	H*	2,008
Cascade winter	Lower Cowlitz (WA)	L	Contributing	M	400
	Upper Cowlitz (WA)	VL	Primary	H	500

	Cispus (WA)	VL	Primary	H	500
	Tilton (WA)	VL	Contributing	L	200
	South Fork Toutle (WA)	M	Primary	H+	600
	North Fork Toutle (WA)	VL	Primary	H	600
	Coweeman (WA)	L	Primary	H	500
	Kalama (WA)	L	Primary	H+	600
	North Fork Lewis (WA)	VL	Contributing	M	400
	East Fork Lewis (WA)	M	Primary	H	500
	Salmon Creek (WA)	VL	Stabilizing	VL	--
	Washougal (WA)	L	Contributing	M	350
	Clackamas (OR)	M	Primary	H*	10,671
	Sandy (OR)	L	Primary	VH	1,519
Gorge winter	Lower Gorge (WA/OR)	L	Primary	H	300
	Upper Gorge (WA/OR)	L	Stabilizing	L	--
	Hood (OR)	M	Primary	H	2,079

[1] LCFRB (2010) used the late 1990s as a baseline period for evaluating status; ODFW (2010a) assume average environmental conditions of the period 1974-2004. VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan NMFS (2013e).
[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.
[3] Abundance objectives account for related goals for productivity (NMFS 2013e).
* Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

If the recovery scenario in Table 2-30 is achieved, it would exceed the WLC TRT's viability criteria in the Cascade winter and summer MPGs. This is intentional given the scenario for uncertainties about the feasibility of meeting the viability criteria for populations within the Gorge MPGs. Questions remain concerning the historical role of the populations, specifically with the winter populations in the Gorge MPGs, and the current habitat potential (NMFS 2013e).

NMFS (2013e) commented on the uncertainties and practical limits to achieving high viability for the populations in the Gorge MPG. Recovery opportunities in the Gorge were limited by the small numbers of populations and the high uncertainty related to restoration because of Bonneville Dam passage and inundation of historically productive habitats. NMFS recognized the uncertainty regarding the TRT's MPG delineations between the Gorge and Cascade MPG populations, including questions of whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum. As a result, the recovery plan recommends improvements in more than the minimum number of populations required in the Cascade summer and winter MPGs, to provide a safety factor to offset the anticipated shortcomings for the Gorge MPGs. This was considered a more precautionary approach to recovery than merely assuming that efforts related to the Gorge MPG would be successful.

Cascade Summer MPG

There are four summer steelhead populations in the Cascade summer MPG: Kalama River, North Fork Lewis River, East Fork Lewis River, and Washougal River. Migratory access for all anadromous fish in the North Fork Lewis River, including summer steelhead, is blocked by a series of impassable dams and summer-run, as yet, are not being considered as part of any reintroduction program. There is some uncertainty regarding the status of this population, specifically if currently residualized *O. mykiss* present above the dam contain a genetic legacy of the historical population and if they are capable of reinitiating an anadromous life-history (NWFSC 2015).

Summer steelhead have the greatest distribution of the Kalama subbasin populations. The Upper Kalama River Falls at RM 35 is the upstream limit to anadromous fish passage. Prior to the creation of a complete passage barrier at the Kalama Falls Hatchery through installation of the fish ladder in 1936, only summer steelhead are believed to have regularly passed upstream of the Lower Kalama Falls at RM 10 (NMFS 2013e). Only unmarked steelhead are passed upstream of the ladder, where WDFW estimates a pHOS (proportion of hatchery-origin spawners) of 4% (WDFW 2014a). Hatchery summer steelhead trapped at the ladder are released back into the lower Kalama River which re-exposes them to harvest (a practice referred to as “recycling”), and are not included in the pHOS estimate. Since brood year 1997, Kalama Falls Hatchery trap counts indicate a high of 817 summer steelhead in 2003, after which annual returns dropped below 440 fish each brood year from 2005 to 2009 (Table 2-31).

Table 2-31. Total Cascade summer MPG steelhead natural-origin spawner abundance estimates in the LCR, 1997-2015 (WDFW SCoRE[1])*.

Brood Year	Trap count	Snorkel Surveys	
	Kalama River	East Fork Lewis River	Washougal
1997	602	197	148
1998	182	141	120
1999	220	139	135
2000	140	229	140
2001	286	271	184
2002	454	440	404
2003	817	910	607
2004	549	425	n/a
2005	435	673	608
2006	387	560	636
2007	361	412	681
2008	237	365	755
2009	308	800	433

2010	370	600	787
2011	534	1,036	n/a
2012	646	1,084	842
2013	738	1,059	n/a
2014	400	617	544
2015	814	843	783
2016	868	824	624

[1] Online at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead
* Date Accessed: October 4, 2017

The East Fork Lewis summer steelhead population is targeted for the largest improvement within the Cascade summer steelhead MPG. Mid-July snorkel index escapement surveys have been conducted in the East Fork Lewis (HSRG 2009; NWFSC 2015), and indicate 2003, 2011, 2012, 2013 and 2015 as the only years that WDFW's established escapement goal of 814 adults spawning was exceeded for this population (Table 2-31). From 2005 to 2009 an average of 562 adult steelhead have been observed spawning, and the spawning population is reported to have the highest pHOS estimate, 35%, for any summer steelhead population in the LCR Steelhead DPS (LCFRB 2010).

According to the most recent status review in 2015, long and short term trends for the Kalama, East Fork Lewis, and Washougal populations are positive, and absolute abundances have been in the hundreds of fish. The most recent surveys (2014) indicate a drop in abundance for all three populations. Whether this is a portent of changing oceanic conditions is not clear, but it is of some concern regardless of its cause (NWFSC 2015).

Washougal summer steelhead abundance estimates show a recent increasing trend (Table 2-31). From 2005 to 2009, snorkel surveys indicate an average of just over 600 annual summer steelhead adults spawning in the Washougal River, or roughly 50% of WDFW's established 1,210 escapement goal. Spawning occurs throughout the Washougal Basin, extending to the mainstem Washougal and tributaries upstream of Dougan Falls (RM 21), the Little Washougal, and the North Fork Washougal.

There are no adequate abundance trend data for the North Fork Lewis summer steelhead population. The North Fork Lewis summer steelhead population likely has low numbers of natural-origin returns (NORs) because of loss of habitat access related to Merwin Dam, ongoing hatchery programs that produce summer steelhead for harvest, and the WDFW's desire not to interfere with winter steelhead recovery efforts in the upper North Fork Lewis. Recovery efforts for summer steelhead in the North Fork Lewis River are likely to occur below Merwin Dam (NMFS 2013e). Summer steelhead counts at the Merwin Dam Fish Collection Facility have remained below 100 NOR steelhead for the past 12 years (Table 2-32). Current spawning is in the lower North Fork Lewis River and tributaries (most notable is Cedar Creek) below Merwin Dam (NMFS 2007a).

Table 2-32. Summer steelhead trapped at Merwin Dam Fish Collection Facility (Personal comm., Kinne 2016).

Year[1]	Hatchery-Origin		Natural-origin	
	Trapped	Released back to stream	Trapped	Released back to stream
2003	8,342	7,240	51	51
2004	12,597	9,207	90	90
2005	9,082	6,894	71	68
2006	9,370	6,818	49	48
2007	3,902	2,549	39	39
2008	6,689	5,857	18	18
2009	6,624	4,407	17	17
2010	9,116	6,642	13	12
2011	2,401	1,453	15	15
2012	3,683	3,065	8	8
2013	455	244	16	16
2014	8,211	6,104	14	14
2015	4,103	2,820	24	24

[1]Before 2003 mark status of adult returns were not collected.

Gorge Summer MPG

The Wind River and Hood River are the two natural populations in this MPG. Hood River summer-run steelhead have not been monitored since the last status review in 2011 (Ford 2011); efforts are currently underway to provide accurate estimates of fish ascending the west fork of the Hood River. Adult abundance in the Wind River remains stable, but at a low level (hundreds of fish; Table 2-33). In addition, there is a catch and release fishery that allows targeting natural-origin summer steelhead in the Wind River; but in the Hood River, estimates for encounters and incidental mortality from fisheries are not currently available. Given the presence of only two summer-run populations, and only one is still currently monitored in this MPG (Table 2-33), the overall status of the MPG is uncertain (NWFSC 2015).

Table 2-33. Total Gorge summer MPG steelhead natural-origin spawner abundance estimates in the LCR, 1997-2015.

Brood Year	Wind River (WA)[1 a *]	Hood River (OR)[2 *]
1997	734	179
1998	320	65
1999	323	98
2000	218	147
2001	486	180
2002	690	414
2003	1,113	543
2004	893	182
2005	600	152
2006	658	170

2007	766	169
2008	638	120
2009	605	280
2010	766	41
2011	1,497	n/a
2012	815	n/a
2013	760	n/a
2014	281	n/a
2015	577	n/a
2016	1,013	n/a

[1] online at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead
[2] online at: http://odfwrecoverytracker.org/explorer/species/Steelhead/run/summer/esu/205/206/
[*] Date Accessed: October 4, 2017
[a] Data since 2000 are based on jumper estimates at Shipherd Falls and are considered preliminary estimates.

The Wind River population has a high baseline persistence probability and is targeted for very high persistence. The smolt yield trend has been increasing, and the adult escapement exceeded the escapement goal of 957 in 2003, 2011, and 2016 (Table 2-33). Baseline abundance and productivity of the Wind River summer steelhead population are the highest in the DPS; however, improvements in diversity will be needed in the population to meet recovery objectives (NMFS 2013).

Cascade Winter MPG

This MPG includes natural-origin winter-run steelhead in 14 populations from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and, in general, are correlated with cyclical changes in ocean conditions. For most populations, total abundances and natural-origin abundances (where available) have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas[9] and Sandy River winter-run steelhead populations, which are exhibiting recent rises in NOR abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (Jacobsen et al. 2014). Abundances in the Tilton and Upper Cowlitz/Cispus rivers are highly variable, in part because juvenile fish passage at dams in the Cowlitz system is highly variable as well as the use of natural-origin adults as broodstock in developing an integrated hatchery stock (NWFSC 2015) which are intercepted prior to reaching the upper tributaries. The most recent total abundance information is provided in Table 2-34.

[9] For the Clackamas River winter steelhead population, the North Fork Dam count provided the longest available data set for statistical analysis. This data set does not include winter steelhead spawning below the dam (for which only a shorter time series based on redd count expansions are available). For 2013 and 2014, total spawners below the dam were 1,831 (85% NOR) and 2,171 (99% NOR), respectively (Jacobsen et al. 2014).

Table 2-34. Total Cascade MPG winter steelhead spawner abundance estimates in the LCR, 1997-2016 (ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCORE[2])*.

Brood Year	Upper Cowlitz[3]	SF Toutle	NF Toutle[4]	Green[5]	Coweeman	EF Lewis	Kalama	Washougal[6]	Clackamas[7]	Sandy[7]
1997	34	388	183	132	108	238	507	92	483	1,253
1998	11	374	149	118	486	376	472	195	473	776
1999	52	562	133	72	198	442	544	294	295	816
2000	215	490	238	124	530	n/a	921	n/a	745	741
2001	295	348	185	192	384	377	1,042	216	1,489	902
2002	766	640	328	180	298	292	1,495	286	2,324	1,031
2003	523	1,510	410	438	460	532	1,815	764	2,049	584
2004	296	1,212	249	256	722	1,298	2,400	1,114	5,181	796
2005	280	520	166	222	370	246	1,982	320	1,559	563
2006	544	656	300	592	372	458	1,733	524	1,164	569
2007	622	548	155	410	384	448	1,011	632	1,208	782
2008	517	412	96	554	722	548	742	732	472	n/a
2009	513	498	89	610	602	688	1,044	418	622	n/a
2010	614	274	252	256	528	336	961	232	2,175	1,498
2011	627	210	170	246	408	308	622	204	1,242	527
2012	580	378	207	266	256	272	1,061	306	2,733	357
2013	343	972	123	430	622	488	811	678	2,427	3,509
2014	24	708	277	310	496	414	948	388	3,404	3,249
2015	151	1,340	618	922	940	678	1,206	648	3,740	4,670
2016	n/a	1,532	326	816	886	984	1,203	636	4,144	5,488

[1]Online at: http://www.odfwrecoverytracker.org/explorer/species/Steelhead/run/winter/esu/223/225/

* Date Accessed: October 4, 2017

[2]Online at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead

[3] Does not include transports to the Tilton River.

[4] Trap counts from the North Toutle Fish Collection Facility represent a census count of the natural-origin steelhead hauled above the Sediment Retention Structure and released into the upper NF Toutle River.

[5] Data are total escapement estimates for the Green River (NF Toutle River tributary) based on expansion of redd counts from mainstem and tributary index areas, including Devils Creek, Cascade Creek and Elk Creek (WDFW 2014c). Data from 1997-2004 are a proportion value, and data from 2005-2015 are total natural spawners

[6] Data from 1997-2004 were collected with aerial flight counts and AUC, and data from 2005-2015 are based on redd count expansion.

[7]Natural-origin spawners.

Within the Cascade winter steelhead MPG, 10 of 14 historical natural populations are targeted for at least high persistence probability. These include the two genetic legacy populations and six core populations (i.e., those that were historically the most productive). One of these, the Clackamas population, is targeted to move from medium to high persistence probability, but ODFW notes that achieving this target status is unlikely because the level of tributary habitat improvement needed is considered infeasible (ODFW 2010a). The sixth core population in this MPG, the North Fork Lewis, is targeted for medium persistence probability. In this stratum, only the Salmon Creek population, occurring in a highly urbanized subbasin, is expected to remain at its baseline persistence probability of very low.

The Cowlitz Basin holds half of all populations in the Cascade winter steelhead MPG. WDFW has not monitored the mainstem Cowlitz at a population scale, so there is very little abundance data currently available. The same is true for the majority of the Upper Cowlitz populations, including the Tilton and Cispus winter steelhead populations. These populations were not historically monitored for and did not have escapement goals established. This is likely due to escapement goals only existing for six populations within this MPG (Coweeman at 1,064, South Fork Toutle at 1,058, North Fork Toutle/Green at 1,100, East Fork Lewis at 204, Washougal at 814, and Kalama at 1,000), as most populations without previously established escapement goals went unmonitored.

Gorge Winter MPG

This MPG contains three populations, Lower Gorge, Upper Gorge, and Hood River. In both the Lower and Upper Gorge populations, surveys for winter steelhead are very limited. Abundance levels have been low, but relatively stable, in the Hood River population. In recent years, spawners from the integrated hatchery program have constituted the majority of naturally spawning fish (NWFSC 2015). The most recent total abundance information for the Hood River winter steelhead population is provided in Table 2-35. The total winter steelhead return to Hood River has numbered in the hundreds in recent years, but has been extremely variable. There are no adequate abundance trend data for the Lower Gorge winter steelhead population.

Table 2-35. Total Gorge winter MPG steelhead spawner abundance estimates in the LCR, 2001-2016 (ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCoRE[2])*.

Year	Hood River[1]	Upper Gorge (Wind River)[2,3]
2001	877	49
2002	950	47
2003	654	25
2004	507	26
2005	273	20
2006	342	21
2007	423	11
2008	264	6
2009	170	18

2010	568	28
2011	271	16
2012	653	19
2013	312	17
2014	177	5
2015	1,233	10
2016	n/a	4

[1] online at: http://www.odfwrecoverytracker.org/explorer/species/Steelhead/run/winter/esu/223/226/
[2] online at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead
[*] Date Accessed: October 4, 2017
[3] Wind River subpopulation. Trap count data for Winter Steelhead on Wind River near Shipherd Falls

Prior to the removal of Powerdale Dam, the Hood River winter steelhead stock hatchery adults were passed above Powerdale Dam in numbers not exceeding a 50:50 ratio between the wild and hatchery components of the winter run. The estimated number of winter steelhead smolts annually migrating downstream from 1994 to 2004 ranged from 4,271 to 22,538 with a carrying capacity estimate of 16,970 (Olsen 2003).

Of the three populations in the Gorge winter steelhead stratum, two—the Lower Gorge and the Hood River (both of which are a core and a genetic legacy population)—are targeted for high persistence probability. The third, the Upper Gorge, is designated as stabilizing and is expected to remain at its low baseline status because of questions about the historical role of the population and current habitat potential.

In the Hood River subbasin, Oregon installed a floating weir to remove stray hatchery winter steelhead and to implement a sliding scale for take of wild winter steelhead broodstock for an integrated hatchery program. In the Lower Gorge, ODFW proposes to investigate placing a new weir and trap to sort hatchery-origin winter steelhead from natural-origin winter steelhead migrating upstream on Eagle Creek, Tanner Creek, or both. There are currently no hatcheries or winter steelhead releases in the Washington Lower Gorge tributaries (NMFS 2013e).

Summary

Spatial structure for LCR steelhead has largely been maintained for most populations in the DPS (NMFS 2013e). This means that returning adults can access most areas of historical habitat. Except for the North Fork Lewis subbasin, where dams have impeded access to historical spawning habitat, most summer steelhead populations continue to have access to historical production areas in forested, mid- to-high-elevation subbasins that remain largely intact. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations, passage to upper basin habitat is partially or entirely blocked by dams (LCFRB 2010; ODFW 2010a); the Upper Gorge winter population is constrained by hatchery weirs, and the Hood River winter population is constrained by the presence and operation of an irrigation dam. However, steelhead distribution has been partially restored in the Upper Cowlitz, Cispus, and Tilton subbasin by trapping and transferring adults and juveniles around impassable dams (NMFS 2013e).

Historical hatchery effects, and ongoing hatchery straying have reduced genetic diversity and productivity in both summer and winter LCR steelhead populations (NMFS 2013e). For summer populations, the Hood River population has the highest pHOS at 53% (ODFW 2010a). The (LCFRB 2010) reported that the highest pHOS rate among the Washington populations was 35% for the East Fork Lewis, and modeled estimates of current production in the LCR indicate pHOS estimates as high at 51% in the Cowlitz River for winter steelhead (WDFW 2014b), Attachment 3).

The methods and results for categorizing spatial distribution from the LCFRB (2010) Plan for LCR steelhead populations are reported in Appendix B of NMFS' recovery plan and summarized with updates from (NWFSC 2015) below in Table 2-36. This overview suggests that risk related to diversity is higher than that for spatial structure (Table 2-37).

Table 2-36. Summary of VSP scores and recovery goals for LCR steelhead populations (NWFSC 2015) (NWFSC 2015).*

Strata	State	Population	Total VSP Score	Recovery Goal
Cascade Summer	WA	Kalama	2	3
	WA	North Fork Lewis	0.5	0.5
	WA	EF Lewis	0.5	3
	WA	Washougal	2	2
Gorge Summer	WA	Wind	3	4
	OR	Hood	0	3
Cascade Winter	WA	Lower Cowlitz	1	2
	WA	Cispus	0.5	3
	WA	Tilton	0.5	1
	WA	South Fork Toutle	2	3.5
	WA	North Fork Toutle	0.5	3
	WA	Coweeman	1	3
	WA	Kalama	1	3.5
	WA	North Fork Lewis	0.5	2
	WA	East Fork Lewis	2	3
	WA	Salmon Creek	0.5	0.5
	WA	Washougal	1	2
	OR	Clackamas	2	3
	OR	Sandy	1	4
Gorge Winter	WA/OR	Lower Gorge	1	3
	WA/OR	Upper Gorge	1	1
	OR	Hood	n/a	n/a

* Summaries taken directly from Figures 75 and 76, in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. VSP scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

The estimated changes in VSP status for steelhead populations in Table 2-36 indicate that a total of 5 out of 22 populations are at or near their recovery viability goals, although only two of these populations had scores above 2.0 under the recovery plan scenario. The remaining populations generally require substantial improvements to reach their viability goals (NWFSC 2015).

Table 2-37 displays the abundance, productivity, spatial structure, diversity, and overall persistence probability for LCR steelhead, organized by individual populations. It is likely that genetic and life-history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 are considered to have a "low" or "very low" probability of persisting over the next 100 years, and six populations have a "moderate" overall persistence probability. All four strata in the DPS fall short of the WLC-TRT criteria for viability (NWFSC 2015).

Baseline persistence probabilities were estimated to be "low" or "very low" for three out of the six summer steelhead populations that are part of the LCR Steelhead DPS, moderate for two, and high for one – the Wind River, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have "low" or "very low" baseline probabilities of persistence, and the remaining four are at "moderate" probability of persistence (Table 2-37) (NWFSC 2015).

Table 2-37. LCR steelhead populations, and scores for the key elements (abundance/productivity (A/P), spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013e)[1].

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

[1]Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

Figure 2-9 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for Oregon populations (ODFW 2010b; Ford 2011). The results indicate low to moderate spatial structure and diversity risk for all but two populations. The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR steelhead populations in Oregon. Risk is characterized as high or very high for three populations and moderate for the remaining populations. For populations other than Sandy, less than 5% of historical habitat has been lost for Oregon populations, indicating spatial structure for Oregon populations is a lower risk factor ((NMFS 2013e, Appendix A).

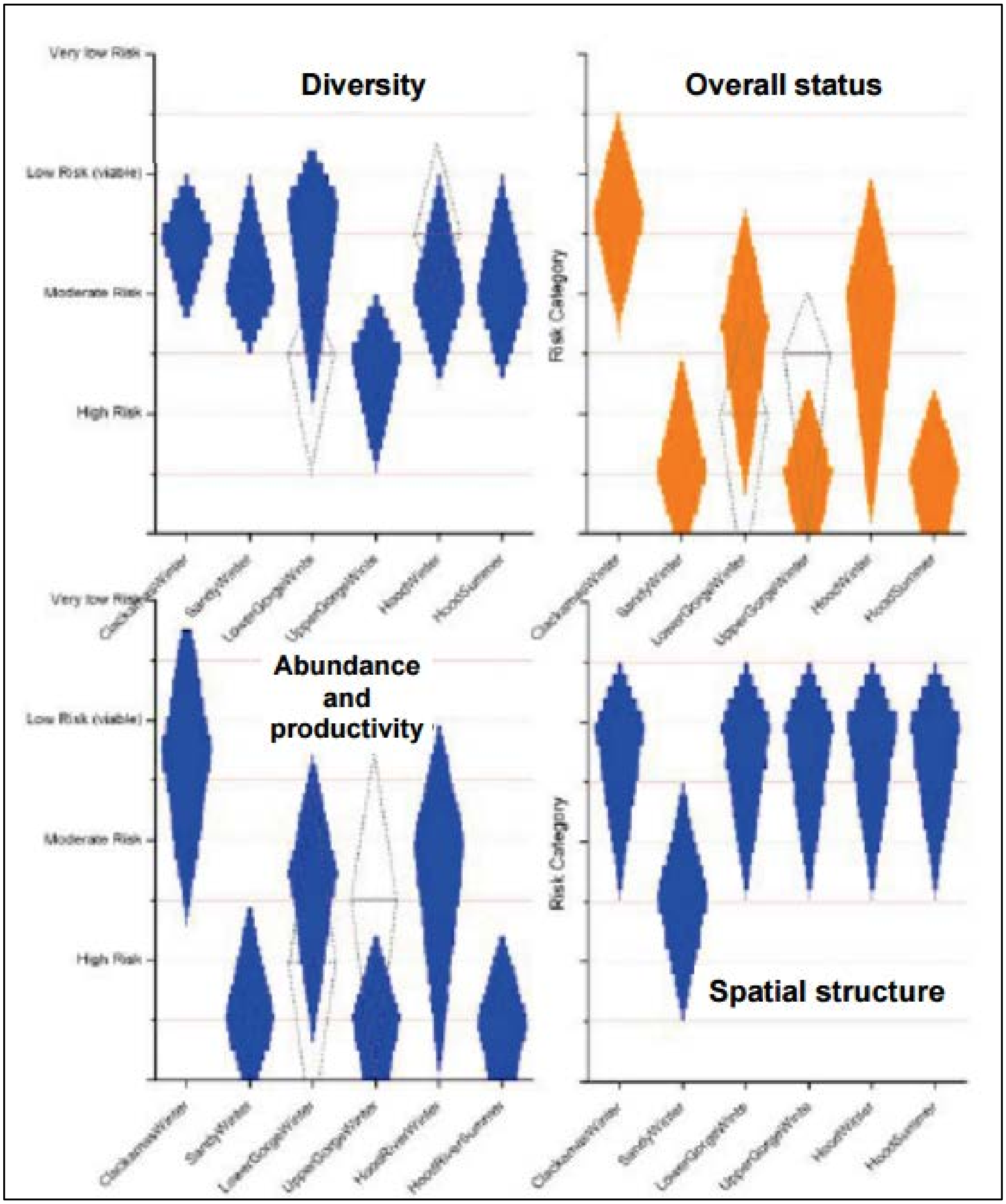


Figure 2-9. Extinction risk ratings for LCR steelhead populations in Oregon for the assessment

attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combined the three attributes (Ford 2011).

The most recent status review (NWFSC 2015) concluded that the majority of winter and summer steelhead populations continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to the prior review in 2011. The decline in the Wind River summer population is a concern, given that this population has been considered one of the healthiest of the summer populations; however, the most recent abundance estimates suggest that the decline was a single year aberration. Efforts to provide passage above dams in the North Fork Lewis River offer the opportunity for substantial improvements in the winter steelhead population and the only opportunity to re-establish the summer steelhead population. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the LCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The recovery plan consolidates the information regarding limiting factors and threats for the LCR Steelhead DPS available from various sources (NMFS 2013e).

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the plan describes limiting factors on a regional scale and how they apply to the four listed species from the LCR considered in the plan. Chapter 9 of the plan discusses the limiting factors that pertain specifically to LCR steelhead with details that apply to the winter and summer populations and MPGs in which they reside. The discussion of limiting factors in Chapter 9 is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Chapter 4 includes additional details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. However, summarizing the recovery plan's discussion of the threat hatchery induced selection poses to LCR steelhead indicates population-level effects of hatchery fish interbreeding with natural-origin fish was a primary limiting factor that we expect to reduce greatly in the near future by NMFS adopting and WDFW implementing terms and conditions from its opinion evaluating Mitchell Act funding criteria (NMFS 2017j) which terminated out-of-DPS releases of hatchery steelhead inside this DPS's geographic range. While the low to very low baseline persistence probabilities of most LCR steelhead populations reflect low productivity, abundance is improving, and it's likely that genetic and life-history diversity have been reduced as a result of pervasive hatchery effects and population bottlenecks (NMFS 2013e), but this will be alleviated by switching to hatchery broodstocks whose genetic origins are from those in the LCR (NMFS 2017j).

2.2.2.6 Life-History and Status of the Columbia River Chum Salmon ESU

On March 25, 1999, NMFS listed the Columbia River Chum Salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014. Critical habitat was designated on September 2, 2005 (70 FR 52746).

Inside the geographic range of the ESU, four hatchery chum salmon programs are currently operational. Table 2-38 lists these hatchery programs, with three included in the ESU and one excluded from the ESU. As explained by NMFS (2005d), genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS (NMFS 2005d).

Table 2-38. Columbia River Chum Salmon ESU description and MPGs. The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (McElhany et al. 2003; Myers et al. 2006; NMFS 2013e).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014.
3 major population groups	17 historical populations
Major Population Group	***Populations***
Coast	Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamokawa (C), Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Cowlitz-fall (C), Cowlitz-summer (C), Kalama, Lewis (C), Salmon Creek, Clackamas (C), Sandy, Washougal
Gorge	Lower Gorge (C,G), Upper Gorge[1]
Artificial production	
Hatchery programs included in ESU (3)	Chinook River/Sea Resources Hatchery, Grays River, Washougal Hatchery/Duncan Creek
Hatchery programs not included in ESU (1)	Big Creek Hatchery

[1] Includes White Salmon population.

The ESU includes all naturally spawning populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, along with the hatchery chum salmon described in

Table 2-38. This ESU is comprised of three MPGs that has 17 natural populations (Table 2-38). Chum salmon are primarily limited to the tributaries downstream of Bonneville Dam and the majority of the fish spawn in Washington tributaries of the Columbia River (Figure 2-10).

Table 2-39. Current status for Columbia River chum salmon populations and recommended status under the recovery scenario (NMFS 2013e).

Major Population Group	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution	Target Persistence Probability[2]	Abundance Target[3]
Coast	Youngs Bay (OR)	VL	Stabilizing	VL	<500
	Grays/Chinook (WA)	M	Primary	VH	1,600
	Big Creek (OR)	VL	Stabilizing	VL	<500
	Elochoman/Skamokawa (WA)	VL	Primary	H	1,300
	Clatskanie (OR)	VL	Primary	H	1.000
	Mill/Abernathy/Germany (WA)	VL	Primary	H	1,300
	Scappoose (OR)	VL	Primary	H	1,000
Cascade	Cowlitz – fall (WA)	VL	Contributing	M	900
	Cowlitz – summer (WA)	VL	Contributing	M	900
	Kalama (WA)	VL	Contributing	M	900
	Lewis (WA)	VL	Primary	H	1,300
	Salmon Creek (WA)	VL	Stabilizing	VL	--
	Clackamas (OR)	VL	Contributing	M	500
	Sandy (OR)	VL	Primary	H	1,000
	Washougal (WA)	VL	Primary	H+	1,300
Gorge	Lower Gorge (WA/OR)	H	Primary	VH	2,000
	Upper Gorge (WA/OR)	VL	Contributing	M	900

[1] VL=very low, L=low, M=moderate, H=high, VH = very high. These are adopted in the recovery plan.

[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.

[3] Abundance objectives account for related goals for productivity.

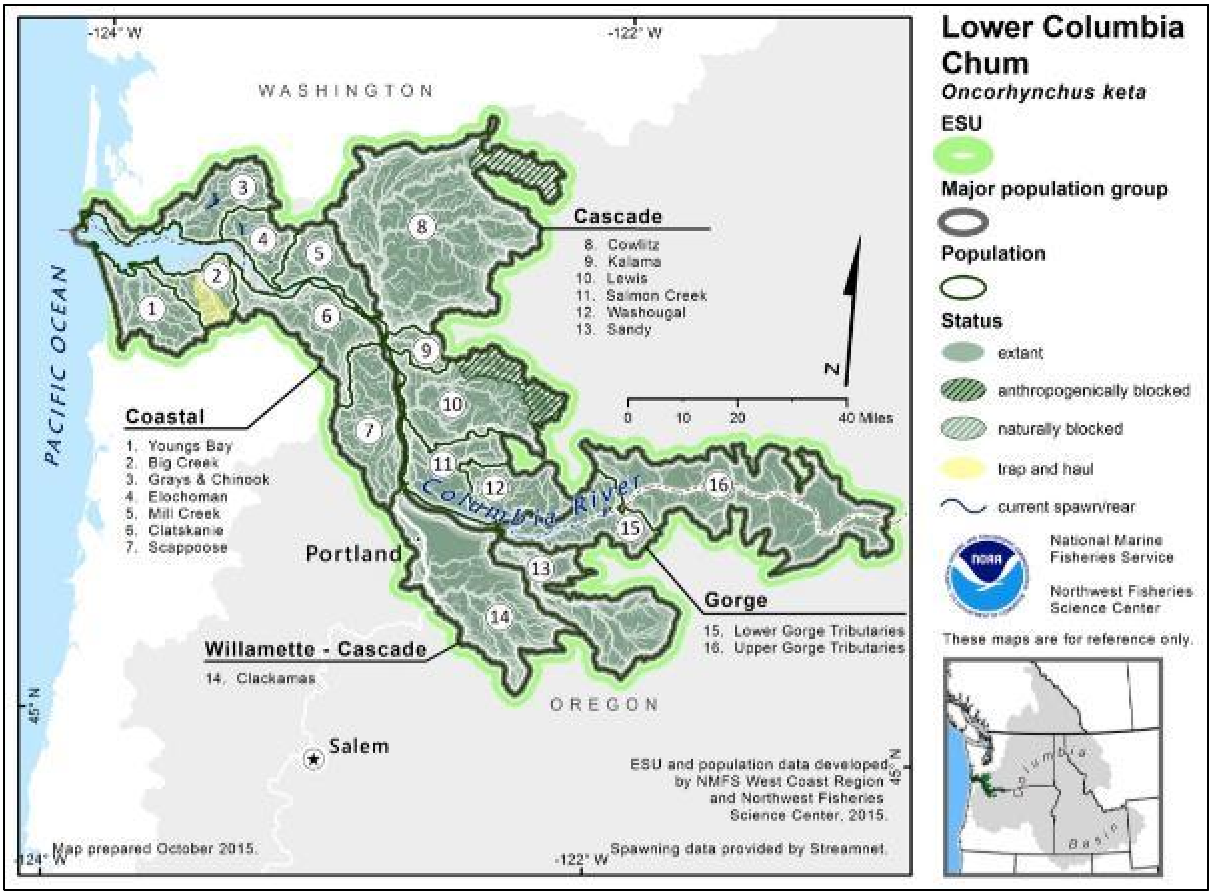


Figure 2-10. Map of the Columbia River Chum Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Columbia River chum salmon are classified as fall-run fish, entering freshwater from mid-October through November and spawning from early November to late December in the lower mainstems of tributaries and side channels. There is evidence that a summer-run chum salmon population returned historically to the Cowlitz River, and fish displaying this life history are occasionally observed there. The recovery scenario currently includes this as an identified population in the Cascade MPG (Table 2-38). Historically, chum salmon had the widest distribution of all Pacific salmon species, comprising up to 50% of annual biomass of the seven species, and may have spawned as far up the Columbia River drainage as the Walla Walla River (Nehlsen et al. 1991). Chum salmon fry emerge from March through May (LCFRB 2010), typically at night (ODFW 2010a), and are believed to migrate promptly downstream to the estuary for rearing. Chum salmon fry are capable of adapting to seawater soon after emergence from gravel (LCFRB 2010). Their small size at emigration is thought to make chum salmon more susceptible to predation mortality during this life stage (LCFRB 2010).

Given the minimal time juvenile chum salmon spend in their natural streams, the period of estuarine residency appears to be a critical phase in their life history and may play a major role in determining the size of returning adults (NMFS 2013e; 2013f). Chum and ocean-type Chinook salmon usually spend more time in estuaries than do other anadromous salmonids—weeks or months, rather than days or weeks (NMFS 2013e; 2013f). Shallow, protected habitats, such as salt marshes, tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon during estuarine residency (LCFRB 2010).

Juvenile chum salmon rear in the Columbia River estuary from February through June before beginning long-distance ocean migrations (LCFRB 2010). Chum salmon remain in the North Pacific and Bering Sea for 2 to 6 years, with most adults returning to the Columbia River as 4-year-olds (ODFW 2010a). All chum salmon die after spawning once.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Columbia River Chum Salmon ESU, is at high risk and remains at threatened status. Each Columbia River chum salmon natural population baseline and target persistence probability is summarized in Table 2-39 along with target abundance for each population that would be consistent with delisting criteria. Persistence probability is measured over a 100 year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

Over the last century, Columbia River chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year (NMFS 2013e). Of the 17 natural populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low, extirpated, or nearly so (Ford 2011; NMFS 2013e; NWFSC 2015). The Grays River and Lower Gorge populations showed a sharp increase in 2002 for several years, but have since declined back to relatively low abundance levels in the range of variation observed over the last several decades. The abundance targets in Table 2-39 for Oregon populations are minimum abundance thresholds (MATs) because Oregon lacked sufficient data to quantify abundance targets. MATs are a relationship between abundance, productivity, and extinction risk based on specific assumptions about productivity; more information about MATs can be found in McElhany et al. (2006).

Currently almost all natural production occurs in just two populations: the Grays/Chinook Rivers and the Lower Gorge area. The most recent total abundance information for Columbia River chum salmon in Washington is provided in Table 2-40, including chum salmon counted passing Bonneville Dam. For the other Washington populations not listed in Table 2-40 and all Oregon populations, there are only occasional reports of a few chum salmon in escapements (NWFSC 2015).

Table 2-40. Peak spawning ground counts for fall chum salmon in index reaches in the LCR, and Bonneville Dam counts 2001-2016 (from WDFW SCORE[1])*.

Return Year	Grays River				Hamilton Creek Total	Hardy Creek	Mainstem Columbia (area near I-205)	Bonneville Count
	Crazy Johnson Creek	Main stem	West Fork Grays	Grays River Total				
2001	1,234	811	2,201	4,246	617	835	n/a	29
2002	2,792	2,952	4,749	10,493	1,794	343	3,145	98
2003	4,876	5,026	5,657	15,559	821	413	2,932	411

2004	1,051	5,344	6,757	13,152	717	52	2,324	42
2005	1,337	1,292	1,166	3,795	257	71	902	139
2006	3,672	1,444	1,129	6,245	478	109	869	165
2007	837	1,176	1,803	3,816	180	12	576	142
2008	992	684	725	2,401	221	3	644	75
2009	968	724	1,084	2,776	216	46	1,118	109
2010	843	3,536	1,704	6,083	594	175	2,148	124
2011	2,133	2,317	5,603	10,053	867	157	4,801	50
2012	3,363	1,706	2,713	7,782	489	75	2,498	65
2013	1,786	1,292	1,754	4,832	647	56	1,364	167
2014	1,380	1,801	1,078	4,259	922	108	1,387	122
2015	3,856	992	6,009	10,857	1,662	350	4,757	176
2016	5,790	6,019	18,599	30,048	1,597	354	5,062	47

[1] online at https://fortress.wa.gov/dfw/score/score/species/chum.jsp?species=Chum
*Date Accessed: October 10, 2017.

The methods and results for categorizing spatial distribution from the LCFRB (2010) Plan for Columbia River chum salmon populations are reported in the recovery plan, and updated scores are summarized here in Table 2-41. Under baseline conditions, constrained spatial structure at the ESU level (related to conversion, degradation, and inundation of habitat) contributes to very low abundance and low genetic diversity in most populations, increasing risk to the ESU from local disturbances. Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (LCFRB 2010). Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. This overview for chum salmon populations suggests that risks related to diversity are higher than those for spatial structure (Table 2-41). The scores generally average between 2 and 3 for spatial structure, and between 1 and 2 for diversity. McElhany et al. (2006) reported the methods used to score the spatial structure and diversity attributes for chum salmon populations in Oregon required more data.

Table 2-41. Columbia River Chum Salmon ESU populations and scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall net persistence probability of the populations (NMFS 2013e)[1].

MPG		**Spawning Population (Watershed)**	**A/P**	**Diversity**	**Spatial Structure**	**Overall Persistence Probability**
Ecological Subregion	**Run Timing**					
Coast Range	Fall	Youngs Bay (OR)	*	*	*	VL
		Grays/Chinook rivers (WA)	VH	M	H	M
		Big Creek (OR)	*	*	*	VL
		Elochoman/Skamokawa rivers (WA)	VL	H	L	VL
		Clatskanie River (OR)	*	*	*	VL
		Mill, Abernathy and Germany creeks (WA)	VL	H	L	VL
		Scappoose Creek (OR)	*	*	*	VL
	Summer	Cowlitz River (WA)	VL	L	L	VL

Cascade Range	Fall	Cowlitz River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		Lewis River (WA)	VL	H	L	VL
		Salmon Creek (WA)	VL	L	L	VL
		Clackamas River (OR)	*	*	*	VL
		Sandy River (OR)	*	*	*	VL
		Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Fall	Lower Gorge (WA & OR)	VH	H	VH	H
		Upper Gorge (WA & OR)	VL	L	L	VL

[1] Ratings range from low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2013a; 2016).
* No data are available to make a quantitative assessment.

The most recent status review (NWFSC 2015) concluded that only 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these three populations are those that have very low recovery goals of 0 (Table 2-42). The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of natural populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (NWFSC 2015).

Table 2-42. Summary of VSP scores and recovery goals for Columbia River chum salmon populations (NWFSC 2015)[1].

MPG	State	Population	Total VSP Score	Recovery Goal
Coast	OR	Youngs Bay	0	0
	WA	Grays/Chinook	2	4
	OR	Big Creek	0	0
	OR	Clatskanie	0	3
	WA	Elochoman/Skamokawa	0.5	3
	WA	Mill/Abern/Ger	0.5	3
	OR	Scappoose	0	3
Cascade	WA	Cowlitz (fall)	0.5	2
	WA	Cowlitz (summer)	0.5	2
	WA	Kalama	0.5	2
	WA	Lewis	0.5	3
	WA	Salmon Creek	0.5	0
	OR	Clackamas	0	2
	OR	Sandy	0	3
	WA	Washougal	0.5	3.5
Gorge	WA	Lower Gorge	3	4
	WA	Upper Gorge	0	2

[1] Summaries taken directly from Figure 82 in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population

abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

Limiting Factors

Understanding the limiting factors and threats that affect the Columbia River Chum Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. Columbia River chum salmon were historically abundant and were subject to extensive harvest until the 1950s (Johnson et al. 1997; NWFSC 2015). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Columbia River Chum Salmon ESU. Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat including the estuary, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the persistence probability of all populations (NMFS 2013e). Other threats to the species include climate change impacts.

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the recovery plan (NMFS 2013e) describes limiting factors on a regional scale and how they apply to the four listed species from the LCR considered in the plan, including the Columbia River Chum Salmon ESU (NMFS 2013e). Chapter 4 (NMFS 2013e) includes details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Chapter 8 of the recovery plan discusses the limiting factors that pertain to Columbia River chum salmon natural populations specifically and the MPGs in which they reside. The discussion in Chapter 8 (NMFS 2013e) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

2.2.3 Middle River ESUs/DPSs

The Middle Columbia River is generally considered the area upstream of the site of Celilo Falls including all the tributaries flowing into the Columbia River up to Priest Rapids Dam and excluding the Snake River and its tributaries. Here we review the species status affected by the proposed action in this geographical stretch of the Columbia River.

2.2.3.1 Life-History and Status of the Middle Columbia River Steelhead DPS

On March 25, 1999, NMFS listed the MCR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the MCR steelhead was designated on September 2, 2005 (70 FR 52808).

The MCR Steelhead DPS includes naturally spawned anadromous *O. mykiss* originating from below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind River (Washington) and Hood River (Oregon) to and including the Yakima River, excluding the Upper Columbia River tributaries (upstream of Priest Rapids Dam) and the Snake River. Four MPGs, composed of 19 historical populations (2 extirpated), comprise the MCR Steelhead DPS. Inside the geographic range of the DPS, 11 hatchery steelhead programs are currently operational. Seven of these artificial programs are included in the DPS (Table 2-43). As explained by NMFS (2005d), genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

Table 2-43. MCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014.
4 major population groups	19 historical populations (2 extirpated)
Major Population Group	***Populations***
Cascades Eastern Slope Tributaries	Deschutes River Eastside, Deschutes River Westside, Fifteenmile Creek*, Klickitat River*, Rock Creek*
John Day River	John Day River Lower Mainstem Tributaries, John Day River Upper Mainstem Tributaries, MF John Day River, NF John Day River, SF John Day River
Yakima River	Naches River, Satus Creek, Toppenish Creek, Yakima River Upstream Mainstem
Umatilla/Walla Walla Rivers	Touchet River, Umatilla River, Walla Walla River
Artificial production	
Hatchery programs included in DPS (7)	Touchet River Endemic summer, Yakima River Kelt Reconditioning summer (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River summer, Deschutes River summer
Hatchery programs not included in DPS (4)	Lyons Ferry NFH summer, Walla Walla River Release summer, Skamania Stock Release summer, Skamania Stock Release winter

* These populations are winter steelhead populations. All other populations are summer steelhead populations.

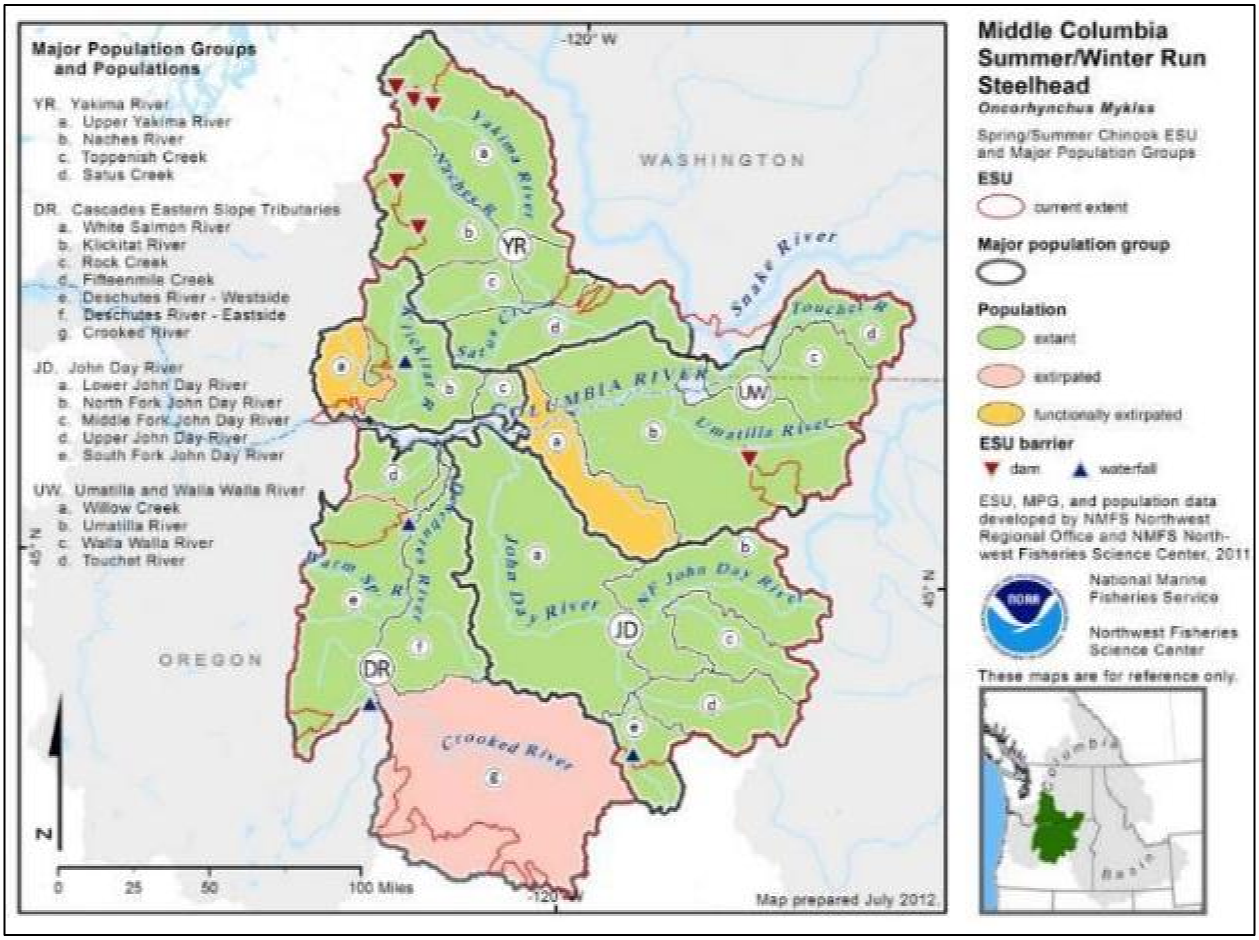


Figure 2-11. Map of the MCR Steelhead DPS's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Steelhead exhibit more complex life history traits than other Pacific salmonid species as discussed in previous steelhead specific DPS sections above (for example see LCR Steelhead DPS Section 2.2.2.5 for general characteristics). While MCR steelhead share these general life history traits, it is worth noting they typically reside in marine waters for two to three years before returning to their natal stream to spawn at four or five years of age (Table 2-44) (NMFS 2011c).

Table 2-44. Key habitat requirements by life stage and time period for steelhead (NMFS 2009).

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Mar-June	Riffles, tail outs, and glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	Mar-June	Riffles, tail outs, and glides are needed for spawning, with sufficient flow for egg and alevin development
Fry Colonization	May-Jul	Shallow, slow velocity areas within the stream channel, often associated with stream margins

Active Rearing	0-age, May-Jul; 1-age, Mar-Oct; 2+ age, Mar-Oct;	Gravel and cobble substrates with sufficient depth and velocity, and boulder/large cobble/wood obstruction to reduce flow and concentrate food
Inactive Rearing	0, 1-age, Oct-Mar	Stable cobble/boulder substrates with interstitial spaces
Migrant	1-age, Mar-June; 2+ age, Mar-June	All habitat types having sufficient flow for free movement of juvenile migrants
Prespawning migrant	Winter, Nov-April; Summer, All	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Prespawning Holding	Winter, Dec-May; Summer, All	Relatively slow, deep-water habitat types typically associated with (or immediately adjacent to) the main channel

The MCR Steelhead DPS includes the only populations of inland winter steelhead in the Columbia River (those populations in the LCR Steelhead DPS and UWR Steelhead DPS that are classified as "winter" are geographically close enough to the Pacific Ocean so as not to be considered inland steelhead). Variations in the migration timing exist between populations. Both summer and winter steelhead occur in British Columbia, Washington and Oregon; Idaho only has summer steelhead; California is thought to have only winter steelhead (Busby et al. 1996). In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April (NMFS 2011c).

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering freshwater, where they may remain up to a year before spawning (Howell et al. 1985); (Olsen et al. 1992). Age-2-ocean steelhead dominate the steelhead run in the Klickitat River, whereas most other rivers with summer steelhead produce about equal numbers of age 1- and 2-ocean fish. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. A non-anadromous form of *O. mykiss* (i.e., rainbow or redband trout) co-occurs with the DPS, which only consists of the anadromous form and its residuals, and juvenile life stages of the two forms can be very difficult to differentiate. In addition, hatchery steelhead are also distributed throughout the range of this DPS (NMFS 2011c).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the MCR Steelhead DPS, is at moderate risk and remains at threatened status. The most recent status update (NWFSC 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis on this DPS. However, this DPS has been noted as difficult to evaluate in several of the reviews for reasons such as: the wide variation in abundance for individual natural populations across the DPS, chronically high levels of hatchery strays into the Deschutes River, and a lack of consistent information on annual spawning escapements in some tributaries (NWFSC 2015).

Many steelhead populations along the West Coast can co-occur with conspecific populations of resident rainbow trout. Previous status reviews (e.g. Ford 2011) have recognized that there may be situations where reproductive contributions from resident rainbow trout could mitigate short-term extinction risk for some steelhead DPS populations (Good et al. 2005). In the MCR Steelhead DPS, a study in the Deschutes River Basin found no evidence of a significant contribution from the very abundant resident form to anadromous returns (Zimmerman and Reeves 2000). A recent study of natural-origin steelhead kelts in the Yakima Basin, comparing chemical patterns in otoliths (i.e., inner ear bones) with water chemistry sampling, found evidence for variable maternal resident contribution rates to anadromous returns, with a high degree of variation among natal areas and across years (Courter et al. 2013; NWFSC 2015).

The productivity of a population (the average number of surviving offspring per parent) is a measure of the natural population's ability to sustain itself. Productivity can be measured as spawner ratios (returns per spawner or recruits per spawner) (or adult progeny to parent), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, typically subject to a high degree of annual variability and sampling-induced uncertainties. The ICTRT recommends estimating current intrinsic productivity using spawner-to-spawner return pairs from low to moderate escapements over a recent 20-year period (NMFS 2009).

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations (Table 2-45) (NMFS 2009).

Table 2-45. Ecological subregions, natural populations, and scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for MCR Steelhead DPS[1].

Ecological Subregions	Population (Watershed)	A/P	Diversity	Integrated SS/D	Overall Viability Risk
Cascade Eastern Slope Tributaries	Fifteenmile Creek	L	L	L	Viable
	Klickitat River	M	M	M	MT
	Eastside Deschutes River	L	M	M	Viable
	Westside Deschutes River	H	M	M	H*
	Rock Creek	H	M	M	H
	White Salmon[2]				E*
	Crooked River[3]				E*
John Day River	Upper Mainstem	M	M	M	MT
	North Fork	VL	L	L	Highly Viable
	Middle Fork	M	M	M	MT
	South Fork	M	M	M	MT
	Lower Mainstem	M	M	M	MT
Walla Walla and Umatilla Rivers	Umatilla River	M	M	M	MT
	Touchet River	M	M	M	H
	Walla Walla River	M	M	M	MT
Yakima River	Satus Creek	M	M	M	Viable (MT)

	Toppenish Creek	M	M	M	Viable (MT)
	Naches River	H	M	M	H
	Upper Yakima	H	H	H	H

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS. Extirpated populations were not evaluated as indicated by the blank cells.
* Re-introduction efforts underway (NMFS 2009).
[2] This population is re-establishing itself following removal of Condit Dam.
[3] This population was designated an experimental population on January 15, 2013 (78 FR 2893)

Limited population abundance data are available for the populations in the MCR Steelhead DPS. Of the 17 populations in this DPS, data on natural-origin spawner abundances for 14 populations is provided below in Table 2-46; such information for the remaining three populations is not available. In the last status review, Ford (2011) summarized that natural-origin and total spawning escapements have increased in the most recent brood cycle, relative to the period associated with the 2005 BRT review, for all four populations in the Yakima River MPG. It is apparent that this trend is continuing through the recent years as well (Table 2-46). The 15 year trend in natural-origin spawners was positive for the West Side Deschutes population, and negative for the East Side Deschutes run (Table 2-46). There is significant tribal and sport harvest associated with the Klickitat steelhead run, with the sport harvest being targeted on hatchery fish (NWFSC 2015). Overall, natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. Natural-origin returns to the Umatilla, Walla Walla, John Day, and Klickitat Rivers have increased over the last several years (Table 2-46).

The most recent status review (NWFSC 2015) revealed that updated information on spawner and juvenile rearing distributions does not support a change in the spatial structure status for the MCR Steelhead DPS natural populations. Status indicators for within population diversity have changed for some populations, although in most cases the changes have not been sufficient to shift composite risk ratings for any particular populations (NWFSC 2015).

In the Cascades Eastern Slope Tributaries MPG, the Fifteen Mile Creek population remains rated at low risk for spatial structure and diversity. Spawning distributions mimic inferred historical patterns, life- history diversity, and phenotypic characteristics are believed to be intact, and adult sampling indicates low contributions from straying out-of-basin hatchery stocks. Additional information obtained from spawner distribution and genetic sampling of the Klickitat River population supports the low risk rating for spatial structure and suggests that the current moderate rating for within population diversity may improve as additional years' data accumulate. The current diversity risk rating of moderate was largely based on uncertainty about effects of the ongoing hatchery program in the basin. Indices for both spatial structure and diversity risk for the Westside Deschutes population remain at moderate risk. The Eastside Deschutes population is rated at low risk for spatial structure. Both populations are rated at moderate risk for diversity based on reductions in life- history diversity as a result of habitat degradation and potential genetic impacts resulting from chronic and widespread hatchery straying from out of basin stocks. Specific information on spawner distribution and composition for the other extant population in this MPG (i.e., Rock Creek population) was available for the first time in the most recent status review. Spawning in this historically small population appears to be dominated by out of basin strays (NWFSC 2015).

The most recent results from spawner surveys and juvenile sampling are consistent with the moderate risk rating assigned to Walla Walla and Umatilla Rivers MPG populations in prior reviews, reflecting the contracted range and the existence of gaps among spawning areas within each population. Diversity risk remains at moderate, with no new information indicating increased life history or phenotypic diversity. Prior reviews have also identified concerns regarding the proportions of out-of-basin hatchery fish contributing to spawning in all three populations, with the highest proportions being observed in the Umatilla River and Touchet River populations. The downward trend in hatchery-origin spawners in the Umatilla River has continued (NWFSC 2015).

Table 2-46. MCR Steelhead DPS natural-origin spawner abundance estimates for the populations with data available (from WDFW SCoRE[1] and ODFW Salmon & Steelhead Recovery Tracker[2])*.

Year	Deschutes River Eastside[2]	Deschutes River Westside[2]	John Day River Lower[2]	John Day River Upper[2]	North Fork John Day River[2]	Middle Fork John Day River[2]	South Fork John Day River[2]	Umatilla River[2]	Walla Walla River[2]	Fifteenmile Creek[2,3]	Klickitat River[1,4]	Naches River[1]	Satus Creek[1]	Toppenish Creek[1]	Yakima Upstream[1]
1997	929	315	911	341	961	436	173	909	439	416	n/a	310	268	233	47
1998	471	369	625	704	978	457	110	769	568	228	n/a	304	348	131	61
1999	1,712	290	1,894	326	1,626	945	103	1,019	419	855	n/a	329	335	201	41
2000	2,510	471	5,524	567	2,143	1,066	263	2,027	772	937	n/a	507	397	434	59
2001	8,637	766	5,544	566	2,235	1,063	526	2,451	1,118	664	n/a	983	645	909	161
2002	5,149	949	7,381	1,599	4,097	3,140	987	3,546	1,746	1,437	n/a	1,454	1,155	1,129	260
2003	3,984	1,284	2,200	771	2,878	1,104	708	2,014	905	836	n/a	709	646	460	133
2004	1,847	516	1,031	415	1,027	723	304	2,001	602	988	n/a	886	567	790	195
2005	1,802	562	516	392	1,674	234	206	1,615	855	352	1,577	1,092	890	801	223
2006	1,000	452	508	148	707	214	269	1,373	825	367	1,751	646	746	260	123
2007	2,071	565	1,449	590	1,264	707	618	2,465	464	196	205	492	521	263	79
2008	1,945	521	840	914	1,241	972	1,142	2,098	675	128	144	976	946	585	190
2009	1,665	329	3,563	732	3,904	2,968	1,756	2,356	862	395	1,290**	1,114	1,044	693	216
2010	1,393	913	1,124	736	2,918	2,597	416	3,722	1,623	737	1,111**	2,138	2,751	621	367
2011	1,467	1,195	2,191	1,057	2,890	5,372	910	3,869	1,632	415	2,483**	1,963	2,274	799	364
2012	1,949	563	3,538	1,035	4,588	5,117	2,057	3,122	1,210	557	1,063**	2,203	1,812	667	475
2013	1,303	601	1,121	1,490	2,094	5,248	1,704	2,408	741	290	1,222**	1,683	928	510	334
2014	1,909	569	9,070	1,247	2,190	6,510	1,488	2,600	n/a	513	2,956**	1,506	919	356	423
2015	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	484	1,785	1,093	504	550
2016	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	51	1,409	1,233	295	528

[1] Data available at: https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geoarea=SRR_MiddleColumbia&geocode=srr
*Date accessed: October 4, 2017
[2] Data available at: http://odfwrecoverytracker.org/explorer/species/Steelhead/run/summer/esu/307/
[3] Winter-run count
[4] Estimates combine both summer and winter counts
**Source for 2009-2014 data: TAC (2015). Data are verified using mark-recapture estimates at Lyle Falls.

The spatial structure ratings for all five natural populations in the John Day River MPG remains at low or very low risk based on updated spawner distribution data in the current status review. Habitat conditions, believed to limit life history and phenotypic diversity, remain relatively unchanged. Hatchery straying and occurrence on the spawning grounds for populations within the John Day River MPG has declined considerably in recent years (NWFSC 2015).

Three of the four natural populations in the Yakima River MPG remain at low risk for structure based on results from the recent radio tag and pit tag studies described above. Distribution across spawning areas for the fourth population, the Upper Yakima River population, continues to be substantially reduced from inferred historical levels and is rated at moderate. As with the populations in the Walla Walla and Umatilla MPG, risks due to the loss of life history and phenotypic diversity inferred from habitat degradation (including passage impacts within the Yakima River Basin) remain at prior levels. There are no within-basin hatchery steelhead releases in the Yakima River Basin and outside source strays remain at low levels (NWFSC 2015).

Strategies outlined in the recovery plan (NMFS 2009) and its management unit components are targeted on achieving, at a minimum, the ICTRT biological viability criteria which require that the DPS should "have all four MPGs at viable (low risk) status with representation of all the major life history strategies present historically, and with the abundance, productivity spatial structure, and diversity attributes required for long-term persistence." The plan recognizes that, at the MPG level, there may be several specific combinations of populations that could satisfy the ICTRT criteria. The recovery plan identifies particular combinations that are the most likely to result in achieving viable MPG status. The recovery plan recognizes that the management unit plans incorporate a range of objectives that go beyond the minimum biological status required for delisting the DPS (NWFSC 2015).

Under the ICTRT approach, population level assessments are based on a set of metrics designed to evaluate risk across the four VSP attributes: abundance/productivity (A/P), spatial structure, and diversity (McElhany et al. 2000). The ICTRT approach calls for comparing estimates of current natural-origin abundance (measured as a 10-year geometric mean of natural-origin spawners) and productivity (estimate of return per spawner at low to moderate parent spawning abundance) against predefined viability curves. In addition, the ICTRT developed a set of specific criteria (metrics and example risk thresholds) for assessing the spatial structure and diversity risks based on current information representing each specific population. The ICTRT viability criteria are generally expressed relative to a particular risk threshold—5% risk of extinction over a 100-year period (NWFSC 2015).

The Mid-Columbia Recovery Plan identifies a set of most likely scenarios to meet the ICTRT recommendations for low risk populations at the MPG level. In addition, the management unit plans generally call for achieving moderate risk ratings (maintained status) across the remaining extant populations in each MPG. Table 2-47 shows the most recent abundance, productivity, spatial structure, and diversity metrics for the 17 populations in the DPS. Overall viability ratings for the populations in the MCR Steelhead DPS remained generally unchanged from the prior five year review (). One population, Fifteenmile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its ICTRT minimum abundance threshold. The Toppenish River population (in the Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the 5% viability curve, and, therefore, its overall rating remained as viable (). The majority of the populations showed increases in estimates of productivity (NWFSC 2015).

Table 2-47. Summary of MCR Steelhead DPS status relative to the ICTRT viability criteria, grouped by MPG (NWFSC 2015)[1].

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity 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	
Eastern Cascades MPG								
Fifteen Mile Creek	500	↓ 356 (.16)	↑ 1.84 (.19)	Moderate	Very Low	Low	Low	Maintained
Deschutes (Westside)	1,500 (1,000)	↑ 634 (.13)	↑ 1.16 (.15)	High	Low	Moderate	Moderate	High Risk
Deschutes (Eastside)	1,000	↓ 1,749 (.05)	↑ 2.52 (.24)	Low	Low	Moderate	Moderate	Viable
Klickitat River	1,000			Moderate	Low	Moderate	Moderate	Maintained
Rock Creek	500				Moderate	Moderate	Moderate	High Risk
Crooked River (ext)	2,000							Extirpated
White Salmon R.(ext)	500							Extirpated.
Yakima River MPG								
Satus Creek	1,000 (500)	↑ 1127 (.17)	↑ 1.93 (.12)	Low	Low	Moderate	Moderate	Viable
Toppenish Creek	500	↓ 516 (.14)	↓ 2.52 (.19)	Low	Low	Moderate	Moderate	Viable
Naches River	1,500	↑ 1,244 (.16)	↑ 1.83 (.10)	Moderate	Low	Moderate	Moderate	Moderate
Upper Yakima River	1,500	↑ 246 (.18)	↑ 1.87 (.10)	Moderate	Moderate	High	High	High Risk
John Day River MPG								
Lower John Day Tribs	2,250	↓ 1,270 (.22)	↓ 2.67 (.19)	Moderate	Very Low	Moderate	Moderate	Maintained
Middle Fork John Day	1,000	↑ 1,736 (.41)	↑ 3.66 (.26)	Low	Low	Moderate	Moderate	Viable
North Fork John Day	1,000	↑ 1,896 (.19)	↓ 2.48 (.23)	Very Low	Very Low	Low	Low	Highly Viable
South Fork John Day	500	↑ 697 (.27)	↑ 2.01 (.21)	Low	Very Low	Moderate	Moderate	Viable
Upper John Day	1,000	↑ 641 (.21)	1.32 (.18)	Moderate	Very Low	Moderate	Moderate	Maintained
Umatilla/Walla Walla MPG								
Umatilla River	1,500	↑ 2,379 (.11)	○ 1.20 (.32)	Moderate	Moderate	Moderate	Moderate	Maintained
Walla Walla River	1,000	↓ 877 (.13)	↑ 1.65 (.11)	Moderate	Moderate	Moderate	Moderate	Maintained
Touchet River	1,000	↓ 382 (.12)	↑ 1.25 (.11)	High	Low	Moderate	Moderate	High Risk

[1]Comparison of updated status summary vs. recovery plan viability objectives; upwards arrow=improved since prior review. Downwards arrow=decreased since prior review. Oval=no change. Shaded populations are the most likely combinations within each MPG to be improved to viable status. Current abundance and productivity estimates are expressed as geometric means (standard error) (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the MCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the MCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the viability of natural population in the MCR Steelhead DPS. Historically, extensive beaver activity, dynamic patterns of channel migration in floodplains, human settlement and activities, and loss of rearing habitat quality and floodplain channel connectivity in the lower reaches of major tributaries, all impacted the MCR Steelhead DPS populations (NWFSC 2015).

The recovery plan (NMFS 2009) summarizes information from four regional management unit plans covering the range of tributary habitats associated with the DPS in Washington and Oregon. Each of the management unit plans are incorporated as appendices to the recovery plan, along with modules for the mainstem Columbia hydropower system and the estuary, where conditions affect the survival of steelhead production from all of the tributary populations comprising the DPS. The recovery objectives defined in the recovery plan are all based on the biological viability criteria developed by the ICTRT (NMFS 2011c).

The recovery plan also provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 6 of the recovery plan describes the limiting factors on a regional scale and how they affect the populations in the MCR Steelhead DPS (NMFS 2009). Chapter 7 of the recovery plan addresses the recovery strategy for the entire DPS and more specific plans for individual MPGs within the DPS (NMFS 2009). The recovery plan addresses the topics of:

- Tributary habitat conditions,
- Columbia River mainstem conditions,
- Impaired fish passage,
- Water temperature and thermal refuges,
- Hatchery-related adverse effects,
- Predation, competition, and disease,
- Degradation of estuarine and nearshore marine habitat, and
- Climate change.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

Overall, there have been improvements in the viability ratings for many populations, but the MCR Steelhead DPS, as a whole, is not currently meeting the viability criteria (adopted from the ICTRT) in the Mid-Columbia Steelhead Recovery Plan. In addition, several factors cited by the 2005 BRT remain as concerns or key uncertainties. Natural-origin returns to the majority of the population in two of the four MPGs in this DPS increased modestly relative to the levels reported in the previous five year review. Abundance estimates for 2 of 3 populations with sufficient data in the remaining two MPGs (Eastside Cascades and Walla Walla and Umatilla Rivers) were marginally lower. Natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. In general, the majority of the population level viability ratings remained unchanged from prior reviews for each MPG within the DPS.

2.2.4 Upriver ESUs/DPSs

The Upper Columbia River is generally considered the area upstream of the confluence with and including the Snake River and all the tributaries flowing into the Columbia River upriver. This includes areas upstream of Priest Rapids Dam. Here we review the species status affected by the proposed action in this geographical stretch of the Columbia River.

2.2.4.1 Life-History and Status of the Snake River Fall-Run Chinook Salmon ESU

On June 3, 1992, NMFS listed the Snake River fall-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802). Critical habitat was designated on December 28, 1993 (58 FR 68543).

The Snake River fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). None of the hatchery programs are excluded from the ESU. As explained above by NMFS (2005d), genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see (NMFS 2005d). Table 2-48 lists the natural and hatchery populations included in the ESU.

Table 2-48. Snake River Fall-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014
1 major population groups	2 historical populations (1 extirpated)
Major Population Group	***Population***
Snake River	Lower Mainstem Fall-Run
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry NFH fall, Acclimation Ponds Program fall, Nez Perce Tribal Hatchery fall, Idaho Power fall.
Hatchery programs not included in ESU (0)	n/a

Two historical populations (1 extirpated) within one MPG comprise the Snake River fall-run Chinook Salmon ESU. The extant natural population spawns and rears in the mainstem Snake

River and its tributaries below Hells Canyon Dam. Figure 2-12 shows a map of the ESU area. The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901 and the Hells Canyon Complex from 1958 to 1967, which extirpated one of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River fall-run Chinook salmon since the 1980s (NMFS 2012d). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total exploitation rate has been relatively stable in the range of 40% to 50% since the mid-1990s (NWFSC 2015).

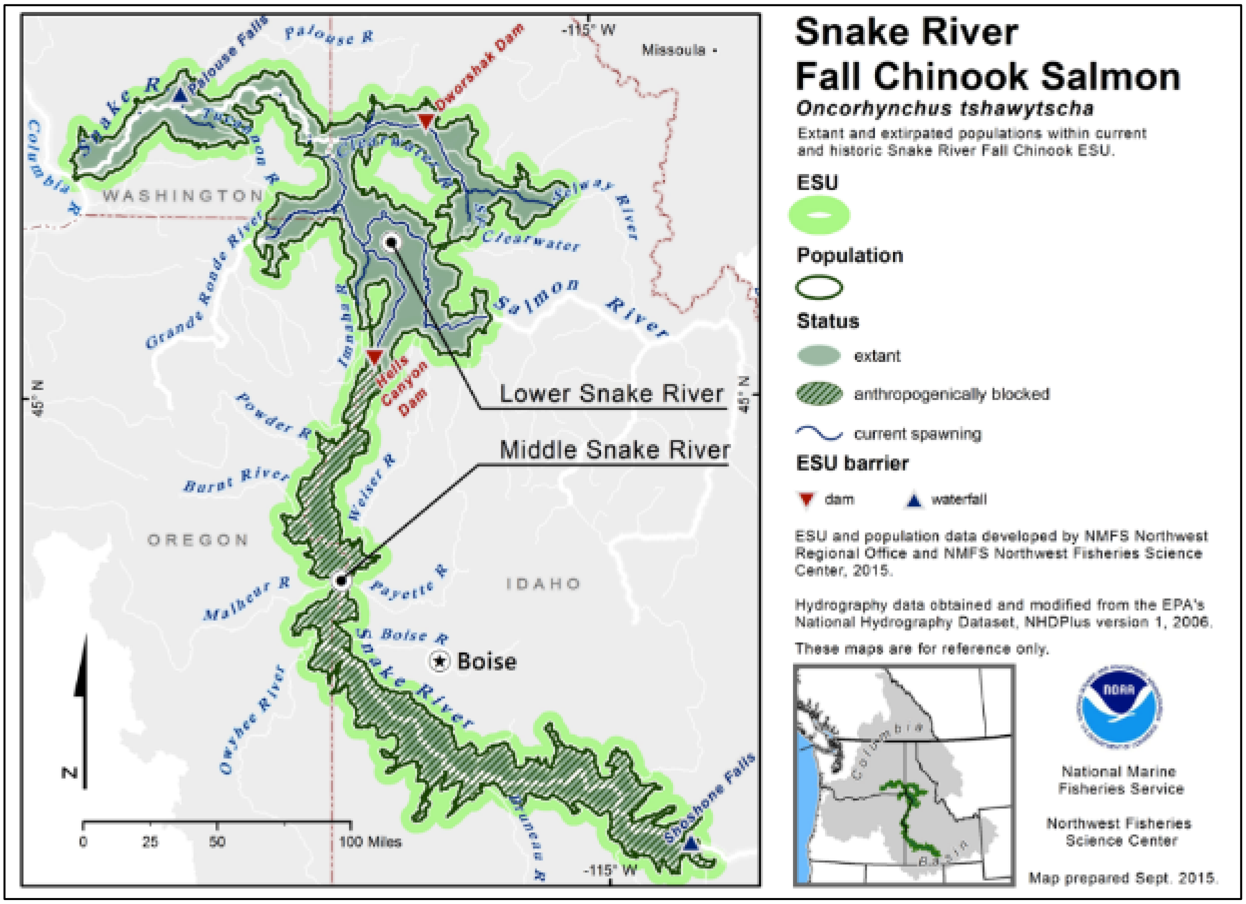


Figure 2-12. Map of the Snake River Fall-Run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Snake River fall-run Chinook salmon spawning and rearing occurs primarily in larger mainstem rivers, such as the Salmon, Snake, and Clearwater Rivers. Historically, the primary fall-run Chinook salmon spawning areas were located on the upper mainstem Snake River (Connor et al. 2005). Now, a series of Snake River mainstem dams block access to the Upper Snake River and about 85% of ESU's spawning and rearing habitat. Swan Falls Dam, constructed in 1901, was the first barrier to upstream migration in the Snake River, followed by the Hells Canyon Complex beginning with Brownlee Dam in 1958, Oxbow Dam in 1961, and Hells Canyon Dam in 1967. Natural spawning is currently limited to the Snake River from the upper end of LGR to Hells Canyon Dam; the lower reaches of the Imnaha, Grande Ronde, Clearwater, Salmon, and

Tucannon rivers; and small areas in the tailraces of the Lower Snake River hydroelectric dams (Good et al. 2005).

Some fall-run Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks and they may be spawning elsewhere. The vast majority of spawning today occurs upstream of LGR, with the largest concentration of spawning sites in the mainstem Snake River (about 60%) and in the Clearwater River, downstream from Lolo Creek (about 30%) (NMFS 2012d).

As a consequence of losing access to historic spawning and rearing sites heavily influenced by the influx of ground water in the Upper Snake River and effects of dams on downstream water temperatures, Snake River fall-run Chinook salmon now reside in waters that may have thermal regimes that differ from those that historically existed. In addition, alteration of the Lower Snake River by hydroelectric dams has created a series of low-velocity pools that did not exist historically. Both of these habitat alterations have created obstacles to Snake River fall-run Chinook salmon survival. Before alteration of the Snake River Basin by dams, Snake River fall-run Chinook salmon exhibited a largely ocean-type life- history, where they migrated downstream during their first-year. Today, fall-run Chinook salmon in the Snake River Basin exhibit one of two life- histories that Connor et al. (2005) have called ocean-type and reservoir-type. Juveniles exhibiting the reservoir-type life-history overwinter in the pools created by the dams before migrating out of the Snake River. The reservoir-type life-history is likely a response to early development in cooler temperatures, which prevents juveniles from reaching a suitable size to migrate out of the Snake River and to the ocean.

Snake River fall-run Chinook salmon also spawned historically in the lower mainstems of the Clearwater, Grande Ronde, Salmon, Imnaha, and Tucannon River systems. At least some of these areas probably supported production, but at much lower levels than in the mainstem Snake River. Smaller portions of habitat in the Imnaha and Salmon Rivers have supported Snake River fall-run Chinook salmon. Some limited spawning occurs in all these areas, although returns to the Tucannon River are predominantly releases and strays from the Lyons Ferry Hatchery (LFH) program (NMFS 2012d).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River fall-run Chinook Salmon ESU, remains at threatened status, which is based on a low risk rating for abundance/productivity, and a moderate risk rating for spatial structure/diversity (NWFSC 2015).

Spawner abundance, productivity, and proportion of natural-origin fish abundance estimates for the Lower Mainstem Snake River population are based on counts and sampling at Lower Granite Dam. Separate estimates of the numbers of adult (age 4 and older) and jack (age 3) fall-run Chinook salmon passing over Lower Granite Dam are derived using ladder counts and the results of sampling a portion of each year’s run using a trap associated with the ladder. A portion of the fish sampled at the trap are retained and used as hatchery broodstock. The data from trap sampling, including the coded-wire tag (CWT) recovery results, passive integrated transponder

(PIT) tag detections, and the incidence of fish with adipose-fin clips, are used to construct daily estimates of hatchery proportions in the run (NWFSC 2015).

At present, estimates of natural-origin returns are made by subtracting estimated hatchery-origin returns from the total run estimates (Young et al. 2012). In the near future, returns from a Parental Based Genetic Tagging (PBT)[10] program will allow for a comprehensive assessment of hatchery contributions and, therefore, a more direct assessment of natural returns and ESU abundance risk (NWFSC 2015).

Sampling methods and statistical procedures used in generating the estimated escapements have improved substantially over the past 10 to 15 years. Beginning with the 2005 return, estimates are available for the total run apportioned into natural and hatchery returns by age (and hatchery-origin) with standard errors and confidence limits (e.g., Young et al. 2012). Current estimates of escapement over Lower Granite Dam for return years prior to 2005 were also based on adult dam counts and trap sampling (Table 2-49). In recent years, naturally spawning fall-run Chinook salmon in the lower Snake River have included both returns originating from naturally spawning parents and from returning hatchery releases (NWFSC 2015). Hatchery-origin fall-run Chinook salmon escaping upstream above Lower Granite Dam to spawn naturally are now predominantly returns from hatchery supplementation program juvenile releases in reaches above Lower Granite Dam and from releases at LFH that have dispersed upstream.

Table 2-49. Escapement data for Snake River fall-run Chinook natural-origin salmon returning to LGR, from 2000-2016 (TAC 2017)*.

Year	Total Unique adult fish Arriving at Lower Granite	Hatchery Adult Sized Fish Arriving at Granite	Natural-origin Adult Sized Fish arriving at Granite
2000	4,036	2,888	1,148
2001	12,793	7,630	5,163
2002	12,297	10,181	2,116
2003	13,963	9,706	4,257
2004	14,984	11,655	3,329
2005	11,670	6,493	5,177
2006	7,807	3,138	4,669
2007	11,186	7,444	3,742
2008	16,200	12,271	3,930
2009	25,262	20,285	4,977
2010	45,335	37,340	7,995
2011	27,714	18,936	8,778
2012	36,338	23,541	12,797

[10] PBT is whereby each parent in a hatchery program, both male and female, are genotyped for polymorphic molecular markers. By genotyping each parent all of their offspring are effectively identifiable, and the method requires no juvenile handling. This allows for assignments back to individual parents when the hatchery releases return as adults wherever they are found, so long as they are genetically sampled.

2013	55,624	34,500	21,124
2014	59,747	45,575	14,172
2015	58,363	42,151	16,212
2016	37,401	27,629	9,772

*Recent years corrected for fallback

Productivity, defined in the ICTRT viability criteria as the expected replacement rate at low to moderate abundance relative to a population's minimum abundance threshold, is a key measure of the potential resilience of a natural population to annual environmentally driven fluctuations in survival. The ICTRT Viability Report (ICTRT 2007) provided a simple method for estimating population productivity based on return-per-spawner estimates for the most recent 20 years. To assure that all sources of mortality are accounted for, the ICTRT recommended that productivities used in interior Columbia River viability assessments be expressed in terms of returns to the spawning grounds. Other management applications express productivities in terms of pre-harvest recruits. Pre-harvest recruit estimates are also available for Snake River fall-run Chinook salmon (NWFSC 2015).

The recently released NMFS Snake River fall-run Chinook Recovery Plan (NMFS 2017m) proposes that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River fall-run Chinook salmon population; the recovery plan notes that such a scenario could be possible if major spawning areas supporting the bulk of natural returns are operating consistent with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning, i.e., low hatchery influence for at least one major natural spawning production area. According to the most recent information available (i.e., redd counts through 2016, (Table 2-50), there is no indication of a strong differential distribution of hatchery returns among major spawning areas, given the widespread distribution of hatchery releases and the lack of direct sampling of reach-specific spawner compositions.

Table 2-50. Fall-run Chinook redd counts in the Snake River Basin, from 2000-2016 (TAC 2017).

Year	Snake River	Clearwater Basin	Asotin Creek[1]	Imnaha River	Grande Ronde River	Salmon River	Total
2000	346	180		9	8	0	543
2001	709	336		38	197	22	1,302
2002	1,113	527		72	111	31	1,854
2003	1,524	571	2	41	91	18	2,247
2004	1,709	631	4	35	161	17	2,557
2005	1,442	487	6	36	129	27	2,127
2006	1,025	526	0	36	42	9	1,638
2007	1,117	718	0	17	81	18	1,951

2008	1,819	965	3	68	186	14	3,055
2009	2,095	1,198	0	36	104	34	3,467
2010	2,944	1,924	35	132	263	8	5,306
2011	2,837	1,621	2	24	154	60	4,698
2012	1,828	1,958	30	85	313	34	4,248
2013	2,667	2,956	53	38	255	31	6,000
2014	2,808	3,118		103	342	42	6,413
2015	3,155	5,082		83	378	142	8,840
2016	1,972	3,731		29	415	35	6,182

[1]Blank cells indicate no survey

In terms of spatial structure and diversity, the Lower Mainstem Snake River fall-run Chinook salmon population was rated at low risk for Goal A (allowing natural rates and levels of spatially mediated processes) and moderate risk for Goal B (maintaining natural levels of variation) in the status review update (NWFSC 2015), resulting in an overall spatial structure and diversity rating of moderate risk (Table 2-51). The moderate risk rating was driven by changes in major life-history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns. In addition, risk associated with indirect factors (e.g., the high levels of hatchery spawners in natural spawning areas, the potential for selective pressure imposed by current hydropower operations, and cumulative harvest impacts) contribute to the current rating level.

The overall current risk rating for the Lower Mainstem Snake River fall-run Chinook salmon population is viable, as indicated by the bold outlined cell in Table 2-51. The single population delisting options provided in the Snake River Fall Chinook Salmon Recovery Plan would require the population to meet or exceed minimum requirements for a risk rating of Highly Viable with a high degree of certainty.

The current rating described above is based on evaluating current status against the criteria for the aggregate population. The overall risk rating is based on a low risk rating for abundance/productivity (A/P) and a moderate risk rating for spatial structure/diversity (SS/D). For abundance/productivity, the rating reflects remaining uncertainty that current increases in abundance can be sustained over the long run. The geometric mean natural-origin fish abundance obtained from the most recent 10 years of annual spawner escapement estimates is 6,418 fish. The most recent status review used the ICTRT simple 20-year recruits per spawner (R/S) method to estimate the current productivity for this population (1990-2009 brood years) and determined it was 1.5. Given remaining uncertainty and the current level of variability, the point estimate of current productivity would need to meet or exceed 1.70, which is the present potential metric for the population to be rated at very low risk. While natural-origin spawning levels are above the minimum abundance threshold of 4,200, and estimated productivity is also high, neither measure is high enough to achieve the very low risk rating necessary to buffer against significant remaining uncertainty (NWFSC 2015).

Table 2-51. Matrix used to assess natural population viability risk rating across VSP parameters for the Lower Mainstem Snake River fall-run Chinook Salmon ESU (NWFSC 2015).[1]

		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk[2]	Very Low (<1%)	HV	HV	V	M
	Low (1-5%)	V	V	V Lower Mainstem Snake R.	M
	Moderate (6 – 25%)	M	M	M	HR
	High (>25%)	HR	HR	HR	HR

[1] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk. The darkest cells indicate combinations of A/P and SS/D at greatest risk (NWFSC 2015).
[2] Percentage represents the probability of extinction in a 100-year time period.

For spatial structure/diversity, the moderate risk rating was driven by changes in major life-history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity detected in samples from natural-origin returns. In particular, the rating reflects the relatively high proportion of within-population hatchery spawners in all major spawning areas and the lingering effects of previous high levels of out-of-ESU strays. In addition, the potential for selective pressure imposed by current hydropower operations and cumulative harvest impacts contribute to the current rating level (NWFSC 2015).

Considering the most recent information available, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required to achieve delisting status, assuming that natural-origin abundance of the single extant Snake River fall-run Chinook salmon population remains relatively high. An increase in productivity could occur with a further reduction in mortalities across life stages (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River fall-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2017m).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River fall-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2017m).

The recovery plan (NMFS 2017m) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Section 3.3 of the plan provides criteria for addressing the underlying causes of decline. Furthermore, Section 4.1.2 B.4. of the plan (NMFS 2017m) describes the changes in current impacts on Snake River fall-run Chinook salmon. These changes include:

- Hydropower systems,
- Juvenile migration timing,
- Adult migration timing,
- Harvest,
- Age-at-return,
- Selection caused by non-random removals of fish for hatchery broodstock, and
- Habitat.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

Overall, the status of Snake River fall-run Chinook salmon has clearly improved compared to the time of listing and since the time of prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of viable developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be “highly viable with high certainty” and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NWFSC 2015).

2.2.4.2 Life-History and Status of the Snake River Spring/Summer-Run Chinook Salmon ESU

On June 3, 1992, NMFS listed the Snake River spring/summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June

28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399).

The Snake River spring/summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 10 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (Jones Jr. 2015). As explained above, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d). Table 2-52 lists the natural and hatchery populations included (or excluded) in the ESU.

Table 2-52. Snake River spring/summer-run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014.
5 major population groups	28 historical populations (4 extirpated)
Major Population Group	***Populations***
Lower Snake River	Tucannon River
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha
South Fork Salmon River	Secesh, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River
Middle Fork	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon
Artificial production	
Hatchery programs included in ESU (10)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Lookingglass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum, McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring.
Hatchery programs not included in ESU (8)	South Fork Chinook Eggbox spring, Panther Creek summer, Yankee Fork SBT spring, Rapid River Hatchery spring, Dworshak NFH spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring.

Twenty eight historical populations (four extirpated) within five MPGs comprise the Snake River spring/summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life-history characteristics. Figure 2-13 shows a map of the current ESU and the MPGs within the ESU.

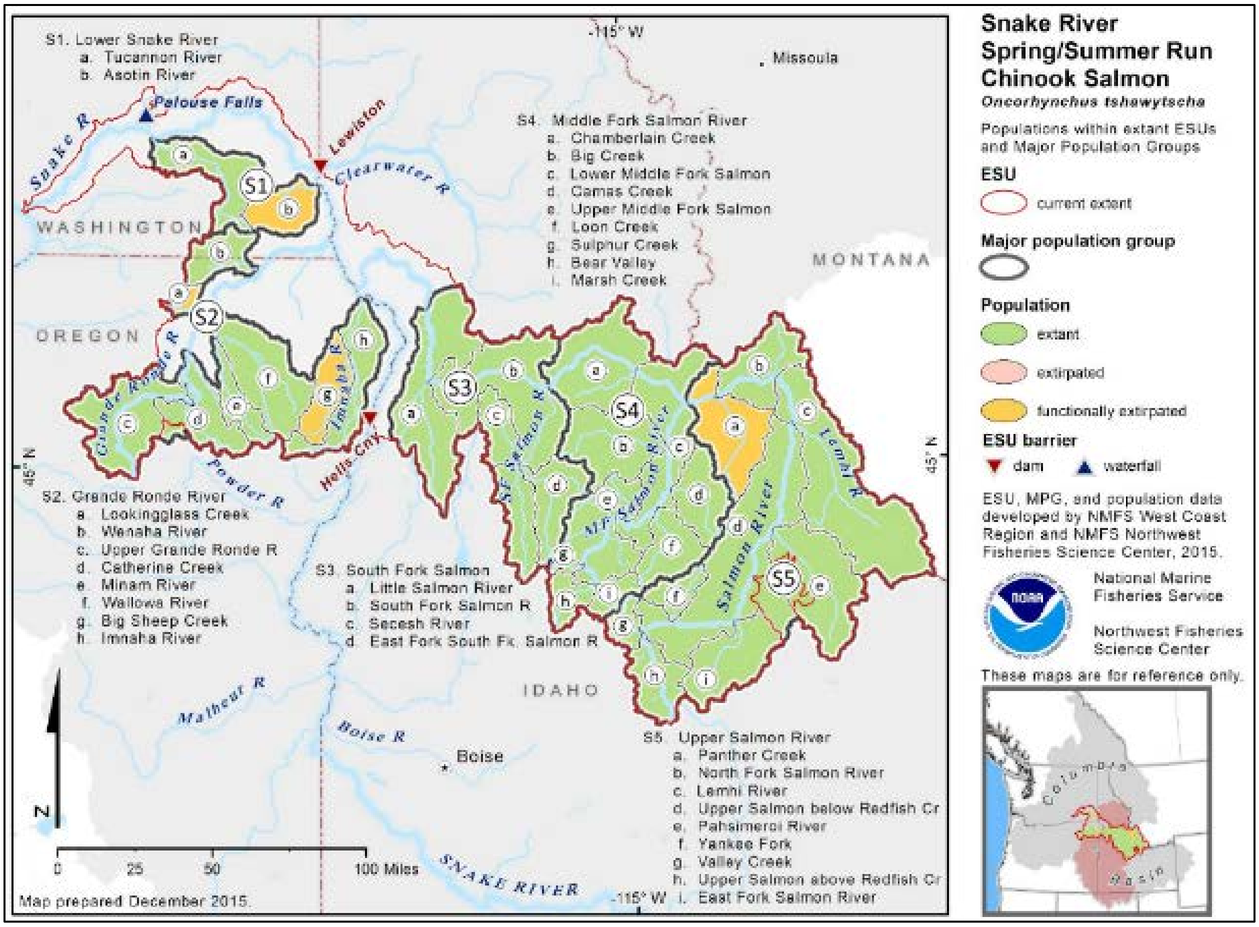


Figure 2-13. Snake River spring/summer-run Chinook Salmon ESU spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. The Snake River spring/summer-run Chinook Salmon ESU consists of "stream-type" Chinook salmon, which spend two to three years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). For a general review of stream-type Chinook salmon, see the UWR Chinook Salmon ESU life-history and status description. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species (NMFS 2012d).

Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer-run Chinook salmon in some years during the late 1800s (Matthews and Waples 1991). By the 1950s, the abundance of spring/summer-run Chinook salmon had declined to an annual average of 125,000 adults, and continued to decline through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon adults returned (hatchery and wild fish combined). Returns at Lower Granite Dam (LGR) (hatchery and wild fish combined) dramatically increased after 2000, with 185,693 adults returning in 2001. The large increase in 2001 was due primarily to hatchery returns, with only 10% of the returns from fish of natural-origin (NMFS 2012d).

The causes of oscillations in abundance are uncertain, but likely are due to a combination of factors. Over the long-term, population size is affected by a variety of factors, including: ocean conditions, harvest, increased predation in riverine and estuarine environments, construction and continued operation of Snake and Columbia River Dams; increased smolt mortality from poor downstream passage conditions; competition with hatchery fish; and widespread alteration of spawning and rearing habits. Spawning and rearing habits are commonly impaired in places from factors such as agricultural tilling, water withdrawals, sediment from unpaved roads, timber harvest, grazing, mining, and alteration of floodplains and riparian vegetation. Climate change is also recognized as a possible factor in Snake River salmon declines (Tolimieri and Levin 2004; Scheuerell and Williams 2005; NMFS 2012d).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River spring/summer-run Chinook Salmon ESU, remains at high overall risk, with the exception of one population (Chamberlain Creek in the MF MPG). NMFS has finalized recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries. A tributary recovery plan for one of the major management units, the Lower Snake River tributaries within Washington state boundaries, was developed under the auspices of the Lower Snake River Recovery Board (LSRB). The LSRB Plan provides recovery criteria, targets, and tributary habitat action plans for the two populations of the spring/summer-run Chinook salmon in the Lower Snake MPG in addition to the populations in the Touchet River (Mid-Columbia Steelhead DPS) and the Washington sections of the Grande Ronde River (NWFSC 2015).

The recovery plans developed by NMFS incorporated viability criteria recommended by the ICTRT. The ICTRT recovery criteria are hierarchical in nature, with ESU/DPS level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements – abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves (NWFSC 2015). 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 recovery plan. Table 2-53 shows the most recent metrics for the Snake River spring/summer-run Chinook Salmon ESU.

The majority of natural populations in the Snake River spring/summer-run Chinook Salmon ESU remain at high risk overall, with one population (Chamberlain Creek in the MF MPG) improving to an overall rating of maintained due to an increase in abundance (Table 2-54). Natural-origin abundance has increased over the levels reported in the prior review (Ford 2011) for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. Ten natural populations increased in both abundance and productivity, seven increased in abundance while their updated productivity estimates decreased, and two populations decreased in abundance and increased in productivity. One population, Loon Creek in the MF MPG, decreased in both abundance and productivity. Overall, all but one population in this ESU remains at high risk for abundance and productivity and there is a considerable range in the relative improvements to life cycle survivals or limiting life stage capacities required to attain viable status. In general, populations within the South Fork grouping had the lowest gaps among MPGs. The other multiple population MPGs each have a range of relative gaps (NWFSC 2015).

Spatial structure ratings remain unchanged or stable with low or moderate risk levels for the majority of the populations in the ESU (Table 2-53). Four populations from three MPGs (Catherine Creek and Upper Grande Ronde of the Grande Ronde/Imnaha MPG, Lemhi River of the Upper Salmon River MPG, and Lower MF Mainstem of the MF MPG) remain at high risk for spatial structure loss. Three of the four extant MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn – the more natural-origin fish that return the fewer hatchery fish that are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels. Efforts to evaluate key assumptions and impacts are underway for several programs (NWFSC 2015).

Table 2-53. Measures of viability and overall viability rating for Snake River spring/summer-run Chinook salmon populations[1] (NWFSC 2015).

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity 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	
Lower Snake River MPG								
Tucannon River	750	↑ 267 (.19	↓ .69 (.23)	High	Low	Moderate	Moderate	HIGH RISK
Asotin Creek	500	extirpated						extirpated
Grande Ronde/Imnaha MPG								
Wenaha River	750	↓ 399 (.12)	↑ .93 (.21)	High	Low	Moderate	Moderate	HIGH RISK
Lostine/Wallowa R.	1,000	↑ 332 (.24)	↑ .98 (.12)	High	Low	Moderate	Moderate	HIGH RISK
Lookingglass R. (ext)	500	extirpated						extirpated
Minam R.	750	↑ 475 (.12)	↑ .94 (18)	High(M)	Low	Moderate	Moderate	HIGH RISK
Catherine Creek	1,000	↑ 110 (.31)	↑ .95 (.15)	High	Moderate	Moderate	Moderate	HIGH RISK
Upper Gr. Ronde R.	1,000	↑ 43 (.26)	↑ .59 (.28)	High	High	Moderate	High	HIGH RISK
Imnaha River	750	↑ 328 (.21)	↑ 1.20 (.09)	High (M)	Low	Moderate	Moderate	HIGH RISK
South Fork MPG								
South Fork Mainstem	1,000	↑ 791 (.18)	↓ 1.21 (.20)	High (M)	Low	Moderate	Moderate	HIGH RISK
Secesh River	750	↑ 472 (.18)	○ 1.25 (.20	High(M)	Low	Low	Low	HIGH RISK
East F./Johnson Cr.	1,000	↑ 208 (.24)	↓ 1.15 (.20)	High	Low	Low	Low	HIGH RISK
Little Salmon River	750	Insf. data			Low	Low	Low	HIGH RISK
Middle Fork MPG								
Chamberlain Creek	750	↑ 641 (.17)	↓ 2.26 (.45)	Moderate	Low	Low	Low	Maintained
Big Creek	1,000	↑ 164 (.23)	↓ 1.10 (.21)	High	Very Low	Moderate	Moderate	HIGH RISK
Loon Creek	500	↓ 54 (.10)	↓ .98 (.40)	High	Low	Moderate	Moderate	HIGH RISK
Camas Creek	500	↑ 38 (.20)	↓ .80 (.29)	High	Low	Moderate	Moderate	HIGH RISK
Lower Mainstem MF	500	Insf. data	Insf.data	-	Moderate	Moderate	Moderate	HIGH RISK
Upper Mainstem MF	750	↑ 71 (.18)	↓ 0.50 (.72)	High	Low	Moderate	Moderate	HIGH RISK
Sulphur Creek	500	↑ 67 (.99)	↑ .92 (.26)	High	Low	Moderate	Moderate	HIGH RISK
Marsh Creek	500	↑ 253 (.27)	↓ 1.21 (.24)	High	Low	Low	Low	HIGH RISK
Bear Valley Creek	750	↑ 474 (.27	↓ 1.37 (.17)	High(M)	Very Low	Low	Low	HIGH RISK

Upper Salmon River MPG									
Salmon Lower Main	2,000	↓ 108 (.18)	↑ 1.18 (.17)	High	Low	Low	Low	HIGH RISK	
Salmon Upper Main	1,000	↑ 411 (.14)	↑ 1.22 (.19)	High (M)	Low	Low	Low	HIGH RISK	
Pahsimeroi River	1,000	↑ 267 (.16)	↑ 1.37 (.20)	High (M)	Moderate	High	High	HIGH RISK	
Lemhi River	2,000	↑ 143 (.23)	↑ 1.30 (.23)	High	High	High	High	HIGH RISK	
Valley Creek	500	↑ 121 (.20)	↑ 1.45 (.15)	High	Low	Moderate	Moderate	HIGH RISK	
Salmon East Fork	1,000	↑ 347 (.22)	↑ 1.08 (.28)	High	Low	High	high	HIGH RISK	
Yankee Fork	500	↑ 44 (.45)	↓ .72 (.39)	High	Moderate	High	High	HIGH RISK	
North Fork	500	Insf. data	Insf. data		Low	Low	Low	HIGH RISK	
Panther Creek (ext)	750	Insf. data	Insf. data					extirpated	

[1]Comparison of updated status summary vs. recovery plan viability objectives; upwards arrow=improved since prior review. Downwards arrow=decreased since prior review. Oval=no change. Shaded populations are the most likely combinations within each MPG to be improved to viable status. Current abundance and productivity estimates are expressed as geometric means (standard error). Extirpated populations were not evaluated as indicated by the blank cells (NWFSC 2015).

Table 2-54. Natural-origin spring-run Chinook salmon spawner estimates (Identified by common spring or summer timing categories) (TAC 2017, Table 2.1.25).

	Idaho Populations							Oregon Populations						
Year	**Bear Valley Creek spring**	**Big Creek spring**	**Marsh Creek spring**	**Sulphur Creek spring**	**Pahsimeroi River summer**	**SF Salmon River Mainstem**	**Total Idaho**	**Minam spring**	**Wenaha spring**	**Catherine Creek spring**	**Lostine spring**	**Upper Grand Ronde**	**Imnaha summer**	**Total Oregon**
1997	234	160	161	36	54	432	1,077	208	313	82	130	68	185	986
1998	391	73	229	101	56	695	1,545	233	286	101	156	92	267	1,135
1999	81	48	0	0	72	485	686	166	93	88	68	4	428	847
2000	325	63	94	10	68	609	1,169	512	523	55	223	53	442	1,808
2001	740	682	508	86	175	984	3,175	676	999	410	484	77	2375	5,020
2002	1,177	551	484	201	169	885	3,467	737	761	252	358	107	1359	3,575
2003	1,315	438	872	190	354	1,797	4,966	621	601	252	368	230	1,577	3,648
2004	342	243	94	15	215	870	1,779	548	751	53	197	43	525	2,117
2005	306	68	65	28	353	551	1,371	387	532	46	146	22	328	1,460
2006	158	43	125	54	104	628	1,112	498	398	113	182	54	294	1,539
2007	312	97	130	56	148	672	1,415	348	326	74	150	36	198	1,132
2008	437	204	177	71	224	691	1,804	485	342	89	382	64	262	1,624
2009	501	448	167	49	324	607	2,096	765	348	125	482	100	444	2,264
2010	791	224	632	112	308	1,585	3,652	865	593	476	733	136	752	3,555
2011	757	297	674	171	423	1,314	3,636	697	592	413	583	129	896	3,310
2012	940	385	411	41	234	828	2,839	584	563	392	744	241	766	3,290
2013	505	195	375	110	354	421	1,960	409	282	247	319	352	277	1,886
2014	993	287	861	203	559	920	3,823	926	606	610	1019	742	825	4,728
2015	594	253	586	119	368	329	2,249	555	609	293	467	395	633	2,952
2016	469	214	411	43	347	351	1,835	614	745	258	672	165	683	3,137
2008-2016 avg.	665	279	477	102	349	783	2,655	656	520	323	600	258	615	2,972
ICTRT minimum threshold	750	1,000	500	500		1,000		750	750	1,000	1,000	1,000	750	

Table 2-55. Snake River spring/summer-run Chinook salmon ecological subregions, populations, and scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for Snake River spring/summer-run Chinook salmon (Ford 2011).[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH), and extirpated (E). Extirpated populations were not evaluated as indicated by the blank cells (NWFSC 2015).

While there have been improvements in the abundance/productivity in multiple populations relative to prior reviews (Ford 2011), those changes have not been sufficient to warrant a change in ESU status (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River spring/summer-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The abundance of spring/summer-run Chinook salmon had already began to decline by the 1950s, and it continued declining through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon total adults (both hatchery and natural-origins combined) returned to the Snake River (NMFS 2017n).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River spring/summer-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, survival through the Federal Columbia River Power System (FCRPS); the degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters, spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high quality spawning gravels; and interbreeding and competition with hatchery fish that far outnumber fish of natural-origin.

NMFS (2017n) determined the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). PCEs for Snake River spring/summer-run Chinook salmon are shown in Table 2-56.

Table 2-56. PCEs identified for Snake River spring/summer-run Chinook salmon (NMFS 2017n).

Habitat Component	**Primary Constituent Elements (PCEs)**
Spawning and juvenile rearing areas	1) spawning gravel 2) water quality 3) water quantity 4) water temperature 5) food 6) riparian vegetation 7) access
Juvenile migration corridors	1) substrate 2) water quality 3) water quantity 4) water temperature 5) water velocity 6) cover/shelter 7) food 8) riparian vegetation 9) space 10) safe passage conditions

Areas for growth and development to adulthood	Ocean areas – not identified
Adult migration corridors	1) substrate 2) water quality 3) water quantity 4) water temperature 5) water velocity 6) cover/shelter 7) riparian vegetation 8) space 9) safe passage conditions

Although the status of the ESU is improved relative to measures available at the time of listing, the ESU remains at threatened status.

2.2.4.3 Life-History and Status of the Upper Columbia River Spring-Run Chinook Salmon ESU

On March 24, 1999, NMFS listed the UCR spring-run Chinook Salmon ESU as an endangered species (64 FR 14308). The endangered status was reaffirmed on June 28, 2005 (70 FR 37160) and most recently on April 14, 2014 (70 FR 20816). Critical habitat for the UCR spring-run Chinook salmon was designated on September 2, 2005 (70 FR 2732).

Inside the geographic range of this ESU, eight natural populations within three MPGs have historically comprised the UCR spring-run Chinook Salmon ESU, but the ESU is currently limited to one MPG (North Cascades MPG) and three extant populations (Wenatchee, Entiat, and Methow populations). Six hatchery spring-run Chinook salmon programs are currently operational, but only three are included in the ESU (Jones Jr. 2015). As explained above, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d). Table 2-57 lists the hatchery and natural populations included (or excluded) in the ESU.

Table 2-57. UCR spring-run Chinook Salmon ESU description and MPG (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Endangered	Listed under ESA in 1999; updated in 2014.
3 major population groups	8 historical populations
Major Population Group	***Populations***
North Cascades	Wenatchee River, Entiat River, Methow River.
Artificial production	
Hatchery programs included in ESU (3)	Methow River spring (in the Twisp and Methow Rivers), Winthrop NFH spring, Chiwawa River spring
Hatchery programs not included in ESU (3)	Leavenworth NFH, Chief Joseph Hatchery spring, Okanogan spring (10)(j)

Approximately half of the area that originally produced spring-run Chinook salmon in this ESU is now blocked by dams. What remains of the ESU includes all naturally spawned fish upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State, excluding the Okanogan River (64 FR 14208, March 24, 1999). Figure 2-14 shows the map of and specific basins within the current ESU.

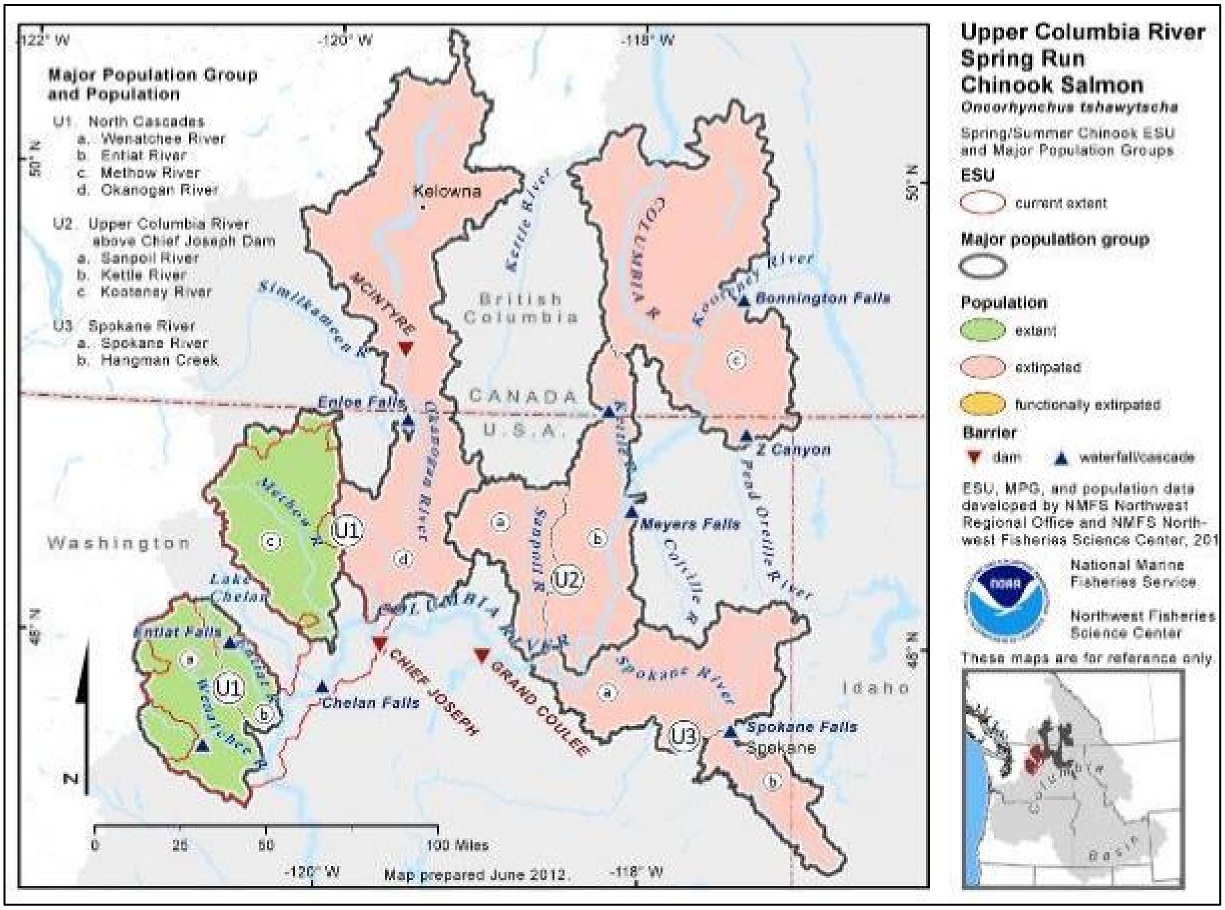


Figure 2-14. Map of the UCR spring-run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. ESA-listed UCR spring-run Chinook salmon are known as "stream-type"; they spend 2 to 3 years in coastal ocean waters, whereas "ocean-type" Chinook salmon spend 3 to 4 years at sea and exhibit offshore ocean migrations. Ocean-type Chinook salmon also enter freshwater later to spawn (May and June) than stream type (February through April). Ocean-type Chinook salmon also use different areas – they spawn and rear in lower elevation mainstem rivers and they typically reside in freshwater for no more than 3 months compared to stream-type (including spring Chinook salmon) that spawn and rear high in the watershed and reside in freshwater for a year (NMFS 2014e).

Spring-run Chinook salmon begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring-run Chinook salmon enter the Upper Columbia tributaries from April through July, and they hold in freshwater tributaries after migration until they spawn in the late summer (peaking in mid to late August) (UCSRB 2007). Juvenile spring-run Chinook salmon spend a year in freshwater before migration to saltwater in the spring of their second year of life.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR spring-run Chinook Salmon ESU, is at high risk and remains at endangered status (NWFSC 2015). The ESA Recovery Plan, developed by the Upper Columbia Salmon Recovery Board (UCSRB) (UCSRB 2007) calls for improvement in each of the three extant spring-run Chinook salmon populations (no more than 5% risk of extinction in 100 years) and for a level of spatial structure and diversity that restores the distribution of natural populations to previously occupied areas and that allows natural patterns of genetic and phenotypic diversity to be expressed. This corresponds to a threshold of at least "viable" status for each of the three natural populations. None of the three populations are viable with respect to abundance and productivity, and they all have a greater than 25 % chance of extinction in 100 years (Table 2-58) (UCSRB 2007).

Table 2-58. Matrix used to assess natural population viability risk rating across VSP parameters for the UCR spring-run Chinook Salmon ESU[1] (ICTRT 2007; Ford 2011; NWFSC 2015).

		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk[2]	Very Low (<1%)	HV	HV	V	M
	Low (1-5%)	V	V	V	M
	Moderate (6 – 25%)	M	M	M	HR

	High (>25%)	HR	HR	HR	HR Wenatchee R. Entiat R. Methow R.

[1] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk. The darkest cells indicate combinations of A/P and SS/D at greatest risk (NWFSC 2015).
[2] Percentage represents the probability of extinction in a 100-year time period.

The Wenatchee, Entiat, and Methow River populations are considered a high risk for both abundance/productivity (A/P) and composite spatial structure/diversity (SS/D), as they are noted in the above table.

In the 2005 status review, the BRT noted that the UCR spring-run Chinook salmon populations had “rebounded somewhat from the critically low levels” that were observed in the 1998 review. Although this was an encouraging sign, they noted this increase in population size was largely driven by returns in the two most recent spawning years available at the time of the review (NWFSC 2015). In the 2011 status review, Ford (2011) reported that the Upper Columbia spring-run Chinook Salmon ESU was not currently meeting the viability criteria (adapted from the Interior Columbia Technical Recovery Team (ICTRT)) in the Upper Columbia Recovery Plan. Increases in the natural-origin abundance relative to the extremely low spawning levels observed in the mid-1990s were encouraging; however, average productivity levels remained extremely low. Overall, the 2011 status report concluded that the viability of the UCR spring-run Chinook Salmon ESU had likely improved somewhat since the 2005 review, but the ESU was still clearly at moderate-to-high risk of extinction and remains so during the latest status review (NWFSC 2015).

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 UCSRB Plan. The plan calls for meeting or exceeding the same basic spatial structure and diversity criteria adopted from the ICTRT viability report for recovery (NWFSC 2015).

Table 2-59. UCR spring-run Chinook Salmon ESU population viability status summary.

Population	**Abundance and productivity metrics[1]**				**Spatial structure and diversity 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**	
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

[1] Current abundance and productivity 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. Oval = no change since prior review (NWFSC 2015).

Overall A/P remains rated at high risk for each of the three extant populations in this MPG/ESU (Table 2-59) (NWFSC 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 abundance and productivity for each population result in a high risk rating when compared to the ICTRT viability curves (NWFSC 2015).

The composite SS/D risks for all three of the extant natural populations in this MPG are rated at high (Table 2-59, Table 2-60). The natural processes component of the SS/D 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 (ICTRT 2008; NWFSC 2015).

Based on the combined ratings for A/P and SS/D, all three of the extant natural populations of UCR spring-run Chinook salmon remain rated at high overall risk (Table 2-59, Table 2-60).

Table 2-60. Scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for spring-run UCR Chinook salmon (NWFSC 2015).[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) and extirpated (E).

In the 2015 status review, updated data series on spawner abundance, age structure, and hatchery/natural proportions were used to generate current assessments of abundance and productivity at the population level. Annual spawning escapements for all three of the extant UCR spring-run Chinook salmon populations showed steep declines beginning in the late 1980s, leading to extremely low abundance levels in the mid-1990s. The steep downward trend reflects the extremely low return rates for the natural population from the 1990-94 brood years. Steeply declining trends across indices of total spawner abundance were a major consideration in the 1998 BRT risk assessment prior to listing of the ESU. Updating the series to include the 2009-2014 data, the short-term (e.g., 15 year) trend in wild spawners has been stable for the Wenatchee population and positive for the Entiat and Methow populations. In general, both total and natural-origin escapements for all three populations increased sharply from 1999 through 2002 and have shown substantial year-to-year variations in the years following, with peaks around 2001 and 2010. Average natural-origin returns remain well below ICTRT minimum threshold levels.

The most recent total natural spawner abundance information for UCR spring-run Chinook salmon is provided in Table 2-61. The proportions of natural-origin contributions to spawning in the Wenatchee and Methow populations have trended downward since 1990, reflecting the large increase in hatchery production and releases and subsequent returns from the directed supplementation program in those two drainages. There is no direct hatchery supplementation program in the Entiat River. The Entiat NFH spring-run Chinook salmon release program was discontinued in 2007, and the upward trend in proportional natural-origin spawners since then can be attributed to that closure. Hatchery supplementation returns from the adjacent Wenatchee River program stray into the Entiat (Ford et al. 2015). The nearby Eastbank Hatchery facility is used for rearing the Wenatchee River supplementation stock prior to transfer to the Chiwawa acclimation pond. It is possible that some of the returns from that program are homing on the Eastbank facility and then straying into the Entiat River, the nearest spawning area (NWFSC 2015).

Table 2-61. UCR spring-run Chinook salmon total spawner escapement abundance estimates in UCR tributaries, 1997-2016 (TAC 2017).

	Wenatchee			**Entiat**			**Methow**		
Year	**Total Spawning Escapement**	**Hatchery-origin Spawners**	**Natural-origin Spawners**	**Total Spawning Escapement**	**Hatchery-origin Spawners**	**Natural-origin Spawners**	**Total Spawning Escapement**	**Hatchery-origin Spawners**	**Natural-origin Spawners**
1997	499	272	226	82	14	68	347	78	269
1998	221	68	153	53	11	42	41	21	20
1999	215	42	173	75	46	29	116	71	45
2000	1,174	523	651	175	121	54	979	862	117
2001	6,920	4,828	2,092	485	146	339	10,971	9,139	1,832
2002	3,007	1,938	1,069	370	126	244	2,636	2,291	345
2003	1,532	603	929	259	83	176	1,138	1,080	58
2004	2,386	1,472	914	302	157	145	1,496	1,008	488
2005	3,830	3,231	599	356	178	178	1,376	849	527
2006	2,263	1,690	573	257	146	111	1,748	1,420	328
2007	3,635	3,308	327	245	135	110	1,079	813	266
2008	6,211	5,574	637	278	142	136	1,002	704	298
2009	5,177	4,377	800	276	141	135	2,641	2,077	564
2010	5,682	4,802	880	490	122	368	2,369	1,768	601
2011	6,680	5,192	1,487	595	274	321	2,936	1,975	961
2012	7,375	4,810	2,565	566	192	374	1,298	1,098	200
2013	4,448	3,386	1,062	238	52	186	1,089	848	241
2014	4,187	2,826	1,361	245	20	225	2,063	1,555	508
2015	3,405	1,942	1,463	509	92	417	1,353	955	398
2016	2,364	1,427	937	334	53	281	1,339	726	613
2008-2016 avg.	5,059	3,815	1,244	392	121	271	1,788	1,301	487
ICTRT minimum threshold			2,000			500			2,000

Limiting Factors

Understanding the limiting factors and threats that affect the UCR spring-run Chinook Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is for all involved parties to ensure that the underlying limiting factors and threats have been addressed. Natural populations of spring-run Chinook salmon within the UCR Basin were first affected by intensive commercial fisheries in the LCR. These fisheries began in the late 1800s and continued into the 1900s, nearly eliminating many salmon stocks. With time, the construction of dams and diversions, some without passage, blocked salmon migrations and killed upstream and downstream migrating fish. Early hatcheries, constructed to mitigate for fish loss at dams and loss of habitat for spawning and rearing, were operated without a clear understanding of population genetics, where fish were transferred to hatcheries without consideration of their actual origin. Although hatcheries were increasing the total number of fish returning to the basin, there was no evidence that they were increasing the abundance of natural populations and it is considered likely that they were decreasing the diversity and productivity of populations they intended to supplement (UCSRB 2007).

Concurrent with these historic activities, human population growth within the basin was increasing, and land uses (in many cases, encouraged and supported by government policy) were in some areas impacting salmon spawning and rearing habitat. In addition, non-native species (for a list of non-native species refer to the recovery plan) were introduced by both public and private interests throughout the region that directly or indirectly affected salmon and trout. These activities acting in concert with natural disturbances decreased the abundance, productivity, spatial structure, and diversity of spring-run Chinook salmon in the UCR Basin (UCSRB 2007).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UCR spring-run Chinook Salmon ESU. According to the recovery plan factors that limit the ESU have been, and continue to be, destruction of habitat, overutilization for commercial/recreational/scientific/educational purposes, disease, predation, inadequacy of existing regulatory mechanisms, and other natural or human-made factors affecting the populations continued existence (UCSRB 2007).

The UCSRB (2007) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Rather than repeating this extensive discussion from the recovery board, it is incorporated here by reference. Based on the information available from the 2015 status review, the risk category for the UCR spring-run Chinook Salmon ESU remains unchanged from the prior review (Ford 2011). Although the status of the ESU is improved relative to measures available at the time of listing, all three populations remain at high risk.

2.2.4.4 Life-History and Status of the Snake River Sockeye Salmon ESU

On April 5, 1991, NMFS listed the Snake River Sockeye Salmon ESU as an endangered species (56 FR 14055) under the Endangered Species Act (ESA). This listing was affirmed in 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802). Critical habitat was designated on December 28, 1993 (58 FR 68543) and reaffirmed on September 2, 2005.

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015) (Table 2-62).

Table 2-62. Snake River Sockeye Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2015c).

ESU Description	
Threatened	Listed under ESA in 1991; updated in 2014.
1 major population group	5 historical populations (4 extirpated)
Major Population Group	***Population***
Sawtooth Valley Sockeye	Redfish Lake
Artificial production	
Hatchery programs included in ESU (1)	Redfish Lake Captive Broodstock
Hatchery programs not included in ESU (0)	Not applicable

The ICTRT treats Sawtooth Valley Sockeye salmon as the single MPG within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015c) (Figure 2-15). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015c). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades; once residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure et al. 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been outplanted to Pettit and Alturas lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011a).

Lakes in the Stanley Basin and Sawtooth Valley are relatively small compared to the other lake systems that historically supported sockeye salmon production in the Columbia Basin. The average abundance targets recommended by the Snake River Recovery Team (Bevan et al. 1994) were incorporated as minimum abundance thresholds into a sockeye salmon viability curve. The viability curve was generated using historical age structure estimates from Redfish Lake sampling in the 1950s to the 1960s, and year –to -year variations in brood -year replacement rates generated from abundance series for Lake Wenatchee sockeye salmon. The minimum spawning abundance threshold is set at 1,000 for the Redfish and Alturas Lake populations (intermediate category for lake size), and at 500 for populations in the smallest historical size category for lakes (i.e., Alturas and Pettit Lakes). Because space in the lakes is limited, the available spawning capacity may also be limited based on available habitat. The ICTRT recommended that long-term recovery objectives should include restoring at least three of the lake populations in this ESU to viable or highly viable status.

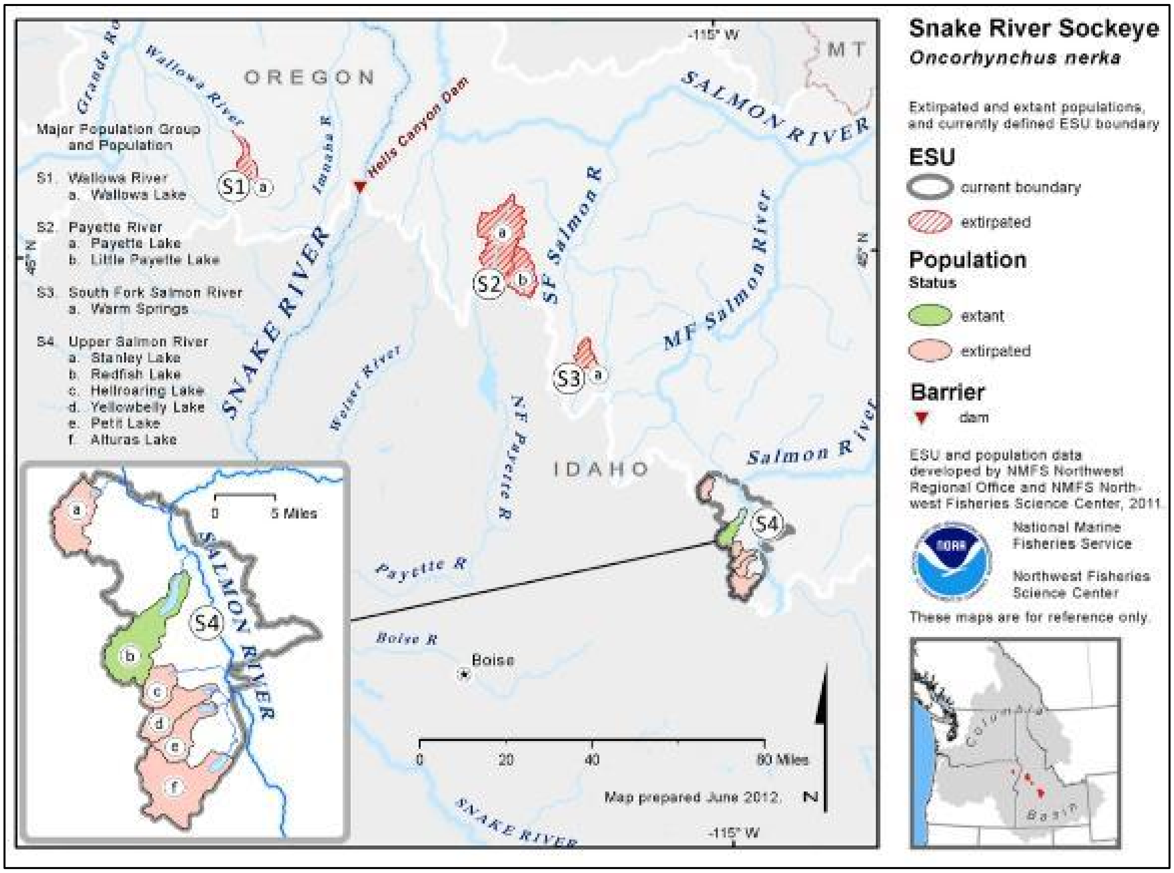


Figure 2-15. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historic population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean (Figure 2-15). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major Federal dams, four on the Columbia River and four on the lower Snake River. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015c).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Sockeye Salmon ESU, is at high risk and remains at endangered status. Although the endangered Snake River Sockeye Salmon ESU has a long way to go before it will meet the biological viability criteria (i.e., indication that the ESU is self-sustaining and naturally producing and no longer qualifies as a threatened species), annual returns of sockeye salmon through 2013 show that more fish are returning than before initiation of the captive broodstock program which began soon after the initial ESA listing (Table 2-63). Between 1999 and 2007, more than 355 adults returned from the ocean from captive brood releases – almost 20 times the number of natural-origin fish that returned in the 1990s. Though this total is primarily due to large returns in the year 2000. Adult returns in the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014(NWFSC 2015).

Table 2-63. Hatchery- and natural-origin sockeye salmon returns to Sawtooth Valley, 1999-2014 (IDFG, in prep.; NMFS 2015c).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns[1]	Observed Not Trapped
1999	7	0	7	0	0
2000	257	10	233	0	14
2001	26	4	19	0	3
2002	22	6	9	1	7
2003	3	0	2	0	1
2004	27	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	646	140	456	1	50
2009	832	86	730	2	16
2010	1,355	178	1,144	14	33
2011	1,117	145	954	2	18
2012	257	52	190	0	15
2013	272	79	191	0	2
2014	1,579	453	1,062	0	63
2015[2]	91	n/a	n/a	n/a	n/a
2016	574	n/a	n/a	n/a	n/a

[1] These fish were assigned as sockeye salmon returns to Alturas Lake and are included in the natural return numbers.
[2] In 2015, 56 fish swam in and 35 Snake Basin origin fish were transported from Granite.

The large increases in returning adults in recent years reflect improved downstream and ocean survivals, as well as increases in juvenile production, starting in the early 1990s. Although total sockeye salmon returns to the Sawtooth Valley in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species historic range (NMFS 2015c; NWFSC 2015).

Furthermore, there is evidence that the historical Snake River Sockeye Salmon ESU included a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin (NMFS 2015c). Historical production from Redfish Lake was likely associated with a lake shoal spawning life history pattern although there may have also been some level of spawning in Fish Hook Creek (NMFS 2015c; NWFSC 2015). In NMFS' 2011 status review update for Pacific salmon and steelhead listed under the ESA (Ford 2011), it was not possible to quantify the viability ratings for Snake River sockeye salmon. Ford (2011) determined that the Snake River sockeye salmon captive broodstock-based program has made substantial progress in reducing extinction risk, but that natural production levels of anadromous returns remain extremely low for this species (NMFS 2012d).

In the most recent 2015 status update, NMFS determined that at this stage of the recovery efforts, the ESU remains at high risk for both spatial structure and diversity (NWFSC 2015). At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural program (NMFS 2015c). There is some evidence of very low levels of early timed returns in some recent years from out-migrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Sockeye Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. In the 1980s, fishery impact rates increased briefly due to directed sockeye salmon fisheries on large runs of UCR stocks. By the 1990s, very small numbers of this species remained in the Snake River Basin (NWFSC 2015).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Sockeye Salmon ESU. Factors that limit the ESU have been, and continue to be the result of impaired mainstream and tributary passage, historical commercial fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, poor ocean conditions, Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures. These combined factors reduced the number of sockeye salmon that make it back to spawning areas in the Sawtooth Valley to the single digits, and in some years, zero. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity (NMFS 2015c; NWFSC 2015).

Today, some threats that contributed to the original listing of Snake River sockeye salmon now present little harm to the ESU, while others continue to threaten viability. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, pose limited concern since most passage barriers have been removed and much of the natal lake area and headwaters remain protected. Hatchery-related concerns have also been reduced through improved management actions (NMFS 2015c).

The recovery plan (NMFS 2015c) provides a detailed discussion of limiting factors and threats and describes strategies and actions for addressing each of them. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. Overall, the recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. An important first step towards that objective has been the successful establishment of anadromous returns from natural-origin Redfish Lake resident stock gained through a captive broodstock program. The long-term strategy is for the naturally produced population to achieve escapement goals in a manner that is self-sustaining and without the reproductive contribution of hatchery spawners (NMFS 2015c).

In terms of natural production, the Snake River Sockeye Salmon ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery based program to amplify and conserve the stock to facilitate reintroductions. At this stage of the recovery program there is no basis for changing the ESU ratings assigned in prior reviews, but the trend in status appears to be positive (NWFSC 2015).

2.2.4.5 Life-History and Status of the Snake River Basin Steelhead DPS

On August 18, 1997, NMFS listed the Snake River Basin Steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769).

The Snake River Basin Steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (Figure 2-16) (NWFSC 2015). Twenty four historical populations within six MGPs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 12 hatchery steelhead programs are currently operational. Five of these artificial programs are included in the DPS (Table 2-64) (Jones Jr. 2015). Genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

This DPS consists of A-Index steelhead, which primarily return to spawning areas beginning in the summer, and the B-Index steelhead, which exhibit a larger body size and begin their migration in the fall (NMFS 2011a).

Table 2-64. Snake River Basin Steelhead DPS description and MPGs (NMFS 2012d; Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014.
6 major population groups	27 historical populations (3 extirpated)
Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, North Fork Clearwater, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater

Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	n/a
Artificial production	
Hatchery programs included in DPS (5)	Tucannon River summer, Little Sheep Creek summer, EF Salmon River Natural A, Dworshak NFH B, SF Clearwater (Clearwater Hatchery) B, Salmon River B
Hatchery programs not included in DPS (7)	Lyons Ferry NFH summer, Wallowa Hatchery summer, Hells Canyon A, Pahsimeroi Hatchery A, Upper Salmon River A, Streamside Incubator Project A and B, Little Salmon River A

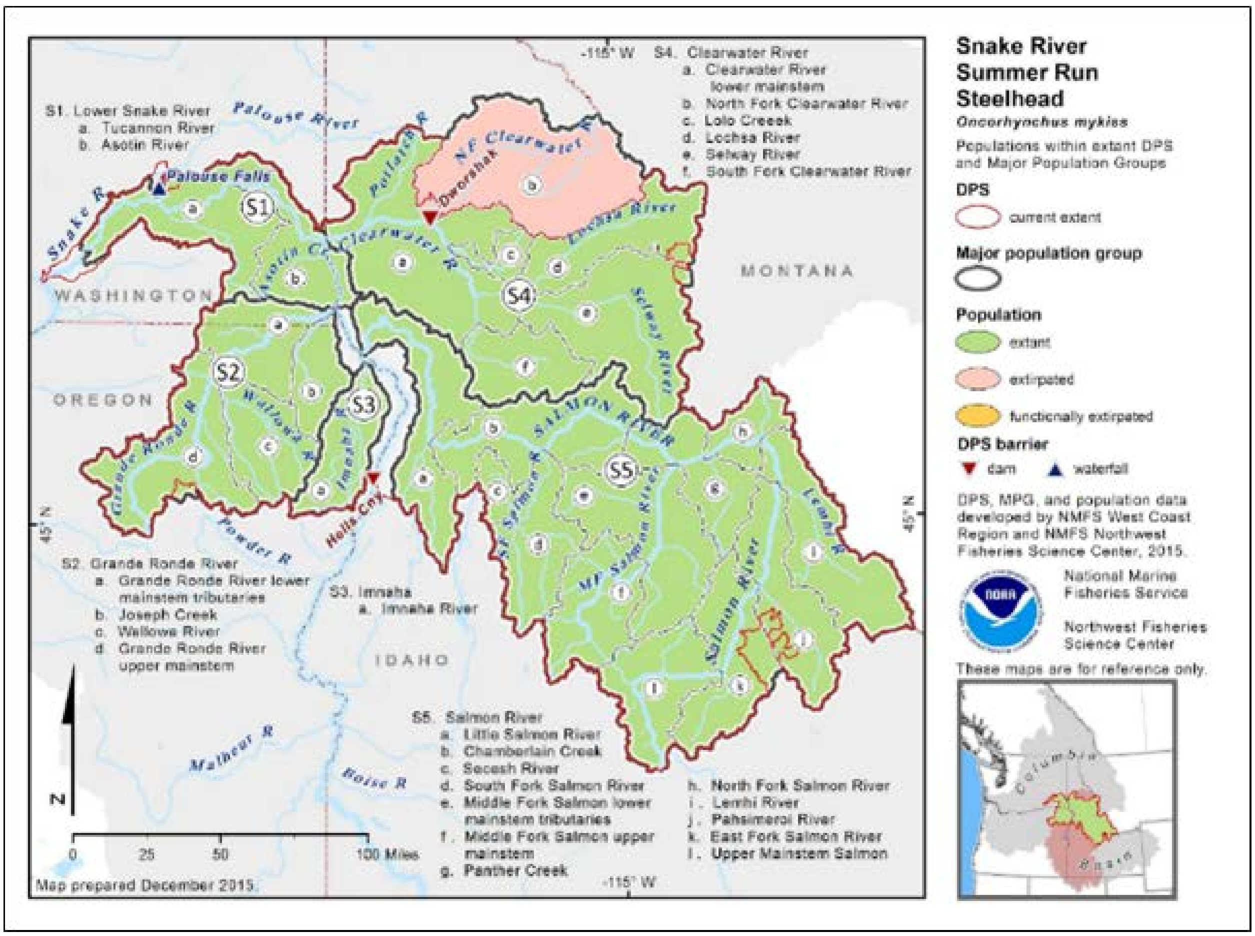


Figure 2-16. Map of the Snake River Basin Steelhead DPS's spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

Snake River Basin steelhead exhibit two distinct morphological forms, identified as "A-Index" and "B-Index" fish, which are distinguished by differences in body size, run timing, and length of ocean residence. B-Index fish predominantly reside in the ocean for 2 years, while A-Index steelhead typically reside in the ocean for 1-year (Copeland et al. 2017). As a result of different ocean residence times, B-Index steelhead are generally larger than A-Index fish. The smaller size of A-Index adults allows them to spawn in smaller headwater streams and tributaries. The differences in the two fish stocks represent an important component of phenotypic and genetic diversity of the Snake River Basin Steelhead DPS through the asynchronous timing of ocean residence, segregation of spawning in larger and smaller streams, and possible differences in the habitats of the fish in the ocean (NMFS 2012d).

Like all salmonid species, steelhead are cold-water fish (Magnuson et al. 1979) that survive in a relatively narrow range of temperatures, which limits the species distribution in fresh water to northern latitudes and higher elevations. Snake River Basin steelhead migrate a substantial distance from the ocean (up to 930 miles) and occupy habitat that is considerably warmer and drier (on an annual basis) than steelhead of other DPSs. Adult Snake River Basin steelhead return to the Snake River Basin from late summer through fall, where they hold in larger rivers for several months before moving upstream into smaller tributaries, and are generally classified as summer-run (NMFS 2012d; 2013d).

Steelhead live primarily off stored energy during the holding period, with little or no active feeding (Shapovalov and Taft 1954; Laufle et al. 1986). Adult dispersal toward spawning areas varies with elevation, with the majority of adults dispersing into tributaries from March through May, with earlier dispersal at lower elevations, and later dispersal at higher elevations. Spawning begins shortly after fish reach spawning areas, which is typically during a rising hydrograph and prior to peak flows (Thurow 1987; NMFS 2012d).

Steelhead typically select spawning areas at the downstream end of pools, in gravels ranging in size from 0.5 to 4.5 inches in diameter (Laufle et al. 1986). Juveniles emerge from redds in 4 to 8 weeks, depending on temperature. After emergence, fry have poor swimming ability. Steelhead fry initially move from the redds into shallow, low-velocity areas in side channels and along channel margins to escape high velocities and predators (Everest and Chapman 1972), and progressively move toward deeper water as they grow in size (Bjornn and Reiser 1991). Juveniles typically reside in fresh water for 2 to 3 years, or longer, depending on temperature and growth rate (Mullan et al. 1992). Juvenile steelhead in the Snake River Basin appear to reside in fresh water for no more than 2 years, a conclusion based on the absence or low numbers of *O. mykiss* greater than 2 years of age in inventories by Chandler and Richardson (2005), Kucera and Johnson (1986), and Fuller et al. (1984). Smolts migrate downstream during spring runoff, which occurs from March to mid-June in the Snake River Basin, depending on elevation (NMFS 2012d).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Basin Steelhead DPS, ranges from moderate to high risk and remains at threatened status. The most recent status update (NWFSC 2015) used new data (i.e., data from 2009 to 2014) to inform the analysis on this DPS. Additionally, ODFW has continued to refine sampling methods for various survey types, which has also led to more accurate data available for use. However, a great deal of uncertainty remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites. Because of this, it is difficult to estimate changes in the DPS viability (NWFSC 2015)

Population-specific adult population abundance is generally not available for the Snake River Basin 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 five 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% per year over the past 15 years (see Table 2-67). 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 (NWFSC 2015).

The ICTRT viability criteria adopted in the Snake River Management Unit Recovery Plans include spatial explicit criteria and metrics for both spatial structure and diversity. With one exception, spatial structure ratings for all of the Snake River Basin 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 (NWFSC 2015).

Updated information is available for two important factors that contribute to rating diversity risk under the ICTRT approach: hatchery spawner fractions and the life history diversity. Hatchery straying appears to be relatively low. At present, direct estimates of hatchery returns based on PBT analysis are available for the run assessed at LGR (IDFG 2015). Furthermore, information from the Genetic Stock Identification (GSI) assessment sampling provide an opportunity to evaluate the relative contribution of B-Index returns within each stock group. No population fell exclusively into the B-Index size category, although there were clear differences among population groups in the relative contributions of the larger B-Index life history type (NWFSC 2015).

NWFSC 2015 status review (NWFSC 2015) has improved our understanding regarding Snake River steelhead life history expressions and adaptation to varying natal habitat conditions. As explained previously, Snake River steelhead were historically commonly referred to as either “A-Index” or “B-Index” based on migration timing and differences in age and size at return. A-Index steelhead occur throughout the steelhead-bearing streams in the Snake River Basin and inland Columbia River, while research indicates that B-Index steelhead only reproduce in the Clearwater River basin and the lower and middle Salmon River basin (NWFSC 2015) (Table 2-65).

Based on its 2015 review, the NWFSC recently determined that some Snake River steelhead populations support both A-Index and B-Index life history expressions (NWFSC 2015). The NWFSC updated the Snake River steelhead life history pattern designations based on initial results from genetic stock identification (GSI) studies of natural-origin returns (NWFSC 2015). Using this new information, the NWFSC designated the populations as A-Index or B-Index based on length (less or more than 78 cm), but further assigned the populations with both A-Index and B-Index steelhead to different categories reflecting their mixtures of the run types (NWFSC 2015). The NWFSC determined that all but one of the populations previously designated by the ICTRT as A-Index steelhead populations had no or negligible B-run returns and should remain as A-Index populations (Table 2-65). It reassigned the Lower Clearwater River population as a B-Index based on analyses showing a mix of A-Index and B-Index steelhead in the population. The remaining populations were assigned to one of three different B-Index categories reflecting the relative contribution of fish exceeding the B-Index size threshold (High >40%, Moderate 15 to 40%, Low <15%) (NWFSC 2015).

Table 2-65. Updated major life history category designations for Snake River Steelhead DPS populations based on initial results from genetic stock identification studies. Designated A-run population have no or negligible B-run size returns in stock group samples. B-run population category designations reflect relative contribution of fish exceeding B-run size threshold (High >40%, Moderate 15-40%, Low <15%) (NWFSC 2015).

Major Population Group	Population	2007 ICTRT Major Life History Pattern	Change	2015 Assessment Update to Major Life History Pattern
Lower Snake River MPG	Tucannon River	A		A
	Asotin Creek	A		A
Grande Ronde River MPG	Joseph Creek	A		A
	Upper Grande Ronde River	A		A
	Lower Grande Ronde River	A		A
	Wallowa River	A		A
Imnaha River MPG	Imnaha River	A		A
Clearwater River MPG	Lower Clearwater Mainstem	A	Provisional	Low B
	South Fork Clearwater River	B	Yes	High B
	Selway River	B	Yes	High B
	Lochsa River	B	Yes	High B
	Lolo Creek	A/B	Yes	High B
Salmon River MPG	South Fork	B	Yes	High B
	Secesh River	B	Yes	High B

	Lower Middle Fork Salmon River	B	Yes	Moderate B
	Upper Middle Fork Salmon River	B	Yes	Moderate B
	North Fork Salmon River	A		A
	Panther Creek	A		A
	Pahsimeroi River	A		A
	Lemhi River	A		A
	Upper Salmon River Mainstem	A		A
	Upper Salmon East Fork	A		A
	Chamberlain Creek	A		A

The overall viability ratings for natural populations in the Snake River Basin Steelhead DPS range from moderate to high risk (Table 2-66). Under the approach recommended by the ICTRT, the overall rating for a DPSs depends on population-level ratings organized by MPG within that DPS.

Table 2-66. Ecological subregions, populations, and scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for the Snake River Basin Steelhead DPS (NWFSC 2015).[1]

Ecological subregions	Spawning Populations (Watershed)	A/P	Diversity	Integrated SS/D	Overall Viability Risk*
Lower Snake River	Tucannon River	**	M	M	H
	Asotin Creek	**	M	M	MT
Grande Ronde River	Lower Grande Ronde	**	M	M	Not rated
	Joseph Creek	VL	L	L	Highly viable
	Upper Grande Ronde	M	M	M	MT
	Wallowa River	**	L	L	H
Clearwater River	Lower Clearwater	M	L	L	MT
	South Fork Clearwater	H	M	M	H
	Lolo Creek	H	M	M	H
	Selway River	H	L	L	H
	Lochsa River	H	L	L	H
Salmon River	Little Salmon River	**	M	M	MT
	South Fork Salmon	**	L	L	H
	Secesh River	**	L	L	H
	Chamberlain Creek	**	L	L	H
	Lower MF Salmon	**	L	L	H

	Upper MF Salmon	**	L	L	H
	Panther Creek	**	M	H	H
	North Fork Salmon	**	M	M	MT
	Lemhi River	**	M	M	MT
	Pahsimeroi River	**	M	M	MT
	East Fork Salmon	**	M	M	MT
	Upper Main Salmon	**	M	M	MT
Imnaha River	Imnaha River	M	M	M	MT

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS (NWFSC 2015).

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

** Insufficient data.

The level of natural production in the two populations with full data series and the Asotin Creek index reaches are encouraging, but the status of most populations in the DPS remain highly uncertain (Table 2-66). Population-level natural-origin abundance and productivity inferred from aggregate data and juvenile indices indicate that many populations are likely below the minimum combination defined by the ICTRT viability criteria (NWFSC 2015).

Population level abundance data sets are limited for multiple populations in this DPS. For the two populations in the Lower Snake River MPG (i.e., Tucannon River and Asotin Creek populations) we have one total Lower Snake River data set, and one Asotin Creek data set, but none for the Tucannon River population alone. Both these populations (the only two in the Lower Snake River MPG) are targeted for viable status, with at least one meeting the criteria for highly viable. Even though population level spawner escapement estimates are not available for the Tucannon River population, indications are that the numbers of spawning steelhead in the system are low. One contributing factor to these low spawning numbers is an apparent high overshoot rate of returning adults passing by and continuing upstream from their natal stream. A portion of the outmigrating natural smolt production from the Tucannon River population has been PIT tagged in recent years (Bumgarner and Dedloff 2013). Analysis of returning PIT tagged adults (2005-2012 return years) indicates overshoot rates past the Tucannon River and over LGR (Bumgarner and Dedloff 2013; NWFSC 2015)

Table 2-67. Snake River Basin Steelhead DPS natural-origin spawner abundance estimates for the populations.

Year	Grande Ronde River			Imnaha River	Lower Snake River		Clearwater River			Salmon River			
	Grande Ronde River[3]	Joseph Creek[2] (500)[4]	Upper Grande Ronde[2] (1,500)[4]	Imnaha River[3] (1,000)[4]	Lower Snake River[3]	Asotin Creek[1] (500)[4]	Lower Clear-water[3] (1,500)[4]	South Fork Clear-water[3] (1,000)[4]	Upper Clear-water[3]	Lower Salmon[3]	South Fork Salmon[3] (1,000)[4]	Middle Fork Salmon[3]	Upper Salmon[3] (1,000)[4]
2009	4,905	3,598	3,148	1,916	2,062	363	1,971	2,428	2,533	985	1,198	2,635	3,242
2010	8,442	1,831	2,736	3,693	4,779	1,411	3,446	3,395	2,652	2,025	2,046	4,927	7,334
2011	9,443	5,647	3,259	3,318	4,374	1,128	3,421	4,228	3,885	1,941	2,512	4,312	6,699
2012	9,329	1,305	3,255	3,489	4,875	915	3,613	2,950	2,426	1,683	1,196	3,069	6,808
2013	5,657	2,148	1,540	1,638	2,871	539	2,187	1,530	1,298	834	843	2,097	4,188
2014	6,168	2,640	2,501	2,369	3,042	532	2,627	1,284	1,288	984	1,030	1,821	4,742
2015	10,192	n/a	n/a	3,481	5,300	839	4,287	2,580	5,064	1,805	2,247	4,000	6,833
2016	8,530	n/a	n/a	2,617	4,062	n/a	3,598	2,046	3,300	1,170	1,334	2,385	4,894
5-Year Average	7,975	2,031	2,432	2,719	4,030	706	3,262	2,078	2,675	1,295	1,330	2,674	5,493

[1] From WDFW SCoRE. https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead; Last Accessed: 10/26/17
[2] From ODFW Recovery Tracker. http://www.odfwrecoverytracker.org/explorer/species/Steelhead/run/summer/esu/271/292/; Last Accessed 10/26/17
[3] Natural-origin Steelhead Passage at Lower Granite Dam Based on Genetic Reporting Groups in BA
[4] Numbers inside parentheticals are the minimum abundance thresholds under the recovery scenario (NMFS 2017n).

All four natural populations in the Grande Ronde MPG were rated at low risk ratings for combined spatial structure and diversity in previous reviews (Ford 2011). The Grande Ronde MPG is tentatively rated at viable status. One population (Joseph Creek) was rated as highly viable, while the Upper Grande Ronde population also meets the criteria for viable, and the remaining two populations are provisionally rated as maintained (NWFSC 2015).

There is a single natural population in the Imnaha River MPG and it will need to meet highly viable status, under the ICTRT criteria, for the DPS to achieve delisting status. This MPG was rated as maintained in the 2011 review, based on moderate ratings for abundance and productivity and spatial structure/density. Based on the information currently available and used in the most recent status review, the Imnaha River steelhead natural population is not meeting the highly viable rating for a single population MPG called for in the Snake River Recovery Plan. It is possible that additional years' information from the PIT tag array project and/or refinements to the genetic stock identification program will result in improved estimates in future reviews (NWFSC 2015).

Based on the updated risk assessments, the Clearwater River MPG does not meet the ICTRT criteria for a viable MPG. Although the more explicit information on natural-origin spawner abundance indicates that the Lower Clearwater, Lochsa River, and Selway River populations are improved in overall status relative to prior reviews, the South Fork Clearwater and Lolo Creek populations do not achieve maintained status due in part to uncertainties regarding productivity and hatchery spawner composition (NWFSC 2015).

The relatively large Salmon River MPG has six populations that have been prioritized for viable status in the draft Idaho Management Unit Recovery Plan. The recovery scenario in this recovery plan is consistent with the ICTRT recommendations and includes the two MF populations, the South Fork River, the Chamberlain Creek, the Panther Creek, and the North Fork Salmon River populations (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Basin Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Steelhead were historically harvested in tribal and non-tribal gillnet fisheries, and in recreational fisheries in the mainstem Columbia River and in tributaries. Steelhead are still harvested in tribal fisheries and there is incidental mortality associated with mark-selective recreational and commercial fisheries. The majority of impacts on the summer run occur in tribal gillnet and dip net fishing targeting Chinook salmon. Because of their larger size, the B-Index fish are more vulnerable to gillnet gear. In recent years, total exploitation rates (exploitation rates are the sum of all harvest) on the A-Index have been stable around 5%, while exploitation rates on the B-Index have generally been in the range of 15-20% (NWFSC 2015).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Basin Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower projects, predation, harvest, hatchery effects, tributary habitat, and ocean conditions; together these factors have affected the natural populations of this DPS (NMFS 2017n). Specifically, limiting factors also include:

- Mainstem Columbia River hydropower-related adverse effects,
- Impaired tributary fish passage,
- Degraded, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality as a result of cumulative impacts of agriculture, forestry, and development,
- Impaired water quality and increased water temperature,
- Related harvest effects, particularly for B-Index steelhead,
- Predation, and
- Genetic diversity effects from out-of-population hatchery releases.

Four out of the five MPGs are not meeting the specific objectives in the Snake River Recovery Plan (NMFS 2017n), and the status of many individual populations remain uncertain. The additional monitoring programs instituted in the early 2000s to gain better information on natural-origin abundance and related factors have significantly improved the ability to assess status at a more detailed level. The new information has resulted in an updated view of the relative abundance of natural-origin spawners and life history diversity across the populations in the DPS. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms (i.e., A-Index versus B-Index). A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations. Overall, the information analyzed for the 2015 status review does not indicate a change in biological risk status (NWFSC 2015).

2.2.4.6 Life-History and Status of the Upper Columbia River Steelhead DPS

On August 18, 1997, NMFS listed the UCR Steelhead DPS as an endangered species (62 FR 43937). The UCR steelhead was then listed as a threatened species as of January 5, 2006 (71 FR 834). This DPS was re-classified as endangered on January 13, 2007 (74 FR 42605). However, the status was changed to threatened again in 2009 (74 FR 42605) and was reaffirmed on April 14, 2014 (79 FR 20802). Critical habitat for the UCR Steelhead DPS was designated on September 2, 2005 (70 FR 52630).

The UCR Steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well as five artificial propagation programs (Table 2-68, Figure 2-17) (Jones Jr. 2015; NWFSC 2015). As explained by NMFS (2005d), genetic resources can be housed in a hatchery program but, for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS.

As with LCR Steelhead DPS, 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 (Table 2-68 and Figure 2-17).

Table 2-68. UCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as endangered in 1997; reviewed and listed as threatened in 2009 and updated in 2014.
3 major population groups	4 historical populations
Major Population Group	***Populations***
North Cascades	Wenatchee River, Entiat River, Crab Creek, Methow River, Okanogan River
Upper Columbia River above Chief Joseph Dam	Sanpoil River, Kettle River, Pend Oreille, Kootenay River
Spokane River	Spokane River, Hangman Creek
Artificial production	
Hatchery programs included in DPS (5)	Wenatchee River summer, Okanogan River summer, Wells Hatchery Complex summer, Winthrop NFH summer, Ringold Hatchery summer
Hatchery programs not included in DPS (0)	n/a

The life-history pattern of steelhead in the UCR Basin is complex (Chapman et al. 1994). UCR steelhead exhibit a stream-type life with individuals exhibiting a yearling life history strategy (NMFS 2016h). Adults return to the Columbia River in the late summer and early fall. Unlike spring-run Chinook salmon, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem Columbia River reservoirs, passing into tributaries to spawn in April and May of the following year. Spawning occurs in the late spring of the year following entry into the Columbia River. Juvenile steelhead generally spend one to three years rearing in freshwater before migrating to the ocean, but have been documented spending as many as seven years in freshwater before migrating (Peven 1990; Mullan et al. 1992). Most adult steelhead return to the UCR Basin after one or two years at sea. Steelhead in the Upper Columbia Basin have a relatively high fecundity, averaging between 5,300 and 6,000 eggs (Chapman et al. 1994; UCSRB 2007).

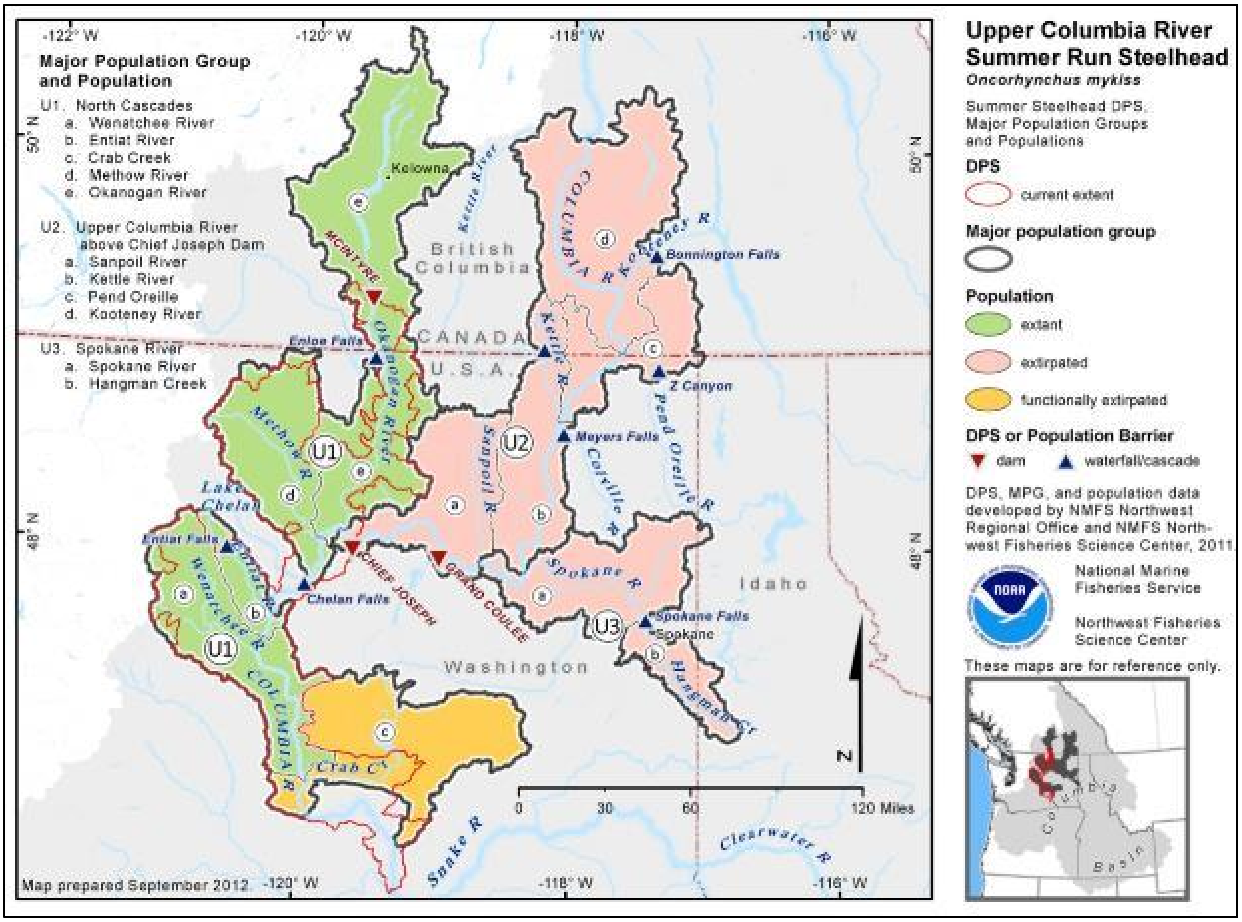


Figure 2-17. Map of the UCR Steelhead DPS's spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

Steelhead can residualize (i.e., lose the ability to smolt) in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. Despite the apparent reproductive exchange between resident and anadromous *O. mykiss*, the two life forms remain separated physically, physiologically, ecologically, and behaviorally. Steelhead differ from resident rainbow trout physically in adult size and fecundity, physiologically by undergoing smoltification, ecologically in their preferred prey and principal predators, and behaviorally in their migratory strategy. Given these differences, NMFS believes that the anadromous steelhead populations are discrete from the resident rainbow trout populations (UCSRB 2007).

The 2011 status review (Ford 2011) evaluated the status of the UCR Steelhead DPS based on data series through cycle year 2008/2009 for each of the four extant populations, along with sampling information collected at Priest Rapids Dam for the aggregate return to the Upper Columbia Basin and Wells Dam (Methow and Okanogan populations combined). Estimates generated using that methodology are currently available through the 2013/2014 cycle years for each population (Ford 2011). It is anticipated that future estimates of annual population level spawning escapements for the UCR Steelhead DPS will be based on improved methods compared to past years.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR Steelhead DPS, is at high risk and remains at threatened status. The most recent status update used updated data series on spawner abundance, age structure, and hatchery-to-wild spawner proportions to generate current assessments of abundance and productivity at the population level. Evaluations were done using both a set of metrics corresponding to those used in the prior BRT reviews as well as a set corresponding to the specific viability criteria based on the ICTRT recommendations for this DPS. The BRT level metrics were consistently applied across all ESUs and DPSs to facilitate comparisons across domains (NWFSC 2015).

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 (Table 2-69). None of the populations have reached their recovery goal numbers during any of the years, much less in successive years with the recovery goals being 500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee (Table 2-69). Specifically, the Okanogan River natural-origin spawner abundance estimates are well below the recovery goal for that population.

Table 2-69. UCR Steelhead DPS natural-origin summer spawner abundance estimates for each of the four populations (WDFW SCoRE[1])*.

Year	Entiat River (500)[2]	Methow River (2,300)[2]	Okanogan River (2,300)[2]	Wenatchee River (3,000)[2]
1997	31	164	27	242
1998	37	69	20	252
1999	38	136	40	239
2000	51	242	64	356
2001	98	336	99	704
2002	266	562	157	1,968
2003	117	489	142	853
2004	94	652	189	656
2005	116	496	142	813
2006	128	422	119	906
2007	59	396	103	387
2008	123	729	213	714
2009	102	656	184	709
2010	297	1,102	314	2,237
2011	293	987	285	2,189
2012	190	770	235	1,420
2013	129	494	152	931
2014	185	1,002	309	1,151
2015	234	1,113	330	1,736

2016	80	942	292	1,130

[1]online at: https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geoarea=SRR_UpperColumbia&geocode=srr
*Date Accessed: October 4, 2017
[2] numbers inside parentheticals are the minimum abundance thresholds under the recovery scenario.

All extant natural populations are considered to be at high risk of extinction (Table 2-70) (Ford 2011; NWFSC 2015). The high risk ratings for SS/D are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery-origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations. In 2015, the 5-year review for the UCR steelhead concluded the species should maintain its threatened listing classification (NWFSC 2015).

Table 2-70. Summary of the key elements (A/P, diversity, and SS/D) and scores used to determine current overall viability risk for UCR steelhead populations (NWFSC 2015).[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

The recovery plan for this species (UCSRB 2007) incorporates viability criteria recommended by the ICTRT. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements- abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). Achieving recovery (delisting) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the recovery plan (NWFSC 2015). Table 2-71 shows the most recent metrics for the UCR Steelhead DPS. This recovery plan includes specific quantitative criteria expressed relative to population viability curves (ICTRT 2007). The plan also establishes minimum productivity thresholds.

The ICTRT had recommended that at least two of the four extant populations be targeted for highly viable status (less than 1% risk of extinction over 100 years) to achieve a recovery target because of the relatively low number of extant populations remaining in the ESU. This recovery plan adopted an alternative approach for addressing the limited number of populations in the ESU—5% or less risk of extinction for at least three of the four extant populations (NWFSC 2015).

The UC Recovery Plan also calls for "… restoring the distribution of naturally produced spring-run Chinook salmon and steelhead to previously occupied areas where practical, and conserving their genetic and phenotypic diversity." Specific criteria included in the UC Recovery Plan reflect a combination of the criteria recommended by the ICTRT (ICTRT 2007) and an earlier pre-TRT analytical project (Ford et al. 2001). The plan incorporates spatial structure criteria specific to each steelhead population. For the Wenatchee River population, the criteria require observed natural spawning in four of the five major spawning areas as well as in at least one of the minor spawning areas downstream of Tumwater Dam. For the Methow River population, natural spawning should be observed in three major spawning areas. In each case, the major spawning areas should include a minimum of 5% of the total return to the system, or 20 redds, whichever is greater. The plan incorporates criteria for spatial structure and diversity adopted from the ICTRT viability report. The mean score for the three metrics representing natural rates and spatially mediated processes should result in a moderate or lower risk in each of the three populations and all threats defined as high risk must be addressed. In addition, the mean score for the eight ICTRT metrics tracking natural levels of variation should result in a moderate or lower risk score at the population level (NWFSC 2015).

UCR steelhead populations have increased in natural-origin abundance in recent years, but productivity levels remain low (Table 2-71). The modest improvements in natural returns are probably primarily the result of several years of relatively good natural survival in the ocean and tributary habitats (NWFSC 2015; NMFS 2016h). The UCR steelhead populations sizes have increased relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remain well below viability thresholds for three out of the four populations (Table 2-71). The status of the Wenatchee River steelhead population continued to improve, based on the additional years information available for the most recent 2015 status review. The abundance and productivity viability rating for the Wenatchee River population exceeds the minimum threshold for 5% extinction risk (Table 2-72). However, the overall DPS status remains unchanged from the prior review at high risk, driven by low abundance and productivity relative to viability objectives and diversity concerns. The required improvements to improve the abundance/productivity estimates for the UCR steelhead populations are at the high end of the range for all listed Interior Columbia DPS populations (NWFSC 2015).

Table 2-71. Viability assessments for extant natural populations within the UCR Steelhead DPS (NWFSC 2015).[1]

Population	Abundance and productivity metrics				Spatial structure and diversity metrics			Overall viability rating
	ICTRT minimum threshold	**Natural spawning abundance**	**ICTRT productivity[2]**	**Integrated A/P risk[3]**	**Natural processes risk**	**Diversity risk**	**Integrated SS/D risk**	
Wenatchee River 2005–2014	1,000	1,025 ↑ (386-2,235)	1.207 ○ (.021, 3/20)	Low	Low	High	High	Maintained
Entiat River 2005–2014	500	146 ↑ (59-310)	0.434 ↓ (.22, 12/20)	High	Moderate	High	High	High risk
Methow River 2005–2014	1,000	651 ↑ (365-1,105)	0.371 ○ (0.37, 3/20)	High	Low	High	High	High risk
Okanogan River 2005–2014	750	189 ↑ (107-310)	0.154 ○ (.275, 6/20)	High	High	High	High	High risk

[1] Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error and number of qualifying estimates for productivities in parentheses. Upward arrows: current estimates increased over prior review. Oval: no change since prior review. Downward arrow: current estimates decreased over prior review (NWFSC 2015).
[2] This column is expressed in most recent 10-year geometric mean, with the range in parentheses.
[3] This column is expressed in 20-year geometric mean for parent escapements below 75% of population threshold.

Table 2-72. Matrix used to assess natural population viability risk rating across VSP parameters for the UCR Steelhead DPS[1].

		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk[2]	Very Low (<1%)	HV	HV	V	M
	Low (1-5%)	V	V	V	M Wenatchee R.
	Moderate (6 – 25%)	M	M	M	HR
	High (>25%)	HR	HR	HR	HR Entiat R. Methow R. Okanogan R.

[1] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk. The darkest cells indicate combinations of A/P and SS/D at greatest risk (NWFSC 2015).
[2] Percentage represents the probability of extinction in a 100-year time period.

Limiting Factors

Understanding the limiting factors and threats that affect the UCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. It is unlikely that the aboriginal fishing (pre-1930s) was responsible for steelhead declines in the Columbia River (UCSRB 2007). Their artisanal fishing methods were incapable of harvesting UCR steelhead at rates that approached or exceeded optimal maximum sustainable yield, probably 69% for steelhead, as estimated in Chapman (1986); UCSRB (2007). Instead, commercial fishing had a significant effect on the abundance of steelhead in the Columbia River. An intense industrial fishery in the LCR, employing traps, beach seines, gillnets, and fish wheels, developed in the latter half of the 1800s. Intensive harvest not only affected abundance and productivity of fish stocks, but probably also the diversity of populations (UCSRB 2007).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower effects, agricultural effects, and habitat degradation; together these factors have affected the populations of this DPS (UCSRB 2007).

The Upper Columbia Recovery Plan (UCSRB 2007) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them (Chapters 4, 5, and 8). The plan indicates that the highest priority for protecting biological productivity of UCR salmonids should be to allow unrestricted stream channel migration, complexity and floodplain function. The principal means to meet this objective is to protect riparian habitat in category 1 and 2 sub-watersheds. The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.
Some of the main limiting factors are listed below:

- Mainstem Columbia River hydropower-related adverse effects,
- Impaired tributary fish passage,
- Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality,
- Hatchery-related effects,
- Predation and competition, and
- Harvest-related effects.

Although all of the natural populations in the DPS remain at high risk and the DPS remains to be listed as threatened, ongoing genetic sampling and analysis could provide information in the future to determine if the diversity risk is abating. The proportions of hatchery-origin returns in natural spawning areas remain high across the DPS, especially in the Methow and Okanogan River populations. The improvements in natural returns in recent years largely reflect several years of relatively good natural survival in the ocean and tributary habitats. Tributary habitat actions called for in the Upper Columbia Recovery Plan are anticipated to be implemented over the next 25 years, and the benefits of some of those actions will require some time to be realized (NWFSC 2015).

2.2.5 Non-salmonid DPSs

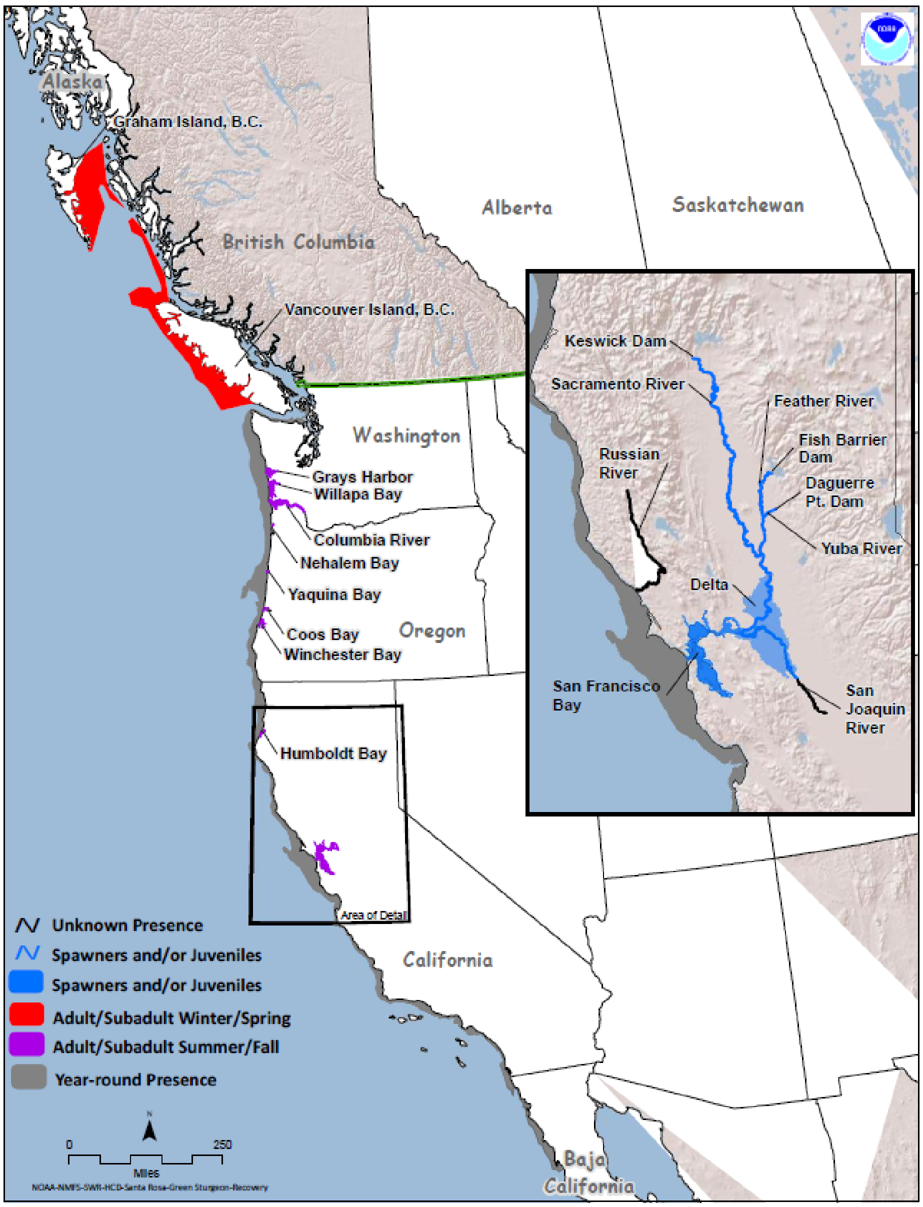
2.2.5.1 Life-History and Status of the Southern DPS of Green Sturgeon

On April 7, 2006, NMFS listed the Southern DPS of North American green sturgeon (*Acipenser medirostris*) as a threatened species (71 FR 17757). Critical habitat for Southern DPS Green Sturgeon was designated on October 9, 2009 (74 FR 52300). NMFS recently published a draft recovery plan for this DPS for the purpose of soliciting public comment.[11]

Green sturgeon are broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Green sturgeon are commonly observed in bays, estuaries, and sometimes the deep riverine

[11] The draft recovery plan is available at http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/other_species/draft_sdps_green_sturgeon_recovery_plan_1_4_18_final.pdf

mainstem in lower elevation reaches of non-natal rivers along the west coast of North America, including the lower Columbia River estuary; however, the distribution and timing of estuarine use are poorly understood (NMFS 2015d). Green sturgeon consist of two Distinct Population Segments (DPS) that co-occur throughout much of their range, but use different river systems for spawning. All naturally-spawned populations of green sturgeon originating from coastal watersheds south of the Eel River in Humboldt County, California (known spawning populations in the Sacramento River system) are considered part of the Southern DPS. The Northern DPS consists of populations originating from coastal watersheds north of and including the Eel River



(known spawning populations in the Eel, Klamath, and Rogue Rivers). The Northern DPS is not listed as threatened or endangered, but is a NMFS Species of Concern.

Figure 2-18. Map of Southern DPS green sturgeon distribution (NMFS 2010c).

No hatchery programs exist for the green sturgeon. Southern DPS green sturgeon are confirmed to occur in the WLC, Oregon Coast (OC), and Southern Oregon/Northern California Coasts (SONCC) recovery domains. In many Oregon coastal systems inadequate data exists to confirm their presence, but presence has been established in Coos Bay, Winchester Bay (Umpqua River), Yaquina Bay, Nehalem Bay, and the Columbia River estuary (Figure 2-18) (NMFS 2010c).

Research conducted and published since 2006 confirms and enhances our understanding of the biology and life history of Southern DPS green sturgeon, including reproductive characteristics. North American green sturgeon are thought to reach sexual maturity at about 15 years of age (Van Eenennaam et al. 2006) or a total length of 150-155 cm for Southern DPS individuals. They can live to be 70 years old. Unlike salmon, they can spawn several times during their long lives, returning to their natal rivers every three to four years (range two to six years; Brown 2007; Poytress et al. 2013). They are long lived, late maturing, and spend substantial portions of their lives in marine and estuarine waters (NMFS 2010c). During spawning runs, adult Southern DPS fish enter the San Francisco Bay between mid-February and early May before rapidly migrating up the Sacramento River to spawn. Spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble, or boulder substrate (NMFS 2015d). In fall, these post spawn adults move back down the river and re-enter the ocean. After hatching, larvae and juveniles rear in their natal river or estuary before migrating to the ocean. As subadults and adults, Southern DPS green sturgeon migrate seasonally along the West Coast, congregating in bays and estuaries in Washington, Oregon, and California during the summer and fall months. During winter and spring months, they congregate off of northern Vancouver Island, B.C., Canada.

It is likely that green sturgeon inhabit estuarine waters to feed and optimize growth (Moser and Lindley 2007). Individual green sturgeon exhibit diel movements using deeper water during the day and moving to shallower water during the night to feed. The movements of green sturgeon are likely influenced by feeding behavior, tidal stage, and possibly light conditions (NMFS 2010c). Little is known about green sturgeon diet in estuaries. Stomach sampling is challenging and most studies have depended on samples collected from specimens at the dock or processing plants where stomachs have been partially or completely empty. The best results are samples collected on the boat immediately after landing. Green sturgeon in Willapa Bay were found to feed primarily on benthic prey (*e.g.* Dungeness crab, crangonid shrimp, and thalassinid shrimp) and fish (Dumbauld et al. 2008). A very limited sample of green sturgeon stomachs in the Columbia River found mostly crangonid shrimp and some thalassinid shrimp (Dumbauld et al. 2008).The presence of these prey species suggest the sampled green sturgeon fed in the saline and brackish water reaches lower in the Columbia River estuary (downstream of approximately Columbia River mile 30) (NMFS 2010c; 2015d).

Overall, the new information on the biology of the species provides insights for protecting Southern DPS green sturgeon habitat in freshwater and marine environments. Estuaries along the West coast are important habitats for subadult and adult Southern DPS green sturgeon populations. A final, approved recovery plan containing objective, measurable data is not yet available for the Southern DPS, though a Federal Recovery Outline was issued in December 2010 (NMFS 2010c; 2015d).

Abundance, Productivity, Spatial Structure, and Diversity

The status of the species is based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that Southern DPS green sturgeon is at moderate risk and remains in threatened status. Reduction of potential spawning habitat, severe threats to the single remaining spawning population, coupled with the inability to alleviate these threats using current conservation measures, as well as the continued decline in numbers of juveniles in the past two decades were determined to be the most critical factors in concluding that the species is threatened. Recent research efforts have focused on monitoring early life history stages and estimating spawning adult abundance to better evaluate overall species status (NMFS 2015d; Mora et al. In press.).

Population-level data for green sturgeon has only recently been collected for some river systems. The most useful present dataset for examining population trends and inferring abundance comes from Dual Frequency Identification Sonar (DIDSON) surveys, which began in 2010 and are ongoing. The surveys have been used to estimate the abundance of Southern DPS adults in the upper Sacramento River (current estimate: 2,106 adults, with 95% confidence interval [CI] = 1,246-2,966; Mora et al. In Press). There are some caveats regarding these estimates. Movement of individual fish in and out of the area throughout the season could affect the estimate. The estimate also potentially does not reflect the total Southern DPS population as it does not include fish spawning in the lower Feather River. Most spawning occurs in the mainstem Sacramento River, but an unknown portion of the population spawns in the lower Feather River and potentially in the lower Yuba River. Data are not available at this time to estimate the number of spawning adults in those rivers. The DIDSON surveys and associated modeling will eventually provide population abundance trends over time.

The proportion of juveniles, subadults, and adults in the Southern DPS population at equilibrium (25% juveniles, 63% sub-adults, and 12% adults; Beamesderfer et al. 2007) can be used to generate estimates of subadult abundance and the overall population abundance. Based on this equilibrium and the above assumptions, the population estimates are 11,055 sub-adults (95% CI = 6,540 – 15,571) and a total 17,548 adults, subadults, and juveniles combined (95% confidence interval = 12,614 – 22,482; Mora et al. In Press).

Information on productivity, recruitment, and diversity for Southern DPS green sturgeon is currently limited. In general, sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010c). Productivity is likely reduced because of restriction of spawning to one area in the mainstem Sacramento River and continuing impacts to the remaining spawning habitat. The loss and alteration of available spawning habitat has also potentially reduced the genetic diversity and diversity of life history traits of Southern DPS green sturgeon. This reduction would increase the risk of extinction to the species by limiting the population's ability to withstand short-term environmental changes and to adapt to long-term environmental changes.

In summary, recent studies are providing preliminary information on the population abundance of Southern DPS green sturgeon. Future surveys and abundance estimates will provide a basis for understanding the population trajectory of the Southern DPS. Since there are no past survey data or abundance estimates that can be used as a reference point, these data do not provide a basis for changing the status of the Southern DPS. These data do suggest that the spawning population of the Southern DPS is smaller than the Northern DPS, which is consistent with the threatened listing for the Southern DPS, but not the Northern DPS. The spawning population of the Southern DPS in the Sacramento River congregates in a limited area of the river compared to potentially available habitat. The reason for this is unknown. This is concerning given that a catastrophic or targeted poaching event impacting just a few holding areas could affect a significant portion of the adult population. No comparable data on holding area occupancy within the Sacramento River were available at the time of the last status review, making it difficult to assess whether the current observations reflect an improvement or decline in the species status. Removal of the Red Bluff Diversion Dam (RBDD) in the Sacramento River did allow Southern DPS green sturgeon to freely access a larger area of the river over their entire spawning period (Thomas et al. unpublished) so the Southern DPS likely now holds in a larger area of the river compared to prior to the decommissioning of the RBDD in 2011. Continued monitoring of the adult population in the Sacramento River will provide valuable trend data and information to enhance spatial protection. The most recent status review notes that no changes to the species status or threats are evident since the last review based on the reviewed information on abundance and demographic trends (NMFS 2015d).

Limiting Factors

Understanding the limiting factors and threats that affect the Southern DPS green sturgeon provides important information and perspective regarding the status of the species. The principal factor for the threatened status of Southern DPS green sturgeon is the reduction of its spawning area to a small portion of the Sacramento River and lower Feather River. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Southern DPS. Factors that limit the Southern DPS have been, and continue to be, human-induced “takes” involving elimination of freshwater spawning habitat, degradation of freshwater and estuarine habitat quality, water diversions, fishing, and other causes (NMFS 2010c; 2015d).Climate change also has the potential to impact Southern DPS green sturgeon, for example, by affecting water temperatures and flow rates in spawning and rearing habitats; however, the direction of the impact on the Southern DPS is not known at this time (NMFS 2015d).

Additionally, retention of green sturgeon in both recreational and commercial fisheries is now prohibited within the western states as of 2007, but the effect of capture/release in these fisheries is unknown. There is evidence of fish being retained illegally, although the primary concern is the extent of injury or mortality occurring during capture and release of these fish (NMFS 2010c; 2015d).

Table 2-73 below lists the fisheries that occur outside of the action area (i.e., fisheries outside of the Columbia River) and that encounter Southern DPS green sturgeon. For each fishery, we summarize the estimated incidental catch and mortality of Southern DPS fish, including adults and subadults. This summary does not include Klamath tribal fisheries because the green sturgeon harvested in that fishery belong to the Northern DPS.

Table 2-73. Summary of estimated incidental catch and mortality of Southern DPS green sturgeon (number of fish) in commercial and recreational fisheries occurring outside of the action area (outside of the Columbia River). The text below describes these estimates.

Fishery	Estimated SDPS Incidental catch		Estimated SDPS Mortalities	
	Low estimate	High estimate	Low estimate	High estimate
Pacific Coast Groundfish Fishery[1]	22	40	3	4
Pacific Halibut Fishery[2]	0	3	0	1
California Halibut bottom trawl fishery[1]	28	631	3	65
Central Valley, CA, recreational fisheries[3]	89	202	3	5
Oregon recreational fisheries[4]	0	33	0	2
Washington State fisheries[5]	375	375	18	18
Canada commercial groundfish trawl fisheries[6]	--	--	--	--
Alaska commercial groundfish trawl fisheries[7]	--	--	--	--
TOTAL	492	1241	24	90

[1] (Lee et al. 2017) (Observed and estimated bycatch of green sturgeon in 2002-2015 West Coast Groundfish Fisheries)
[2] (NMFS 2017s), Consultation Number 2017-6480 (Consultation on Pacific Halibut Fishery for 2017)
[3] CDFW sturgeon report card data for 2007-2016 (Gleason et al. 2008; DuBois et al. 2009; DuBois et al. 2010; DuBois et al. 2011; DuBois et al. 2012; DuBois 2013; DuBois et al. 2014; DuBois and Harris 2015; 2016; DuBois and Danos 2017)
[4] ODFW Sturgeon Catch Data 1995-2015, excluding fisheries in the Columbia River (ODFW 2017)
[5] (WDFW 2011)(Draft Fishery Management and Evaluation Plan for state-managed commercial and recreational salmon and white sturgeon fisheries that encounter green sturgeon); pers. comm. with K. Hughes, WDFW, January 30, 2015.
[6] (Fisheries and Oceans Canada 2016)
[7] North Pacific Groundfish Observer Program data

For the Pacific Coast groundfish fishery and California halibut bottom trawl fishery, data on green sturgeon incidental catch are available from the NOAA Observer Programs (Lee et al. 2017). Most of the green sturgeon encountered are released alive; however, some portion of the fish are observed dead or die after being released back into the water. This bycatch mortality rate (including immediate and post-release mortality) is estimated at 8% for the Pacific Coast groundfish fishery and 10.3% for the California Halibut fishery (NMFS 2017s).

The Pacific Halibut fishery includes commercial and recreational long-line, troll, and hook-and-line fisheries operating in Puget Sound and throughout the coast from Washington to northern California. Catch monitoring for green sturgeon is limited and varies by fishery sector and area. Overall, encounters with green sturgeon are rare, ranging from zero to three fish per year, with no encounters in most years (NMFS 2017s, Consultation number 2017-6480). All green sturgeon encountered are released alive; however, some portion may die following release, estimated at 2.6% based on the gear used (Robichaud et al. 2006).

In California, the commercial sturgeon fishery has been closed since 1917 (Pycha 1956) but recreational white sturgeon fisheries continue in the Central Valley and involve incidental catch of Southern DPS green sturgeon. CDFW sturgeon report card data from 2007 – 2016 show that incidental catch of green sturgeon has ranged from 215-311 fish per year from 2007-2009 and from 89-202 fish per year from 2010-2016, after enactment of sturgeon fishing area closures in 2010 (Gleason et al. 2008; DuBois et al. 2009; DuBois et al. 2010; DuBois et al. 2011; DuBois et al. 2012; DuBois 2013; DuBois et al. 2014; DuBois and Harris 2015; 2016; DuBois and Danos 2017). All green sturgeon are released alive, but some portion may die after release, estimated at 2.6% for hook-and-line fisheries (Robichaud et al. 2006).

In Oregon, green sturgeon were historically harvested in the recreational sturgeon fisheries conducted in coastal estuaries. Catch of green sturgeon has been reduced compared to historical levels to 6-59 fish per year from 2008-2015, with no reported green sturgeon catches in 2011-2013 (excluding fisheries in the Columbia River; ODFW 2017). Assuming that 16-55% of green sturgeon caught in Oregon belong to the Southern DPS (based on genetic stock composition analyses; Israel et al. 2009), we estimate that the recreational fisheries incidentally catch 0-33 and kill 0-2 Southern DPS green sturgeon per year, using an estimated post-release mortality rate of 2.6% for hook-and-line fisheries (Robichaud et al. 2006).

In Washington, harvest of green sturgeon primarily occurred in state-regulated commercial and recreational fisheries targeting white sturgeon or salmon in the large coastal estuaries. Catch of green sturgeon has been reduced from historical levels as a result of management measures (WDFW 2011). WDFW estimates that state commercial and recreational fisheries (excluding the Columbia River fisheries) may incidentally catch up to 375 and kill up to 18 Southern DPS green sturgeon per year (Kirt Hughes, pers. comm., WDFW, January 30, 2015). These are conservative estimates (potentially overestimates), based on the maximum historical harvest levels recorded during a time when the salmon and white sturgeon fishing seasons were structured similarly to what is expected in the future (WDFW 2011).

Incidental catch of green sturgeon also occurs in commercial fisheries off British Columbia and Alaska; however, limited information is available at this time to estimate incidental catch and mortality levels and whether the fish belong to the Northern or Southern DPS. Off British Columbia, green sturgeon are encountered in the commercial groundfish trawl fishery, with incidental catch recorded by weight rather than number of fish (Fisheries and Oceans Canada 2016). Canada prohibits retention of green sturgeon in all fisheries; thus, green sturgeon encountered in this fishery are released alive. Off Alaska, green sturgeon are encountered on a rare basis in Federal groundfish trawl fisheries, based on data from the North Pacific Groundfish Observer Program (data received April 2015). No information is available on green sturgeon catch in fisheries off Baja California, Mexico; however, catch is likely negligible, given the rare occurrence of green sturgeon in waters off Mexico.

Overall, many of the principle factors considered when listing Southern DPS green sturgeon as threatened are relatively unchanged. For example, recent studies confirm that the spawning area used by Southern DPS green sturgeon is small. Many threats are ongoing, such as impassable barriers in the Sacramento River system that limit the species' spawning range. Current levels of green sturgeon catch in commercial and recreational fisheries have been considerably reduced compared to historical levels, due to prohibitions on retention of green sturgeon and other management measures to reduce incidental catch. However, incidental catch of green sturgeon continues to occur in fisheries. This population remains at a threatened status and further research and monitoring is needed to inform future status assessments for this species.

2.2.6 Status of Critical Habitat

This Section of the opinion examines the range-wide status of designated critical habitat for the affected species. NMFS has reviewed the status of critical habitat affected by the proposed action. Within the action area (defined in Section 2.3, Action Area), critical habitat is designated for those species affected by the proposed action listed in in Sections 2.2.2 through 2.2.5. Critical habitat for these species includes the stream channels within designated stream reaches and a lateral extent, as defined by the ordinary high-water line (33 CFR 319.11).

We review the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the range of the action area. Examining these physical and biological features is important because these features support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging) and are essential to the conservation of the listed species.

For salmon and steelhead, NMFS categorized watersheds as high, medium, or low in terms of the conservation value that the watersheds provide to each listed species they support[12] within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC_5). 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 (i.e., spawning gravels, wood and water condition, side channels), the relationship of the specific geographic area being examined compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005b). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential because of factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution to the population it served (e.g., for a population at the extreme end of geographic distribution), or the fact that it serves another important role besides providing habitat (e.g., obligate area for migration to upstream spawning areas).

This Section examines relevant critical habitat conditions for the affected anadromous species discussed in the previous Section. The analysis is grouped by the similarity of essential physical and biological features for each species and the overlapping critical habitat areas.

NMFS determines the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The species in Table 1-1 have overlapping ranges, similar life history characteristics, and, therefore, many of the same PCEs. These PCEs include sites essential to support one or more life stages (spawning, rearing, and/or migration) and contain the physical and biological features essential to the conservation of each species. For example,

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[12] 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" (NMFS 2005b).

important features include spawning gravels, forage species, cover in the form of submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

The complex life cycle of many salmonids gives rise to complex habitat needs, particularly when the salmonids are in freshwater. ESU's or DPS's specific needs are captured in each general life history characteristic table in Sections 2.2.2 through 2.2.4. For each species, the gravel they utilize for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need in-stream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005c).

The watersheds within the action area (as described in Section 2.3) have been designated as essential for spawning, rearing, juvenile migration, and adult migration for many of the listed species in Table 1-1. Specific major factors affecting PCEs and habitat related limiting factors within the action area are described for each species in Sections 2.2.2. through 2.2.4. However, across the entire action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Within estuaries, essential PCEs have been defined as "areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation" (NMFS 2008b).

The conservation role of salmon and steelhead critical habitat is to provide PCEs that support populations that can contribute to conservation of ESUs and DPSs. NMFS' critical habitat designations for salmon have noted that the conservation value of critical habitat also considers

"(1) the importance of the populations associated with a site to the ESU conservation, and (2) the contribution of that site to the conservation of the population either through demonstrated or potential productivity of the area." (68 FR 55926, September 29, 2003). This means that, in some cases, having a small area within the total area of designated critical habitat with impaired habitat features could result in a significant impact on conservation value of the entire designated area, when that particular habitat location serves an especially important role to the population and the species' recovery needs (e.g., unique genetic or life history diversity, critical spatial structure). In other words, because the conservation value of habitat indicates that its supporting important viability parameters of populations, conservation values themselves therefore may be considered impaired (NMFS 2016h).

Critical habitat for Southern Green Sturgeon DPS was designated on October 9, 2009 (74 FR 52300). Coastal waters included as critical habitat stretch from Monterey Bay, CA to Cape Flattery, WA and include the Strait of Juan de Fuca to the U.S. border with Canada. Bays in California, Oregon, and Washington are included as well as the Columbia River estuary, the Sacramento-San Joaquin Delta, and the Sacramento, lower Feather, and lower Yuba Rivers in California (NMFS and NOAA 2009). Evidence of limited green sturgeon spawning in the lower Feather River below Oroville Dam has been documented during wet years, indicating this area may be important in supporting additional reproduction that could potentially allow the population size to increase (Seesholtz et al. 2015).

Willamette/Lower Columbia Recovery Domain

NMFS has designated critical habitat in the WLC recovery domain for the UWR spring-run Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, UWR Steelhead DPS, Columbia River Chum Salmon ESU, and the Southern DPS of Green Sturgeon (Table 1-1). This recovery domain is described in Section 2.3. In addition to the Willamette River and Columbia River mainstems, important tributaries to the WLC are also described in Section 2.3 for both Oregon and Washington. Most watersheds have some or a high potential for improvement and the only watersheds in good to excellent condition with no potential for improvement are the watersheds in the upper McKenzie River and its tributaries (NMFS 2016h).

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 subbasin mainstem reaches, high density urban development and widespread agricultural effects have reduced aquatic and riparian habitat quality and complexity, and altered sediment composition and water quality and/or 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% since before modern development began. In addition, the construction of 37 dams in the basin blocked access to more than 435 miles of stream and river habitat, including much of the best spawning habitat in the basin. 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, agriculture, urbanization, and gravel mining in the Cascade and Coast Ranges have contributed to increased erosion and sediment loads throughout the WLC domain (NMFS

2016h).

On the mainstem of the Columbia River, hydropower projects, including the FCRPS, have significantly degraded salmon and steelhead habitats. 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. 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 as a result of the FCRPS modifications to these mainstem river processes. Furthermore, 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 (NMFS 2016h).

Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia recovery domain, which includes the Snake River Basin, for the Snake River spring/summer-run Chinook Salmon ESU, Snake River fall-run Chinook Salmon ESU, UCR spring-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, MCR Steelhead DPS, UCR Steelhead DPS, and Snake River Basin Steelhead DPS (Table 1-1). Major tributaries relative to the interior Columbia River recovery domain are described later on in Section 2.3 for areas where the WLC and interior Columbia River overlap, as well as tributaries specific just to the interior Columbia River upstream into Oregon, Washington, and Idaho. The boundary to this large and diverse recovery domain is described in Section 2.3, Action Area. 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, Upper and Lower Imnaha Rivers HUC_5 watersheds are in good-to-excellent condition with no potential for improvement. In Idaho, some watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, MF Salmon, Little Salmon, Selway, and Lochsa Rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (NMFS 2016h).

Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and road-less areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through 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 reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the interior Columbia River recovery domain (NMFS 2016h).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper

Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in higher water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016h).

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho'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 for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016h). They can negatively impact critical habitat and the organisms associated with these areas.

Estuaries

Critical habitat has been designated in the estuary of the Columbia River for every species listed in Section 2.2.2 through 2.2.5. This area is described in Section 2.3. Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008g).

Over time, more than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008g).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more. The significance of these changes for anadromous species under NMFS' jurisdiction in this area is unclear, although estuarine habitat is likely to provide ecosystem services (e.g., food and refuge from predators) to subyearling migrants that reside in estuaries for up to two months or more (NMFS 2008g).

(NMFS 2005c) identified the PCEs for Columbia basin salmonids in estuaries:

- Estuarine areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

These features are essential to conservation because, without them, juvenile salmonids cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2008e).

2.2.7 Climate Change

One factor affecting the rangewide status of species in Table 1-1, and aquatic habitat at large is climate change. The U.S. Global Change Research Program (USGCRP)[13], mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011 and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the Independent Scientific Advisory Board (ISAB)[14], these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, these watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

[13] http://www.globalchange.gov

[14] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Overall, climate change effects are likely to occur to some degree over the next ten years expected at a similar rate as the last ten years.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- direct effects of increased water temperatures of fish physiology
- temperature-induced changes to stream flow patterns
- alterations to freshwater, estuarine, and marine food webs
- changes in estuarine and ocean productivity

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011). This occurred in 2015 on Upriver Sockeye in the Columbia River when over 475,000 sockeye entered the River but only 2% of sockeye counted at Bonneville Dam survived to their spawning grounds. Most died in the Columbia River beginning in June when the water warmed to above 68 degrees, the temperature at which salmon begin to die. It got up to 73 degrees in July due to elevated temperatures associated with lower snow pack from the previous winter and drought conditions exacerbate due to increased occurrences of warm weather patterns.

Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals), therefore increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. (2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes including: increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016). As examples of this, high mortality rates for adult sockeye salmon in the Columbia River have recently been attributed to higher water temperatures and likewise in the Fraser River, as increasing temperatures during adult upstream migration are expected to result in increased mortality of sockeye salmon adults by 9 to 16% by century's end (Martins et al. 2011). Juvenile parr-to-smolt survival of Snake River Chinook salmon are predicted to decrease by 31 to 47% due to increased summer temperatures (Crozier et al. 2008b).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

Freshwater Effects

As described previously, climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower elevation streams will have larger fall/winter flood events and lower late summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (Salmon River Basin, Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while others were determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and perhaps the rate of the increases while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River Basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

Marine Impacts

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "The Blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016), and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years of 2004-2009 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs" are predicted to increase in the future (Di Lorenzo and Mantua 2016). This is likely to occur to some degree over the next ten years, but at a similar rate as the last ten years.

As with changes to stream ecosystems, expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification, will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with the tools available at this time.

Pacific Northwest anadromous fish inhabit as many as three marine ecosystems during their ocean residence period: the Salish Sea, the California Current, and the Gulf of Alaska (Brodeur et al. 1992; Weitkamp and Neely 2002; Morris et al. 2007). The response of these ecosystems to climate change is expected to differ, although there is considerable uncertainty in all predictions. It is also unclear whether overall marine survival of anadromous fish in a given year depends on conditions experienced in one versus multiple marine ecosystems. Several are important to Columbia River Basin species, including the California Current and Gulf of Alaska.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift towards food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified down welling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish (see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015).

Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on Pacific Northwest in particular and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species examined in this analysis rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. (2008b); Martins et al. (2011); Martins et al. (2012). This means it is likely that there will be "winners and losers" meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of each individual population and on the level and rate of change. They should be able to adapt to some changes, but others are beyond their adaptive capacity (Crozier et al. 2008a; Waples et al. 2009). With their complex life cycles, it is also unclear how conditions experienced in one life stage are carried over to subsequent life stages, including changes to the timing of migration between habitats. Systems already stressed due to human disturbance are less resilient to predicted changes than those that are less stressed, leading to additional uncertainty in predictions (Bottom et al. 2011; Naiman et al. 2012; Whitney et al. 2016).

Climate change is expected to impact anadromous fish, (e.g., salmon, steelhead, and green sturgeon), during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

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). For purposes of this opinion, the action area includes the foot print of fisheries mentioned in the *US v Oregon* Agreement, and accessible salmon spawning and rearing areas in the Columbia River basin. As described in the biological assessment (TAC 2017) proposed fisheries may also have an indirect effect on the amount of marine derived nutrients returning to spawning and rearing areas due to a reduction in the number of adult fish that would otherwise return to spawn and die. The action area therefore extends from the fishery footprint upstream to include all accessible salmon spawning and rearing areas in the Columbia River basin. Thus, it includes portions of the states of Washington, Oregon, and Idaho and is described in more detail below with various major tributary points of reference. In regards to hatcheries, the action area includes all the areas where biological and or environmental effects resulting from hatchery programs referenced in the *US v Oregon* Agreement may occur.

The action area includes the Columbia River mainstem, the primary segment of the river as contrasted to tributary rivers that drain into it, from its mouth (an area of the estuary commonly referred to as Buoy 10 by the *US v Oregon* parties) upstream to Wanapum Dam (river mile 415) and to the Idaho – Washington state boundary just upstream of Lower Granite Dam on the Snake River mainstem (Snake River river mile (RM) 107) (Figure 2-19). These mainstem Columbia and Snake River areas are where the *US v Oregon* parties regulate fishing activities detailed in the *US v Oregon* Agreement in order to fairly share harvestable salmon and steelhead.

The *US v Oregon* Agreement also includes certain treaty Indian tributary fisheries as described in Section 1.3 Proposed Action, but since we have included all accessible salmon spawning and rearing areas in the Columbia River basin these areas are already included.

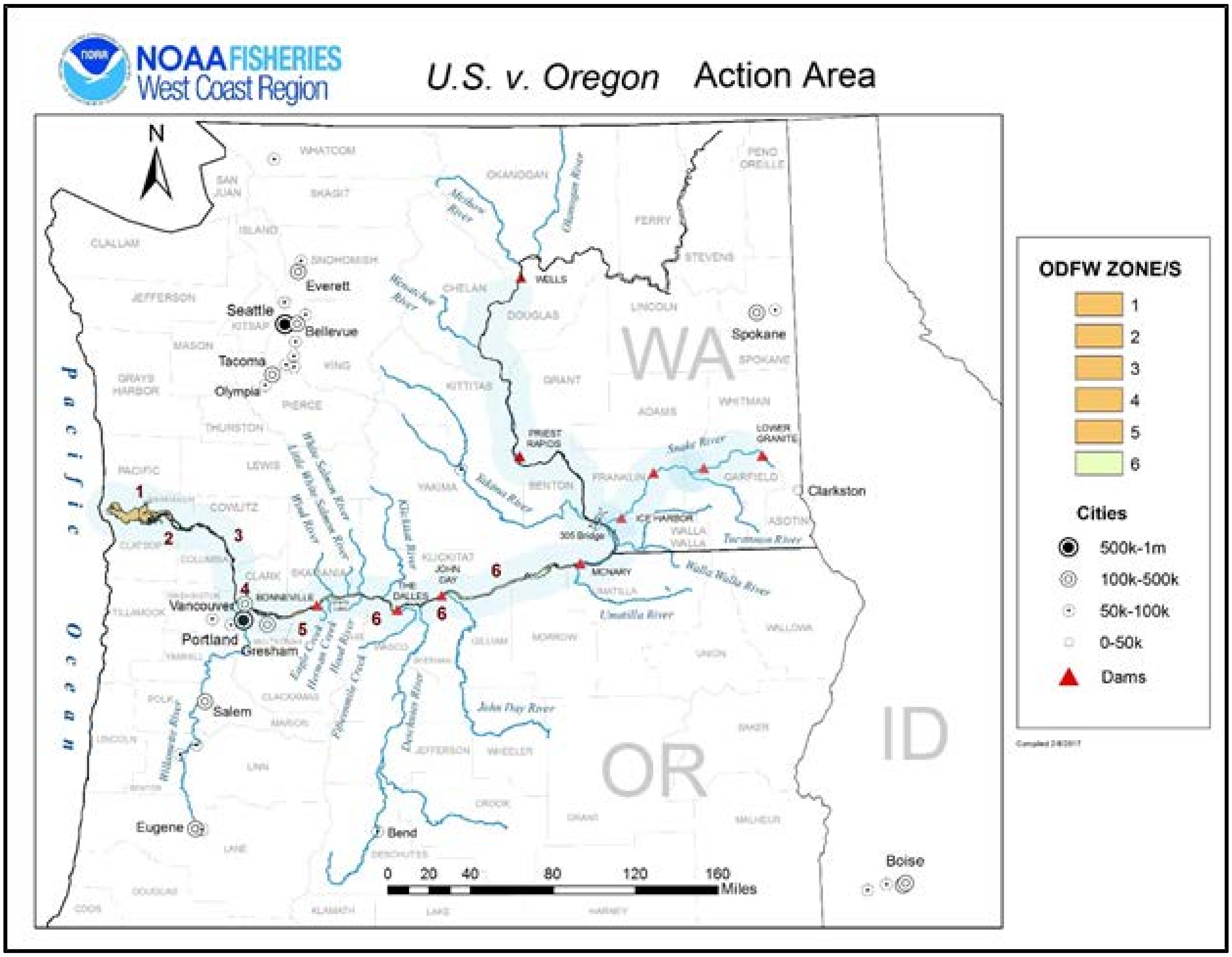

Figure 2-19. Action area inside the Columbia River Basin where fisheries occur. (The states of Washington and Oregon have each adopted for statistical data-gathering, management of fisheries, and jurisdictional purposes, boundaries of areas where fisheries operate. Commercial fishery boundaries are referred to as “zones”. Columbia River treaty tribes, and other *US v Oregon* parties have, in general, adopted the Oregon boundary terminology and therefore we present the Oregon Department of Fish and Wildlife (ODFW) commercial fishery management zones here for general reference, as these geographical boundaries and terminology are used throughout this analysis.)

The action area includes rivers, streams, and hatchery facilities where hatchery-origin salmon and steelhead occur or are anticipated to occur in the Columbia River Basin, including the Snake River and all other tributaries of the Columbia River in the U.S. This area also includes the

Columbia River estuary[15] and plume[16].

This indicates the action area comprises two salmon recovery domains (the Willamette/Lower Columbia and the Interior Columbia (IC)) as established by NMFS under its ESA recovery planning responsibilities (Figure 2-20). This area contains seven ecological provinces and more than 37 subbasins (i.e., tributaries to the Columbia or Snake Rivers).

The Willamette/Lower Columbia Recovery Domain includes the Willamette River Basin and all Columbia River tributaries from the mouth of the Columbia River to the confluence of Hood River in Oregon and the confluence of White Salmon River in Washington. The domain contains four ESA-listed ESUs of salmon and two ESA-listed DPSs of steelhead: LCR Chinook Salmon ESU, Columbia River Chum Salmon ESU, UWR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, and UWR Steelhead DPS.

The Interior Columbia Recovery Domain covers all of the Columbia River Basin accessible to anadromous salmon and steelhead above Bonneville Dam. The Interior Columbia Recovery Domain contains four ESA-listed ESUs of salmon and three ESA-listed DPSs of steelhead: Snake River Sockeye Salmon ESU, Snake River spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River Steelhead DPS, MCR Steelhead DPS, and UCR Steelhead DPS.

[15] The estuary is broadly defined to include the entire continuum where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This geographic scope encompasses areas from Bonneville Dam (River Mile [RM] 146; River Kilometer [RKm] 235) to the mouth of the Columbia River. The scope includes the lower portion of the Willamette River (from Willamette Falls, at RM 26.6 [RKm 42.6], to the Willamette's confluence with the Columbia River), along with the tidally influenced portions of other tributaries below Bonneville Dam. This region is that which experiences ocean tides, extending up the Columbia River to Bonneville Dam and up the Willamette River to Willamette Falls (south of Portland at Oregon City, Oregon) from the mouth of the Columbia River.

[16] The plume is generally defined by a reduced-salinity contour of approximately 31 parts per thousand near the ocean surface. The plume varies seasonally with discharge, prevailing near-shore winds, and ocean currents. For purposes of this opinion, the plume is considered to be off the immediate coast of both Oregon and Washington and to extend outward to the continental shelf. This definition is consistent with the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (NMFS 2011b, Appendix D).

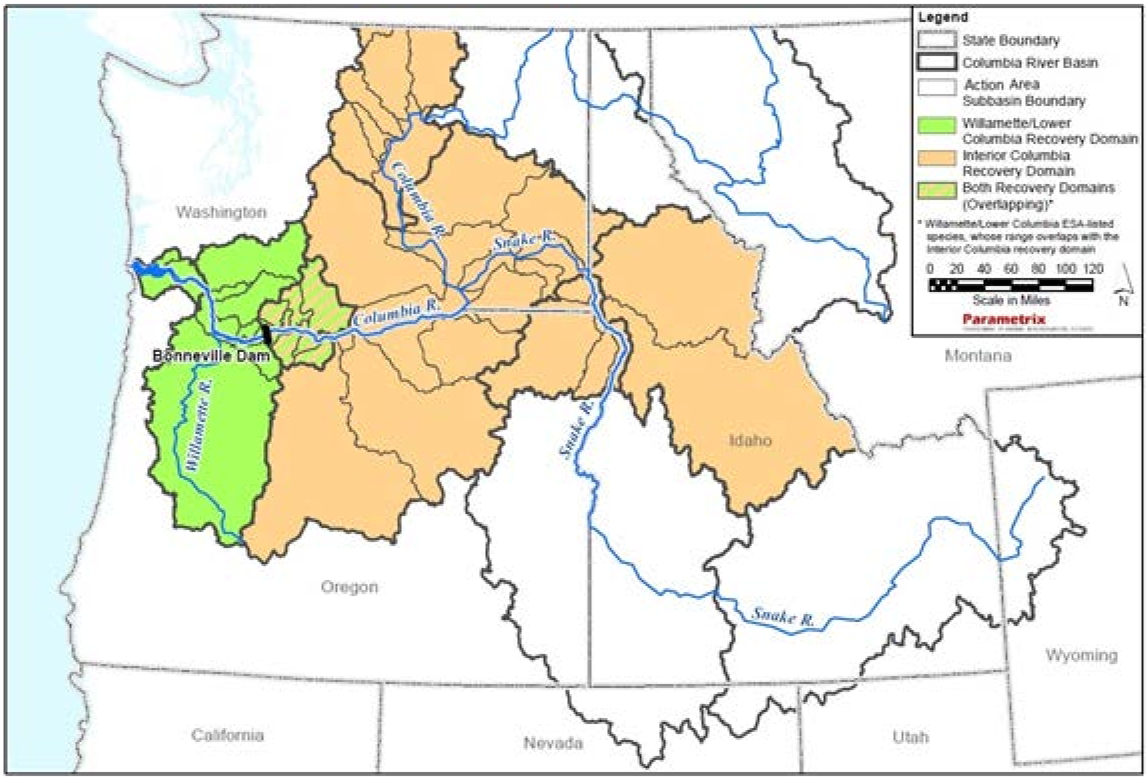

Figure 2-20. Action area inside the Columbia River Basin where hatchery fish may interact biologically.

Each recovery domain consists of several ecological provinces, as identified by the NPCC (see www.nwcouncil.org for more information). Ecological provinces encompass subbasins with similar climates and geography. This action area encompasses only 7 of the 11 Columbia River Basin ecological provinces because anadromous salmon and steelhead do not currently have access to the other four ecological provinces (the Middle Snake, Upper Snake, Intermountain, and Mountain Columbia Ecological Provinces). A sample of these respective domains and associated subbasins are captured in Table 2-74 in order to provide a geographic reference to their general locations.

Table 2-74. Action area by recovery domain, ecological province (with subbasin examples).

Recovery Domain	Ecological Province	Subbasin[1]
Willamette/ Lower Columbia	Columbia Estuary	Grays River (WA)
		Elochoman River (WA)
		Youngs River (OR)
		Klaskanine River (OR)
	Lower Columbia	Cowlitz River (WA)

		North Fork Toutle River (WA)
		South Fork Toutle River (WA)
		Coweeman River (WA)
		Kalama River (WA)
		Lewis River (WA)
		Salmon Creek (WA)
		Washougal River (WA)
		Willamette River (OR)
		Sandy River (OR)
Overlap of Willamette/ Lower Columbia and Interior Columbia[2]	Columbia Gorge	Wind River (WA)
		Little White Salmon River (WA)
		Klickitat River (WA)
		Hood River (OR)
		Fifteen Mile Creek (OR)
Interior Columbia	Columbia Plateau	Yakima River (WA)
		Walla Walla River (WA/OR)
		Umatilla River (OR)
		Lower Middle Columbia River (WA/OR)
		Lower Snake River (WA)
	Columbia Cascade	Wenatchee River (WA)
		Entiat River (WA)
		Methow River (WA)
		Okanogan River (WA/BC)
		Upper Middle Columbia River (WA)
	Blue Mountain	Asotin Creek (WA)
		Grande Ronde River (WA/OR)
		Imnaha River (OR)

		Snake Hell's Canyon (OR/ID)
	Mountain Snake	Clearwater River (ID)
		Salmon River (ID)

[1] Not all subbasins are included in this table, instead these were chosen simply to represent the geographic range that the action area encompasses given these subbasins are thought to be more commonly known.
[2] The Willamette/Lower Columbia Recovery Domain and the Interior Columbia Recovery Domain overlap within the Columbia Gorge Ecological Province (see Figure 2-20).

The hatchery programs that are referenced collectively by the *US v Oregon* Agreement are located in three regions: the LCR, MCR, and Snake River (Figure 2-20).

NMFS considered whether the ocean should be included in the action area but the effects analysis was unable to detect or measure effects of the proposed action beyond the area described above (i.e., outside of the Columbia River plume), based on best available scientific information (NMFS 2011b). Available knowledge and techniques are insufficient to discern the role and contribution of the proposed action to density dependent interactions affecting salmon and steelhead growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. While there is evidence that hatchery production can impact salmon survival at sea, the degree of impact or level of influence is not yet understood or predictable. NMFS will monitor emerging science and information and will reinitiate section 7 consultation in the event that new information reveals effects of the action to ESA-listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4 Environmental Baseline

Under the environmental baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the proposed action. 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).

In order to understand what is affecting a species, it is first necessary to understand the biological requirements of the species. Each stage in a species' life-history has its own biological requirements (Groot and Margolis 1991; NRC 1996; Spence et al. 1996). Generally speaking, anadromous fish require clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100% saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling. Embryo survival and fry emergence depend on substrate conditions (e.g., gravel size, porosity, permeability, and oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 13ºC or less. Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting. Migration of juveniles to rearing areas, whether the ocean, lakes, or other stream reaches, requires free access to these habitats.

Wide varieties of human activities have affected the ESA-listed animals in Table 1-1 and PBFs in the action area. The quality and quantity of habitat throughout the Columbia River Basin has declined dramatically in the last 150 years. The current state of the action area baseline originates from hydropower system effects, tributary habitat effects, estuary and plume habitat effects, predation and disease effects, hatchery effects, harvest effects, and large-scale environmental factors. In general, Columbia River anadromous species have been adversely affected by a broad number of human activities including habitat losses from all causes (population growth, urbanization, roads, diking, etc.), fishing pressure, flood control, irrigation dams, pollution, municipal and industrial water use, introduced species, and hatchery production (NRC 1996). In addition, these species have also been strongly affected by ocean and climate conditions.

Regarding the Southern DPS of green sturgeon, available acoustic tagging data indicate they may occur in the Columbia River from early May through early November (Moser and Lindley 2007) with a peak presence from June through August (NMFS 2010c). Within the Columbia River, distribution is limited to lower tidal reaches, but green sturgeon have been observed as far upriver as Bonneville Dam. Work by Israel et al. (2009) and Schreier et al. (2016) determined that the Southern DPS and Northern DPS co-occur in the Columbia River estuary, but a greater proportion of the green sturgeon found in the Columbia River estuary during late summer and early fall are part of the Southern DPS. However, inter-annual variability may be high and in some years the Southern DPS may constitute a significantly lower proportion (Lindley et al. 2011; NMFS 2015d; Schreier et al. 2016). In the most recent analysis, the proportion of Southern DPS fish in the Columbia River estuary was 89% in 2011 and 48% in 2012, with an average of 72% across the two years (Schreier et al. 2016).

In the past, take of green sturgeon may have occurred from direct harvest in sport and commercial fisheries and from catch and release mortality in commercial fisheries. In more recent years, the take of green sturgeon in the Columbia River was incidental to fisheries directed at white sturgeon. The numerous management actions implemented by the states of Oregon and Washington since 1994 to control white sturgeon harvest also reduced harvest of green sturgeon, including a reduction of impacts to the listed Southern DPS. The reduced catch of green sturgeon in recent years is believed to be due to these collective management actions by the states resulting in lower catch, and is not considered indicative of lower abundance of the stock (TAC 2008).

Since 1989, all fisheries affecting lower Columbia River white sturgeon have been managed for Optimum Sustainable Yield (OSY) to provide sustainable broodstock recruitment and ensure the overall health of the white sturgeon population. Beginning in 1996, the states formally adopted a three-year Joint State management agreement based on OSY to guide Columbia River sturgeon fisheries and management decisions.

Although the majority of the tenets within the current Joint State sturgeon management agreement focus on white sturgeon, a few objectives specific to benefit green sturgeon management were also included. Beginning July 7, 2006, and in response to the ESA listing of the Southern DPS, retention of green sturgeon in the commercial fisheries was disallowed (TAC

2008). Beginning in January 2007, the states changed the regulations to also disallow retention of green sturgeon in the recreational fisheries (TAC 2008). The delay in the implementation of non-retention requirements in the recreational fishery were related to the prescribed process for changing sport regulations and the need for a concurrent public education process.

Incidental catch of green sturgeon primarily occurs during the early-fall (August) and late-fall (September-November) seasons, concurrent with peak abundance of green sturgeon in the lower Columbia River. Sturgeon angler effort and catch in the estuary increased steadily during the 1990s and peaked in 1998 when anglers made 86,400 trips and caught 30,300 white sturgeon, or 73% of the total catch below Bonneville Dam (TAC 2008).

Harvest of green sturgeon has declined from an average of 1,388 fish annually during 1991-2000 to 154 fish per year since 2001-2007, due to changes in regulations and season structure. During 1996-2006, an average of 61 green sturgeon were harvested in the recreational fishery. During 1996-2006, anglers released an average of seven green sturgeon annually (2.7 sub-legal, 3.1 legal, and 1.3 over legal-sized) (TAC 2008). With the listing of the Southern DPS green sturgeon, the states took additional emergency action to disallow retention of green sturgeon during commercial fisheries beginning in July 2006, when the ESA listing became effective. During the remainder of 2006, the states started a public awareness and education process so that the sport fishing community would be better able to recognize the differences between white and green sturgeon. The states also disallowed retention of green sturgeon in the recreational fishery starting in 2007 (TAC 2008). Between 2007 and 2013 an average of 144 green sturgeon (range: 61 to 255 fish) were incidentally caught and released in the recreational fishery; incidental catch rates were lower from 2014 to 2016 when white sturgeon retention was prohibited (TAC 2017). The total lethal take of green sturgeon in recreational fisheries is estimated to be less than 10 fish misidentified by anglers and kept, and less than seven fish killed from release mortalities (up to about 255 fish released) (TAC 2017).

Green sturgeon have also been incidentally caught in sturgeon research and monitoring activities conducted in the lower Columbia River. WDFW and ODFW conduct cooperative sturgeon stock assessment projects in the lower Columbia River, including white sturgeon and green sturgeon mark-recapture studies. Both studies involve the use of gillnets to capture and tag sturgeon. All fish are released alive, with an estimated post-release mortality rate of up to 5.2%, based on the maximum annual rate observed during WDFW lower Columbia River sturgeon tagging studies from 1986 – 1993 (TAC 2008). For white sturgeon gillnet tagging studies from 2008-2016, incidental catch of green sturgeon has varied by year, ranging from 2-22 fish between 2008 and 2014 and increasing to 40 and 48 fish in 2015 and 2016 (TAC 2017). Estimated post-release mortality ranged from 0-2 green sturgeon per year. In the WDFW green sturgeon gillnet tagging studies, up to 79 green sturgeon are estimated to be handled per year, with an estimated mortality of three fish per year (TAC 2017).

Regarding salmon and steelhead, the environmental baseline for the action analyzed in this opinion incorporates, by reference, the environmental baseline discussed in detail in the relevant actions and their effects from the following:

- FCRPS and Reclamation opinions (NMFS 2008e; 2010b; 2014g),
- Chapter 5 of the SCA (NMFS 2008g, Chapter 5),

- the opinion evaluating the effects of the National Flood Insurance Program in the State of Oregon (NMFS 2016h),
- the opinion evaluating the effects of Federal and non-Federal hatchery programs that collect, rear and release unlisted fish species in the Columbia River Basin (NMFS 1999e),
- the opinion evaluating Fisheries Management and Evaluation Plans (FMEPs) submitted by the WDFW and the ODFW for recreational fisheries in tributaries to the LCR affecting LCR ESA-listed species under Limit 4 of the ESA 4(d) Rule (50 CFR 223.203(b)(4))(65 FR 42422, July 10, 2000) (NMFS 2003b),
- the opinion evaluating NMFS' implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding (NMFS 2017j), and;
- the opinion associated with the *US v Oregon* CRFMA (NMFS 2008d).

The following discussion updates and supplements or summarizes the analyses and opinions referenced above reviewing recent developments in climate change, the hydropower system, habitat conditions, harvest, and hatcheries, and outlining their impacts on natural conditions and the listed ESUs and DPSs affected by the proposed action.

2.4.1 Climate Change

In Section 2.2.7, we describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, these present impacts are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion.

2.4.2 Hydropower System

The Columbia River Basin has more than 450 dams, which are managed for hydropower, flood control, water supply, and other uses. The total water storage in the Columbia River system is 55 million acre-feet, of which 42 million acre-feet are available for coordinated water management (power production, flood control, water supply, fish operations, etc.) (BPA et al. 2001). Flow management operations at large storage reservoirs in the interior of the Columbia River Basin (Grand Coulee, Dworshak, etc.) affect habitat in the LCR mainstem and estuary, and the volume of the Columbia River plume.

The general effects of mainstem and tributary dams on salmonids and the functioning of critical habitat include:

- Lost access to historical spawning areas behind dams built without fish passage facilities (safe passage in the migration corridor);
- Juvenile and adult passage survival at dams with passage facilities (safe passage in the migration corridor);
- Water quantity (i.e., flow) and seasonal timing (water quantity and velocity, cover/shelter, food/prey, riparian vegetation, and space in rearing areas, including the estuarine floodplain, and migration corridors);
- Temperature, both in the reaches below the large mainstem storage projects and in

rearing areas and migration corridors (water quality and safe passage in the migration corridor);
- Sediment transport and turbidity (water quality and safe passage in the migration corridor);
- Total dissolved gas (water quality and safe passage in the migration corridor);
- Food webs, including both predators and prey (food/prey and safe passage in rearing areas and migration corridors).

The effects of hydroelectric dams on habitat including access to historical spawning and rearing areas (and recent dam removals or efforts to improve passage) are described in section 2.4.3 (Habitat Effects).

2.4.3 Habitat Effects

Salmon and steelhead habitat in the Columbia River Basin is greatly affected by human development. This section divides habitat in the action area into three main regions: 1) tributary streams flowing into Columbia River; 2) the Columbia River itself upstream of the estuary (often referred to as the migration corridor); and 3) the estuary and plume.

Since 2007, the FCRPS Action Agencies, including the U.S. Bureau of Reclamation (BOR), the U.S. Army Corp of Engineers (USACE), and the Bonneville Power Administration (BPA), along with Federal, state, tribal, and other local agencies have been actively working toward protecting and improving salmonid habitat throughout the Columbia River Basin. The progress toward completing the conservation actions that are included in the 2008 biological opinion and the 2014 supplemental biological opinion for the operation of the FCRPS are summarized below (NMFS 2008e; 2014g). For more details, see the 2007-2015 Comprehensive Evaluation (CE) (ACOE 2017).

The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are also presented below. These actions have helped restore habitat, improve fish passage, and reduce pollution. While these programs have already undergone section 7 consultation and therefore part of the environmental baseline, funding levels may vary on an annual basis. However, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish passage at hydropower sites will result in increased net benefit for salmon and steelhead compared to the current conditions. The projects vary, ranging from small- to large-scale efforts that include habitat conservation, creation, enhancement, restoration, and protection. These projects may also be initiated and developed under recovery plans prepared for threatened and endangered species. Project examples include donating conservation easements, excavating new tidal channels, removing invasive species, stabilizing streambanks, installing or upgrading culverts, removing barriers to fish migration, planting riverbanks, conserving water, restoring wetlands, and managing grazing to protect high-quality aquatic habitat, among others.

Northwest Power Planning and Conservation Council – Fish and Wildlife Program

The Fish and Wildlife Program was developed for the 31 dams within the Columbia River Basin that USACE (21 dams) and BOR (10 dams) operate. Due to construction and operation of these dams, the Northwest Power Act requires the NPCC to prepare to implement a program to protect, mitigate, and enhance fish and wildlife habitat and related spawning grounds affected by hydroelectric development. In 2017, the Council approved recommendations for hundreds projects in Oregon, Washington, and Idaho. The forecast program budget for fiscal year 2018 is over $11.6 million[17]. Funding is allocated for projects to support fish survival, predator control, fish habitat improvements, funding support for the Fish Passage Center, and designation of new protected areas.

Pacific Coastal Salmon Recovery Fund (PCSRF)
The PCSRF was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007c). This is a Federal fund that awards grants to the states of Washington, Oregon, California, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes from NMFS each year. The fund supplements existing state, tribal and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery. Under this fund source, each state has made substantial progress in achieving program goals, as indicated in annual Reports to Congress, workshops, and independent reviews and NMFS considers the projects completed by the states and tribes as permanent improvements that will continue to increase VSP scores into the future.

NOAA Restoration Center Programs
NMFS has completed ESA consultation on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004a). Similarly to PCSRF, these activities support local non-Federal programs through participation in the Damage Assessment, Remediation, and Restoration Program (DARRP); Cooperative Research Program (CRP); and the Restoration Research Program. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration projects that permanently contribute to increased VSP scores into the future.

Habitat improvement is especially important to salmonid recovery because several populations have not reached recovery, despite increases in natural spawning abundance. Since the increases in abundance are still well below historical levels, the populations’ carrying capacity appears to be constrained by the habitat quality (ISAB 2015). Lower habitat quality results in a lower carry capacity, thus limiting salmonid recovery (ISAB 2015). The FCRPS Action Agencies are addressing this problem through tributary and estuary habitat actions.

Tributary Habitat Actions
Tributary habitat actions include protecting and improving instream flow, improving habitat complexity, riparian area improvement, reducing fish entrainment, and removing barriers to spawning and rearing habitat. Quantitatively, these actions are tracked as the metrics shown in Table 2-75 for five ESUs/DPSs. One example of a successful tributary habitat action was completed in 2010 by The Nature Conservancy (TNC). Through their Channel Reconnect Project, TNC was able to place 22 log structures in the Middle Fork John Day River and improve habitat complexity.

[17] See https://www.nwcouncil.org/reports/financial-reports/2016-8/history

Table 2-75. 2007-2015 Tributary Habitat Quality Improvement Metrics by ESU/DPS (ACOE 2017).*

Habitat Improvement Metric	Snake River spring/summer-run Chinook Salmon	Snake River Basin Steelhead	Upper Columbia River spring-run Chinook Salmon	Upper Columbia River Steelhead	Middle Columbia River Steelhead
Acre-feet/year of water protected	58,854.3	58,854.3	23,708.8	39,908.6	94,135.5
Acres protected	2,203.5	2,203.5	283.5	250.0	42,823.5
Acres treated	5,095.5	5,095.5	356.6	1,435.0	7,488.7
Miles of enhanced or newly accessible habitat	980.0	980.0	110.4	201.0	1,857.6
Miles of improved stream complexity	142.1	142.1	21.8	28.2	157.5
Miles protected	140.6	140.6	8.32	11.2	1,139.4
Screens installed or addressed	69	69	10	82	265

* Note: Some projects benefit multiple species. In those instances, therefore, metrics by species shown above include numbers for both steelhead and Chinook ESUs/DPSs present in the same watershed.

Estuary Habitat Actions

In addition to tributary habitat actions, the FCRPS Action Agencies are also tracking the progress of estuary habitat actions. Improvements and protections to estuary habitat include protecting riparian areas, restoring off-channel habitats, restoring and improving hydrology/access, reducing invasive plants, using dredged material beneficially, and acquiring land. Table 2-76 shows the summary of estuary habitat action metrics completed in the year 2015. From 2007-2016, 8,835 cumulative acres of estuary floodplain and 48.6 cumulative miles or estuary riparian area have been improved (ACOE 2017). One example of an improvement to estuary habitat is the restoration completed at LaCenter Wetlands by The Lower Columbia Estuary Partnership in which approximately 453 acres of floodplain habitat was reconnected to the East Fork Lewis River, off-channel habitat was restored, and non-native Reed Canary Grass was removed.

Table 2-76. Summary of Estuary Habitat Action Metrics, 2015 (ACOE 2017).

Action	Acres
Protect riparian areas (CRE 1.3)*	0
Restore off-channel habitat (CRE 9.4)	43
Restore full hydrology/access (CRE 10.1)	634

Improve hydrology/access (CRE 10.2)	256
Improve access (CRE 10.3)	0
Reduce invasive plants (CRE 15.3)	343
Use dredged materials beneficially (CRE 6.3)	0
Land acquisition (CRE 9.3)	46
Total	**1,321**

* "CRE" refers to an action type described in NOAA Fisheries' "*Columbia River estuary ESA recovery plan module for salmon and steelhead*" (NMFS 2011b).

While many of the quantifiable tributary habitat actions benefit Upper Columbia and Snake River populations, the FCRPS Action Agencies have recorded many estuary habitat improvements in the Middle and Lower Columbia River benefitting additional populations.

Ultimately, there have been improvements to salmonid habitat since the implementation of the FCRPS biological opinion (NMFS 2008e).

2.4.3.1 Tributary Habitat

Most salmon and steelhead spawning and rearing habitat is found in tributaries to the Columbia and Snake rivers. The quality and quantity of habitat in many Columbia River Basin watersheds has declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydrosystem development, mining, and urbanization have changed the historical habitat conditions. Currently, spawning and rearing is limited now to thirty-two subbasins in the action area.

Many tributaries are significantly depleted by water diversions. In 1993, state, Tribal, and conservation group experts estimated that 80% of 153 Columbia tributaries had low flow problems, of which two-thirds were caused, at least in part, by irrigation withdrawals (OWRD 1993). The NPCC showed similar problems in many Idaho, Oregon, and Washington tributaries (NPPC 1992). Diminished tributary streamflows have been identified a major limiting factors for most species in the Columbia River Basin upstream of Bonneville Dam (NMFS 2007d).

In many watersheds, access to historical habitat areas is also lost to land development, primarily due to road culverts that are not designed or installed to permit fish passage.

Water quality in many Columbia River Basin streams is degraded to varying degrees by human activities, such as construction and operation of dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities, and urbanization. A large number of the streams, river segments, and lakes draining into the Columbia River Basin do not meet Federally-approved, state or Tribal water quality standards and are now listed as water-quality-impaired under Section 303(d) of the Clean Water Act (CWA), which is referred to as the 303(d) list. Water quality problems in the upper tributaries contribute to poor water quality in mainstem reaches and the estuary, where sediment and contaminants from the tributaries settle.

Most of the water bodies in Oregon, Washington, and Idaho in the Columbia River Basin are on the 303(d) list and do not meet water quality standards for temperature. Temperature alterations affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification. Many factors can cause high stream temperatures, but they are primarily related to general land-use practices rather than localized discharges, such as at dams and hatcheries. Some common actions that result in high stream temperatures are the removal of trees or shrubs that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have contributed to lower base-stream flows, which in turn contribute to water temperature increases because streams with lower flow increase in temperature more rapidly than streams with higher flow. Channel widening and land uses that create shallower streams also increase water temperatures because such streams also increase in temperature more rapidly than deeper streams.

Pollutants also degrade tributary water quality. Salmon require clean gravel for spawning, egg incubation, and emergence of fry. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs and they also can entomb fry and prevent them from emerging into the water column. Excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH also directly affect water quality for salmon and steelhead.

Effects of the Loss of Marine Derived Nutrients

All losses of anadromous fish before they reach their spawning and rearing areas reduce the transport of marine-derived nutrients (MDN), which are important for salmonid production and consequently for ecosystem function (Bisson and Bilby 1998; Naiman et al. 2002). Gresh et al. (2000) estimated that the marine-derived nitrogen and phosphorus load delivered to Pacific Northwest rivers has decreased over 90% in the last 140 years. That study attributed the loss of MDN to habitat changes due to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing.

MDN have been shown to support the growth of coastal populations of coho salmon, which feed on salmon eggs and spawned-out carcasses. Bilby et al. (2001) observed an increase in the amount of marine-derived nitrogen in the muscle of coho salmon parr with increasing abundance of carcass tissue up to about 0.15 kg/m^2-wet weight. Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading. Helfield and Naiman (2001) hypothesized that MDN are transferred from streams to riparian vegetation through the transfer of dissolved nutrients from decomposing carcasses into shallow subsurface flow paths and through the dissemination in feces, urine, and carcasses partially eaten by bears and other animals. Bilby et al. (2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material at sites in the Salmon and John Day Rivers.

In summary, a sizable body of work suggests that carcass biomass affects the productivity of salmonid rearing habitat, but functional and quantitative relationships are poorly understood and difficult to generalize from the specific conditions studied. Limiting factors, and thus the ecological importance of MDN, differ among streams, but reduced adult returns caused by mortality from hydrosystems are likely limiting biogeochemical processes that are important to salmonid productivity in some watersheds by depriving rearing areas of some nutrient inputs. These nutrient limitations also result from habitat degradation, harvest, and adverse ocean conditions, all of which have reduced salmon survival and adult returns over time (Scheuerell and Williams 2005).

Basin-Specific Tributary Habitat Details

Information in this section is taken from completed recovery plans for the LCR, UWR, MCR, and UCR Basins (NMFS 2009; 2012f; UCSRB 2014) and from several Snake River Basin management unit recovery plans (SRSRB 2011; NMFS 2012a; 2014a; 2015c; 2017m; 2017n), all of which are incorporated by reference.

Lower Columbia River Basin

Historically, tributary habitat in the ranges of the LCR Salmon ESUs and steelhead DPS supported millions of fish in populations that were adapted to the characteristics of individual watersheds (NMFS 2013e). Stream channels contained abundant large wood from the surrounding riparian forests that helped structure pools and create complex habitat in streams. Beavers also contributed to diverse instream habitats, with deep pools and strong connections to floodplains. Water temperatures sufficient to support salmon and steelhead throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored streambanks, thus shading the water, protecting against erosion, and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side-channel, and off-channel habitats and lower reaches included important refuge and feeding areas in the form of swamp and marsh habitat. However, over the last 150 years, tributary habitat conditions have been severely degraded or the habitat has been eliminated altogether.

Tributary habitat loss and degradation from land and water use development is limiting LCR salmon and steelhead populations. Widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most of the LCR subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon, steelhead (LCFRB 2010; ODFW 2010a; NMFS 2014g). Specific land use or water management activities and their impacts include the following:

- Logging and other forest management practices on unstable slopes and in riparian areas is degraded watershed processes through erosion and sedimentation. Improperly located, constructed, or maintained forest roads disrupt stream flow patterns and sediment supply processes, disconnect streams from floodplains, and reduce wood recruitment to streams. Past use of splash dams to transport logs reduced instream structure and spawning gravel in several stream systems. Impacts continue in many areas, and the legacy of historical practices will continue for some time.

- Agricultural activities have diminished overall habitat productivity and connectivity and degraded riparian areas and floodplains in many areas of the LCR region, especially along lowland valley bottoms. Floodplain habitats have been lost through levee construction and the filling of wetlands. Pesticide, herbicide, and fertilizer runoff from agricultural lands has reduced water quality. Water withdrawal for irrigation alters stream flow and raises water temperatures. Livestock grazing affects soil stability (via trampling), reduces streamside vegetation (via foraging), and delivers potentially harmful bacteria and nutrients (via animal wastes) to streams.

- Man-made fish passage barriers affect salmon and steelhead habitat in the LCR. The main barriers for anadromous fish passage are dams and culverts, with occasional barriers such as irrigation diversion structures, fish weirs, road crossings, tide gates, channel alterations, and localized temperature increases (LCFRB 2010). Although dams are responsible for the greatest share of blocked habitat, inadequate culverts make up the vast majority of all barriers (LCFRB 2010). Many barriers have been improved to allow for fish passage, but a substantial number of barriers remain. Hatchery structures also sometimes act as passage barriers in tributaries (LCFRB 2010; ODFW 2010a).

- Urban and rural development has diminished overall habitat productivity and connectivity, degraded riparian and floodplain conditions, and increased urban surface water runoff. The drainage network from roads, ditches, and impervious surfaces alters the hydrograph and delivers sediment and contaminants to streams, reducing water quality, and thus, the health and fitness of salmonids and other aquatic organisms. Loss of riparian vegetation to development increases stream temperatures by increasing the sun exposure of the stream, bank hardening, channel simplification, and disruptions in natural flow regimes. Municipal water withdrawal alters stream flows and increased water temperatures.

- Mining. Sand and gravel mining along some lower Columbia streams has reduced the quantity and quality of spawning habitat (ODFW 2010a).

Large tributary hydropower dams were built on the Cowlitz, Lewis, and White Salmon rivers in Washington and on the Sandy and Hood rivers in Oregon. Effects on LCR salmon and steelhead include habitat inundation, impaired fish passage, elevated downstream temperatures during the late summer and fall, and alterations in the timing and magnitude of flow that affect habitat-forming processes. Of these, Condit (White Salmon River), Marmot (Sandy River), and Powerdale (Hood River) dams have been removed and reintroductions are in progress in the Cowlitz and Lewis River subbasins as described in section 2.2 (Rangewide Status).

Collectively, these factors have reduced the amount and quality of habitat available to LCR salmon and steelhead, severed access to other historically productive habitats, and degraded watershed processes and functions that once created healthy ecosystems for salmon and steelhead production. Many streams now have lower pool complexity and frequency compared to historical conditions and stream channels also lack the complex structures needed to retain gravels for spawning and invertebrate (prey) production. Also missing from many channels is connectivity with shallow, off-channel habitat and floodplain areas that once provided productive early rearing habitat, flood refugia, overwintering habitat, and cover from predators. In many areas, contemporary watershed conditions have changed so much that they now pose a significant impediment to achieving recovery of the listed species (LCFRB 2010; ODFW 2010a).

Willamette River Basin

The Willamette River Basin covers 11,500 square miles and encompasses parts of three physiographic provinces. The Cascade Range covers 60% of the basin and consists of volcanic rocks with elevations exceeding 10,000 feet. The range forms the eastern boundary of the basin. The Willamette River Valley covers 30% of the basin. The elongated valley floor is structurally an erosional lowland, filled with flows of Columbia River Basalt (in the northern half of the basin) and younger unconsolidated sediment (Wentz et al. 1998). The Coast Range, comprised of marine sedimentary and volcanic rocks at elevations over 4,000 feet, covers the remainder of the basin and constitutes the western boundary of the Willamette River Valley. The Willamette River Valley is home to 70% of Oregon's human population (NPCC 2004) including Oregon's three largest cities (Portland, Eugene, and Salem). Approximately 70% of the basin is forested, with approximately 36% of the basin in Federal forest ownership. Most of the Federal forest land is located in the higher elevations of the Cascade and Coast Ranges and is managed by the U.S. Forest Service and U.S. Bureau of Land Management. About 22% of the basin area is in agricultural production, and the remaining 8% is urbanized or in other uses (Wentz et al. 1998). More than 60% of the basin area is outside the urban growth boundaries, and more than 90% of the valley floor is privately owned (PNERC 2002). Several major flood control or hydropower facilities have been developed in the Clackamas River subbasin and in subbasins of the upper Willamette River Basin, including facilities in the North Santiam, South Santiam, McKenzie and MF Willamette Rivers. Dam construction and operations impact salmonids by hindering fish passage to the most productive and important upstream spawning and rearing habitat, and by altering the natural hydrologic regimes, especially during summer and fall low flow periods. Anadromous fish habitat in the Willamette River Basin has been strongly affected by flood control, hydropower management, and land use.

Specific threats from flood control and hydropower management include: 1) blocked or impaired fish passage for adults and juveniles, 2) loss of riverine habitat (and associated functional connectivity) due to reservoirs, 3) reduction in instream flow volume due to water withdrawals, 4) lack of sediment transport that provides spawning habitat, 5) altered physical habitat structure, and 5) altered water temperature and flow regimes.

Within the Willamette River Basin, the largest flood control/hydropower complex, called the Willamette Project, is managed principally as a flood control system by the USACE. Operation of the Willamette Project has been determined to jeopardize UWR Chinook salmon and steelhead (NMFS 2008c). Where these projects are located, the flood control structures block or delay adult fish passage to the most important holding and spawning habitat for UWR Chinook salmon and UWR steelhead. In addition, most Willamette Project dams have had limited facilities or operational provisions to safely pass juvenile Chinook salmon and steelhead downstream of the facilities. The operation and configuration of the Willamette Project dams has impacted several salmonid life stages, through effects on downstream flows (alterations to the seasonal hydrograph and the loss of channel-forming flows), water temperatures, total dissolved gas (TDG), and sediment transport. NMFS (2008c) completed consultation on the Willamette

Project, providing a reasonable and prudent alternative to the USACE's proposed action. Actions include:

- Improvements to adult fish facilities and outplanting measures to reduce prespawn mortality and improve adult access to holding and spawning areas above the dams;
- Temperature control structures to release water that more closely resembles normative temperatures, reduces TDG exceedances, and meets Total Maximum Daily Load (TMDL) temperature targets;
- Safe and effective downstream passage;
- Revetment modifications and habitat restoration actions to improve the amount, complexity, diversity, and connectivity of riparian, confluence, and off-channel habitats;
- Increases in the frequency of occurrence of peak flows to increase channel complexity and habitat diversity below the dams; and
- Flow targets for salmon and steelhead rearing and migration habitat in the mainstem Willamette River.

In addition to the Federally owned and operated flood control/hydropower facilities, other facilities, such as the Portland General Electric (PGE) complex in the Clackamas River basin, the Eugene Water & Electric Board (EWEB) Carmen-Smith complex in the McKenzie River basin, and municipal flow control facilities, contribute to the flood control/hydropower effects. NMFS has completed consultation with the Federal Energy Regulatory Commission (FERC) on new operating licenses for each of these projects with the following measures intended to contribute to the species' recovery;

- Correct water temperature effects, improve habitat complexity and diversity, increase the retention and sourcing of spawning gravels below PGE's Clackamas Hydroelectric Project; and
- Provide safe and effective downstream passage at EWEB's Trail Bridge Dam, operate Trail Bridge to minimize adverse effects of ramping on fish stranding, redd desiccation, and loss of habitat downstream in the McKenzie River.

In the UWR subbasins, reservoirs associated with dams have created habitat conditions that make juvenile salmonids more susceptible to introduced predatory fishes, especially largemouth and smallmouth bass. Predation by bass is a concern in other areas as well, such as slow water areas in sub-basins and the mainstem Willamette River that are associated with the remaining floodplain.

Past and present land management affects salmonid population viability by affecting abundance, productivity, spatial structure, and/or diversity. Past land uses (including agriculture, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR Chinook salmon and UWR steelhead. These factors severed access to historically productive habitats and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. Oregon's Independent Multidisciplinary Science Team (IMST) recently published an extensive review of land use effects (including those imposed by dams) on the rehabilitation of salmonids in Oregon, and references therein can be reviewed for conditions specific to the Willamette River Basin (IMST 2010).

Mid-Columbia River Basin
In the MCR region, only steelhead are listed and our habitat discussion is focused on effects on steelhead. The range of the MCR Steelhead DPS extends over approximately 35,000 square miles in the Columbia plateau of eastern Washington and eastern Oregon. Major drainages within the range of this DPS are the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat River systems. The Cascade Mountains form the western border of the plateau in both Oregon and Washington, while the Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day basins from the Oregon high desert and drainages to the south. The Wenatchee Mountains and Palouse areas of eastern Washington border the MCR Basin on the north.

Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the western and eastern boundaries and warmer and drier climates at the lower elevations. The mountainous regions are predominantly coniferous forests, while the arid regions are characterized by sagebrush steppe and grassland.

Most of the region is privately owned (64%), with the remaining area under Federal (23%), tribal (10%) and state (3%) ownership. The landscape, throughout the range of this DPS, is heavily modified for human use, even where populations are low. Most of the landscape consists of rangeland and timberland with significant concentrations of dryland agriculture in parts of the range. Irrigated agriculture and urban development are generally concentrated in valley bottoms and human populations in these regions are growing.

Habitat degradation from past and/or present land use impacts the steelhead populations in this DPS. Extensive beaver activity created diverse instream habitats, with deep pools and strong connections to floodplains. Many stream channels contained abundant large wood from surrounding riparian forests, which included cottonwood, aspen, willow, and upstream conifers. Stream temperatures sufficient to support all steelhead life stages throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored stream banks, providing protection against erosion and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side channel, and off-channel habitats.

Today, nearly all historical habitat lies in areas modified by human settlement and activities. Historical land use exerted a large and widespread impact on steelhead habitat quality and quantity across the range of the DPS. These development practices included removal of wood from streams, even through the 1980s; removal of riparian vegetation; timber harvest; road construction; agricultural development; livestock grazing; urbanization; wetland draining; gravel mining; alteration of channel structure through stream relocation, channel confinement, and straightening; beaver removal; construction of dams for multiple purposes; and direct withdrawal of water for irrigation or human consumption.

While some streams and stream reaches retain highly functional habitat conditions to this day, these various human activities have degraded streams and stream reaches across the range of the

MCR Steelhead DPS, leaving them with insufficient large wood in channels, insufficient instream complexity and roughness, and inadequate connectivity to associated wetlands and off-channel habitats. Many streams lack sinuosity and associated meanders and suffer from excessive streambank erosion and sedimentation, as well as altered flow regimes and higher summer water temperatures. In many areas, the contemporary watershed conditions created by past and current land use practices are so different from those under which native fish species evolved that these conditions now pose a significant impediment to achieving recovery. The recovery plans contain detailed descriptions of tributary habitat threats and limiting factors.

In some tributary systems, local hydro-development blocks fish passage and results in flow modifications that affect water quality, habitat conditions, and predation rates. The Pelton-Round Butte Dam Complex on the Deschutes River blocked fish passage to upstream habitat on the Deschutes, Crooked, and Metolius rivers and smaller tributaries until the Surface Withdrawal (i.e., juvenile passage) Facility went online in 2010. Condit Dam blocked steelhead access to historical habitat on the White Salmon River from 1913 until it was removed in 2011. Five storage dams – Cle Elum, Kachess, Keechelus, Bumping Lake, and Tieton – continue to block historical habitat in the Yakima River basin. Some steelhead found ways to pass Bennington Dam on Mill Creek, a tributary to the Walla Walla River, even before a passage structure was built in the 1980s. As recently as 2001, 18 dead adults were found stranded in a portion of the stilling basin below the dam. Thus, Bennington Dam remains a significant passage obstruction for Walla Walla River steelhead. Numerous smaller barriers block or impair access to smaller tributaries throughout the basin.

Pelton Dam on the Deschutes and Roza and Chandler Power Plants in the Yakima River system significantly modify flow, affecting downstream water quality, habitat conditions, and predation rates. Water management for agricultural irrigation alters seasonal flow patterns with serious consequences for steelhead rearing and both juvenile and adult migration in the Umatilla, Willow Creek, John Day, Deschutes, and especially the Yakima and Walla Walla basins.

The human population in the Yakima River subbasin is growing (now over 300,000) and most likely will continue to grow. Planners expect that most land use and development for future population growth will occur near the Yakima River mainstem and major tributary corridors. Water storage and delivery systems have major impacts on the Yakima River subbasin’s hydrology. An extensive water supply system, run by the BOR’s Yakima Irrigation Project, stores and delivers water for over 400,000 acres (~156 square miles) of irrigated agriculture and, to a lesser degree, industrial, domestic, and hydropower use. Management of water storage and delivery systems results in stream flows across the subbasin that are often out of phase (e.g., heavy flows at times when naturally there would be low flows) with the life history requirements of native salmonids (Fast et al. 1991) and riparian species such as cottonwoods (Braatne and Jamieson 2001).

Upper Columbia River Basin

The UCR Basin consists of six subbasins- Crab Creek, Wenatchee River, Entiat River, Lake Chelan, Methow River, and Okanogan River-extending from central Washington into British Columbia. Approximately 18,600 square miles lies within the U.S.

The Crab Creek subbasin is located in central Washington. Considered one of the longest ephemeral streams in North America, Crab Creek flows southwest for 140 miles, draining into the Columbia River about five miles downstream from Wanapum Dam. The subbasin consists of about 5,096 square miles, most of which are used to raise crops. Anadromous steelhead use only the lower portion of Crab Creek.

The Entiat River subbasin, located in north-central Washington, is relatively small at 466 square miles. Approximately 91% of the subbasin is in public ownership. The remaining 9% is privately owned and is primarily within the valley bottoms. The subbasin consists of two primary watersheds: the Entiat and Mad Rivers. Spring-run Chinook salmon, steelhead, and bull trout spawn and rear in the Entiat River subbasin.

The Wenatchee River subbasin covers an area of 1,334 square miles. Approximately 90% of the subbasin is in public ownership and the remaining 10% is within the valley bottoms and in private ownership.

The Lake Chelan subbasin is located in north-central Washington and consists of 937 square miles. Approximately 87% of the subbasin is publically owned with the remainder being privately owned. The most prominent feature of the subbasin is Lake Chelan, which occupies 50 miles of the 75-mile-long basin. The majority of inflow to Lake Chelan is from two major tributaries, the Stehekin River (65%) and Railroad Creek (10%). About 50 small streams provide the remaining 25% of the inflow to Lake Chelan. Because of the shape of the valley, most tributaries are relatively steep and short. Lake Chelan drains into the 4.1-mile-long Chelan River. Presently, nearly all the flow from Lake Chelan is diverted through a penstock, which passes the water through the Lake Chelan powerhouse located near the mouth of the river.

The Methow subbasin is located in north-central Washington and lies entirely within Okanogan County. The subbasin consists of approximately 1,825 square miles. Approximately 89% of the subbasin is in public ownership. The remaining 11% is privately owned and is primarily within the valley bottoms.

The Okanogan subbasin is the largest of the UCR subbasins. Originating in British Columbia, the Okanogan River enters the Columbia River between Wells Dam and Chief Joseph Dam. The subbasin is approximately 8,942 square miles in size. However, only about 26% of the subbasin lies within the U.S. (Washington). Of this portion, 41% is in public ownership, 21% is in Tribal ownership, and the remaining 38% is privately owned and is primarily within the valley bottoms. There are three major watersheds within the subbasin in Washington (Similkameen River, Omak Creek, and Salmon Creek). The Similkameen River, located primarily in Canada, contributes 75% of the flow to the Okanogan River.

Human activities acting in concert with natural occurrences (e.g., floods, drought, fires, wind, volcanism, and ocean cycles) within the UCR Basin have impacted habitat conditions and compromised ecological processes. Although habitat within many of the upper reaches of most subbasins is in relatively pristine condition (e.g., upper reaches of the Wenatchee River, Entiat River, and Methow River subbasins), human activities have reduced habitat complexity, connectivity, water quantity and quality, and riparian function in many lower stream reaches.

Loss of large woody debris and floodplain connectivity have reduced rearing habitat for Chinook salmon, steelhead, and bull trout in larger rivers (e.g., Wenatchee, Entiat, Methow, and Okanogan Rivers). Fish management, including past introductions and persistence of non-native (exotic) fish species, continues to affect habitat conditions for listed species.

The implementation of several programs and projects that regulate land-use activities on public and private lands have improved habitat conditions over the last decade in the UCR Basin. For example, improved farm and ranch practices and numerous voluntary restoration and protection projects have occurred throughout the region. While difficult to quantify, the overall effect of improvements is important to salmon and trout recovery. Counties continue to protect and enhance critical areas, including salmon and trout habitat through Washington state law, and other local land-use regulations. The Forest Service, the largest landowner in the UCR Basin, manages spawning and rearing streams through several programs, including the Northwest Forest Plan and the PACFISH/INFISH Strategy (Henderson et al. 2005). WDFW and the Washington State Department of Natural Resources also own land in the UCR Basin and have modified and continue to modify land management practices to improve habitat conditions. However, habitat improvements are still needed to improve populations of listed species.

Snake River Basin

The Snake River Basin, while considered a part of the Columbia River Basin, by itself encompasses 107,000 square miles that extend across parts of Idaho, Nevada, Utah, Oregon, Washington, and Wyoming, although areas above natural barriers (e.g., Shoshone Falls) are not available to anadromous fish. The Snake River drains approximately one-half of the total area of the Columbia River Basin (219,000 square miles), and is the Columbia River's largest tributary. Historically, the Snake River Basin is believed to have been the most important drainage for production of anadromous fish in the entire Columbia River Basin. Once, the Snake River was estimated to have produced at least 40% of all Columbia River spring- and summer-run Chinook salmon, more than half of Columbia River steelhead, and substantial numbers of fall Chinook, sockeye, and coho salmon (Chapman et al. 1990; Good et al. 2005). Within the Snake River Basin, the Salmon River is the largest river system, followed by the Clearwater River, both in Idaho.

The topography and climate characteristics of the Snake River Basin are extremely diverse. Terrestrial habitats include high elevation interior deserts, alpine peaks, dense forests, and the deepest river canyon in North America (Hells Canyon: - 7,993 feet). Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas and warmer and drier climates in the lower elevations.

Land management and development within the Snake River Basin vary from wilderness to agriculture and rangeland to small towns and cities. The growth of towns typically affects streams in numerous ways. As with logging roads, urban and rural roads built across or along streams introduce fines and toxic substances such as motor oil into the water. Improperly designed and constructed stream crossings block or impede fish passage. Paving of parking lots and roads increases the amount of impervious surface and reduces the infiltration of precipitation into the aquifer. As a consequence, streams draining watersheds with a high proportion of impervious surface area tend to be flashy, unstable and embedded with fine sediments. Pollutants also enter streams as a result of lawn and garden fertilization or cultivation, or from factories or other businesses. The Snake River Basin contains the largest contiguous wilderness in the lower 48 states. Of the 31,862 square miles of land in the Snake River recovery domain, 69.4% is Federally owned, 24.3% is privately held, and 6.5% is state or tribally owned.

Currently, salmon and steelhead occupy only a portion of their former range in the Snake Basin. Starting in the 1800s, dams blocking anadromous fish from their historical habitat were constructed for irrigation, mining, milling, and hydropower. Construction of the Hells Canyon Complex of impassable dams along the Idaho-Oregon border in the 1960s completed the extirpation of anadromous species in the upper Snake River and its tributaries above Hells Canyon Dam. Major tributaries upstream from Hells Canyon Dam that once supported anadromous fish include the Wildhorse, Powder, Burnt, Weiser, Payette, Malheur, Owyhee, Boise, Bruneau, and Jarbidge Rivers, and Salmon Falls Creek. These tributaries supported most of the sockeye salmon and fall Chinook salmon populations in the basin and an estimated 15 steelhead populations and 25 spring/summer-run Chinook salmon populations (McClure et al. 2005). However, these extirpated populations are not part of the listed ESUs.

Other dams besides the Hells Canyon complex have significantly reduced access to salmon and steelhead tributary habitat. Dworshak Dam, completed in 1971, caused the extirpation of Chinook salmon and steelhead runs in the North Fork Clearwater River drainage. Lewiston Dam, built in 1927 and removed in 1973, is believed to have caused the extirpation of native Chinook salmon, but not steelhead, in the Clearwater drainage above the dam site. Harpster Dam, located on the South Fork Clearwater River at approximately RM 15, completely blocked both steelhead and Chinook salmon from reaching spawning habitat from 1949 to 1963. The dam was removed in 1963 and fish passage was restored to approximately 500 miles of suitable spawning and rearing habitat. Sockeye salmon spawned in Wallowa Lake and its tributaries in northeastern Oregon until the construction of a barrier at the lake outlet in 1916 blocked anadromous passage. Sunbeam Dam, constructed on the Salmon River (near RM 368) in 1910, was a serious impediment to migration of anadromous fish (spring and summer Chinook and sockeye salmon) and may have completely blocked passage, at least in some years, before its partial removal in 1934 (Waples et al. 1991).

Idaho Tributaries

Spawning, rearing, and migration habitat quality in tributary streams in Idaho occupied by salmon and steelhead varies from excellent in wilderness and road less areas to poor in areas subject to intensive human land uses. Mining, agricultural practices, alteration of stream morphology, riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, and urbanization have degraded stream habitat throughout much of the Snake River Basin. Reduced summer stream flows, impaired water quality, and loss of habitat complexity are common problems for stream habitat in non-wilderness areas. Human land use practices throughout the Snake River Basin have modified streams reducing rearing habitat and increasing water temperature fluctuations.

In many stream reaches occupied by anadromous fish in Idaho, water diversions substantially reduce stream flows during summer months. Withdrawal of water, particularly during low flow periods, increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport. Reduced tributary streamflow is considered a major limiting factor for Snake River spring/summer-run Chinook salmon and Snake River Basin steelhead (NMFS 2011b).

Many streams occupied by salmon and steelhead are listed on the State of Idaho's CWA Section 303(d) list for impaired water quality, such as impairment for elevated water temperature (IDEQ 2014). High summer stream temperatures may currently restrict salmonid use of some historically suitable habitat areas, particularly rearing and migration habitat. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Water quality in spawning, rearing, and migration habitat has also been impaired by high levels of sedimentation, and by other pollutants such as heavy metal contamination from mine waste (IDEQ 2001; 2003).

The reduction in abundance of adult salmon and steelhead returning to Idaho streams has also reduced the transport of MDNs to freshwater spawning and rearing areas. The loss of these nutrients limits biogeochemical processes important to salmonid productivity in some streams by depriving rearing areas of some nutrient inputs (NMFS 2008g) and reducing the productivity of the food web. Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading (Helfield and Naiman 2001). In two Interior Columbia watersheds, the Salmon and John Day Rivers, Bilby et al. (2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material, suggesting that salmon carcasses are important to aquatic productivity and the availability of food for rearing fish (NMFS 2008g). Kohler et al. (2008) also found a positive stream food web response to the addition of salmon carcass analogs (define what an analog is) in two Salmon River tributaries. These studies indicate that the loss of MDNs, due to a reduction in adult spawners, likely has contributed to reduced Chinook salmon and steelhead abundance and productivity in tributary areas.

Oregon Tributaries

The Northeast Oregon region of the Snake River Basin comprises 4,880 square miles in the Columbia River plateau of northeastern Oregon, and a small section of southeastern Washington. It is characterized by a rolling, semi-arid landscape that is bordered by the plush terrain of the Blue Mountains. The nearby Wallowa Mountains lie just east of the main Blue Mountain range and near the Oregon/Idaho border, which forms the eastern boundary of this region. Three major rivers, along with their tributaries, flow into the Snake River drainage: the Grande Ronde, Imnaha, and Wallowa Rivers. The Grande Ronde River in southeastern Washington also drains into the mainstem Snake River, marking the region's northern boundary. To the south, the upper Grande Ronde River and the eastern portion of the John Day River basin form the region's southern border.

Temperatures and precipitation in Northeast Oregon vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the eastern and western boundaries, and warmer and drier climates in the lower portions of the region. Mountainous regions are predominantly coniferous forests, while arid regions are characterized by sagebrush steppe and grassland. Elevation in the region varies from mountain peaks that exceed 9,000 feet to grasslands ranging from 2,000 to 4,000 feet.

Public land constitute 54% of the area while 45% is privately held, and the remainder is partitioned for both state and tribal use. The region is dominated by agricultural and rangeland use, as well as forestlands used for recreational purposes. Northeast Oregon's human population is growing at a slower pace than other areas in the Pacific Northwest, but development is nonetheless occurring, particularly along valley bottoms.

Numerous efforts have been made in recent years to protect and restore habitat conditions on public and private lands. Landowners and land managers have improved habitat management to restore healthy watershed conditions and support salmon and steelhead recovery. In some areas, actions to improve watershed conditions from the uplands to the floodplain are allowing natural ecosystem functions to recover. Still, habitat problems remain throughout the area. Many more habitat improvements are likely needed to achieve viability for Snake River spring/summer-run Chinook salmon and steelhead (Ford 2011).

Both current and historical management practices pose threats to the recovery of the Snake River spring/summer-run Chinook Salmon ESU and Steelhead DPS. Overall, the effects of development and land use activities over the last 200 years have altered watershed hydrology and reduced habitat quality and complexity, floodplain connectivity, and water quality. The alteration of tributary habitats has affected spring/summer-run Chinook salmon and steelhead population abundance, productivity, and spatial structure. To recover, the fish need streams with abundant cold water, plenty of clean gravel, pools where they can find food and shelter, and unhindered access to spawning and rearing areas. Thus, their health depends greatly on how lands and water are managed.

Several land use-related limiting factors and threats are common across the salmon ESU and steelhead DPS. Many of the threats have both historical, or legacy, and current components. Historical threats are those in which actions taken previously—such as road construction, and agricultural and timber harvest activities—continue to have lingering effects on tributary habitat. These common limiting factors and threats include agricultural practices, timber harvest, roads, water withdrawal, recreation activities, and noxious weed infestation.

Agricultural practices have improved over the years; however, habitat conditions still display the lingering effects of past practices and, in some cases, continue to be damaged from current practices. Agricultural practices have reduced habitat quality and complexity through stream channelization, levee and dike construction, wetland conversion, and removal of riparian vegetation. Such activities have restricted stream floodplain connectivity, resulted in down cutting of stream channels, and led to a reduction in pools and large woody debris. Agricultural practices have also affected habitat conditions by altering natural hydrologic regimes through conversion of native grasslands and other natural conditions that stored water and slowed surface runoff, and by increasing fine sediment (e.g., dirt and sand) input to streams. They have reduced water quality by removing large shade-producing trees and by the leaching of pesticides, herbicides, and fertilizers into streams.

Another key aspect of agriculture affecting habitat conditions is livestock. Livestock grazing practices threaten salmon and steelhead viability by damaging and/or compacting streambanks, increasing the input of fine sediments into streams, reducing riparian vegetation, and contributing harmful bacteria and excessive nutrients to streams. Current livestock management, compared to historical management practices, tends to have less impact on salmonid habitat because of improved practices and lower numbers of livestock than historical levels. Negative habitat effects, however, continue to exist when livestock have unrestricted access to stream channels, especially during hot summer and early fall months.

Timber harvest-related threats include lingering effects from historical detrimental timber harvest activities and some current practices. Historical activities reduced salmonid habitat quality and quantity by harvesting large trees from riparian areas, removing large wood from streams, skidding logs across and adjacent to streams, clear-cutting across intermittent or perennial streams, building roads in sensitive areas and/or without proper erosion control structures, and constructing stream crossings that impaired or completely blocked fish from reaching important spawning and rearing areas. Unregulated forest practices, along with livestock grazing and fire suppression, also modified vegetation patterns on forest lands, which led to the alteration of important ecosystem processes, such as wildfire burning, insect invasions, and ecological succession. Current timber harvest activities continue to threaten salmonid viability when they remove riparian area trees that provide shade and future large wood recruitment to streams and adjacent areas, do not adequately protect streams from sediment input, and/or construct roads in sensitive areas. Timber harvest activities have improved and are likely to result in improved conditions for fish, in the future.

Roads affect habitat conditions and salmon and steelhead viability by contributing fine sediment to streams, by channeling runoff and fine sediments, by being located across stream channels in riparian areas, or through other mechanisms to contribute sediment to streams. Roads can also intercept subsurface water drainage, disrupting natural drainage patterns and concentrating runoff flow. Roads can confine channels, preventing them from interacting with their floodplain. Most negative road-related effects are from roads built in the past.

The withdrawal of water from streams becomes a threat when habitat is dewatered, when fish are stranded, when eggs in the gravel are desiccated, when streamflows are too low for adult or juvenile fish passage, and when water temperature rise. Most streams in Northeast Oregon are over-allocated for irrigation water withdrawal purposes and streamflows reach low levels at critical times in fish life history. Low flows caused by withdrawals, in addition to providing less habitat because there is less water, can increase summer stream temperatures, increase sedimentation, and impair fish passage. Diversion structures can limit or prevent passage of juveniles and/or returning adults, and unscreened diversions can result in entrainment of fish in irrigation ditches. Push-up dams used for water diversion can restrict fish passage and contribute fine sediment to the channel.

Barriers to fish passage in Northeast Oregon include culverts, water withdrawal diversion structures, weirs at hatchery facilities, and any other human-made structure that impede fish passage. Barriers can prevent returning adults from accessing upstream spawning habitat, and juvenile fish from migrating up or down stream.

Recreation activities can affect habitat quality when campgrounds, trailheads, trails, and other facilities are located in riparian areas. Recreational access to and around streams can result in loss of riparian vegetation, sediment input, compaction of streambanks, and harassment of spawning fish.

New residential development in certain watersheds places higher demands on limited ground water sources. It can also lead to increases in the discharge of sewage and the leaching of chemicals used in residential applications. The change from porous to impervious surfaces can increase the amount of surface water runoff and pollutants that enters the stream system. Residential development along streams can also result in the loss of native riparian vegetation and streambank stability, and increased erosion.

Noxious weed infestations are a threat to Snake River spring/summer-run Chinook salmon and steelhead in specific watersheds. These invasive species often out-compete native vegetation located within riparian areas, resulting in loss of habitat diversity and riparian area degradation. Together, past land use practices across the region over the last 200 years contributed to causing many of the factors now limiting salmonid abundance and productivity. While some past land use practices were less destructive than other practices, the overall impact was a reduction in habitat quality and complexity, water quality, and a general disruption in the proper functioning of watershed processes in many parts of the Grande Ronde and Imnaha drainages.

Fortunately, habitat conditions in many areas are improving. While harmful land use practices still continue in some areas, many land management activities, including forestry and agricultural practices, now have much less impact to salmonid habitat because of raised awareness and less invasive techniques. For example, timber harvest on public land has declined drastically since the 1980s, and current harvest techniques (e.g., the use of mechanical harvesters and forwarders) and silvicultural prescriptions (i.e., thinning and cleaning) require little, if any, road construction and produce much less sediment. Riparian areas also receive more protection under current forest management. Agriculture activities have also improved to reduce the impact on habitat. Many landowners are implementing good conservation practices to farming and grazing so that important ecosystem processes and functions can recover, and are also protecting and restoring stream corridors. For example, they have protected many miles of stream adjacent to farmland in Union and Wallowa counties through easement programs, such as the Conservation Reserve Enhancement Program, that protect streambanks and riparian vegetation through land management contracts. Such changes are slowly improving habitat conditions for spring/summer-run Chinook salmon and steelhead and other fish and wildlife species, while also restoring overall watershed health.

A final effect to be considered is the reduction in supply of MDNs. The decrease in adult salmon and steelhead returning to Northeast Oregon streams has reduced the transport of MDNs to freshwater spawning and rearing areas. The loss of these nutrients limits biogeochemical processes important to salmonid productivity by depriving rearing areas of unique and important nutrient inputs (NMFS 2008g). Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading (Helfield and Naiman 2001). This and other studies indicate that the loss of MDNs due to a reduction in adult spawners may have affected habitat diversity and productivity.

Washington Tributaries

The Washington portion of the Snake River Basin (called the South East Washington Management Unit (SEWMU)) is located in the southeast corner of the state, generally bounded by the Washington/Oregon state line on the south, the Columbia River (to the confluence with the Snake River) on the west, and the Snake River (including southern flowing tributaries, such as the Palouse River below Palouse Falls, Alkali Flats Creek, Penawawa Creek, and Almota Creek) on the north and the east. The region is generally characterized by rolling, semi-arid lands flanked by the forested Blue Mountains in the south. The major rivers draining the area are the Snake, the Grande Ronde, the Tucannon, and the Walla Walla[18] Rivers and Asotin Creek. Elevations along the Snake River range from approximately 400 to 500 feet near its confluence with the Columbia River to 750 feet near Clarkston.

The region's climate is influenced by the Cascade Mountains, the Pacific Ocean, and the prevailing westerly winds. The Cascades intercept the maritime air masses as they move eastward, creating a rain shadow effect that reaches as far as the Blue Mountains. The results are warm and semi-arid conditions in the lower elevations of the SEWMU, and cool and relatively wet conditions in the higher elevations. In the semi-arid portions of the region, the annual precipitation is less than 15 inches per year, varying by area from 5 to more than 45 inches (Whiteman et al. 1994). Temperatures can range from -20°F in the winter to 105°F in the summer.

The SEWMU has experienced a variety of changes that impacted salmonids and their habitat since the arrival of Euro-American settlers in the 19th century. The decimation of the beaver population in the 1830s and 1840s reduced an important source of large woody debris and pools in streams. Settlers, who began arriving in the late 1840s and 1850s, were attracted by the agricultural possibilities, and agriculture remains an important land use today. Logging and urbanization have also affected salmonids and their habitat, as have construction and operation of hydroelectric dams on the Snake and Columbia Rivers and their tributaries. General causes of salmonid population declines include irrigation diversion dams, hydroelectric generation, hatcheries, agriculture, logging, urbanization (including residential and industrial development), recreation, and harvest. Activities associated with these endeavors have dewatered streams, removed riparian vegetation, increased stream water temperatures and effects of parasites and diseases, altered and/or dewatered stream courses, introduced pollutants into streams and wetlands, and blocked or impeded fish passage both up- and downstream. Fish populations have been depleted by over-harvest in the late 19th and early 20th centuries. Hatcheries have introduced fish with different run timing and fish that prey upon or compete with non-hatchery fish. Diseases carried by hatchery fish are also a concern.

Agriculture has had a large impact on habitat. Water needed for irrigations was historically diverted from streams by dams or other structures that often present partial or total passage barriers to adults and juvenile fishes and/or entrainment hazards to emigrating juveniles. Some historical irrigation diversions totally dewatered downstream stream reaches; in others, the temperature in small quantities of water that was left in the natural stream channel can easily reach unhealthy or lethal levels. Cropping practices in upland areas, the roads, stream crossings,

[18] For recovery planning purposes, the Washington portion of the Walla Walla River Basin is considered part of the Snake River Basin, even though the Walla Walla River is a tributary to the Columbia River. The Walla Walla Basin is also considered in mid-Columbia recovery planning, as part of the MCR Steelhead DPS.

and drainage systems have increased erosion and contributed large quantities of fine sediment to spawning riffles. Chemicals and pesticides have entered the stream as pollutants harmful to fish. Livestock grazing has negatively affected salmonid habitat in a variety of ways, such as by removing riparian vegetation and eliminating natural shade. The lack of shade frequently results in increased water temperatures. The reduced input of leaves, insects, and other organic material limits food available to fish and their prey. Trampling of stream banks by grazing livestock causes the banks to collapse, increasing sedimentation. Livestock feces introduces excessive concentrations of nutrients which, in warm, slow-moving streams, results in low levels of dissolved oxygen (eutrophication). Grazing encourages channel incision as grasses and shrubs are removed from the riparian zone. Channel incision causes the riparian corridor to narrow and the water table to recede. Conversion of bunch grass prairie to production of annual crops has led to erosion of fine sediments into streams and increased intensity of runoff events, and increased channel bank erosion from runoff.

Logging can involve a number of practices harmful to salmonids and their habitats. When trees along stream courses are removed, water temperatures increase. Logging access roads often parallel or cross streams. Improperly sized and placed stream crossings can fail and dramatically increase the introduction of sediment into streams as well as block fish passage. Runoff from roads that parallel streams may allow sediment and road oils to enter the stream. Removal of riparian vegetation also reduces plant and animal inputs into the stream as food sources, root structure that maintains bank stability, and the source of large woody debris important to maintenance of suitable in-stream conditions. Harvest of trees can affect hydrology and stream discharge dynamics. Past logging practices in the Pacific Northwest were devastating to salmonid streams, such as splash dams and associated removal of large boulders and logs to improve transportation of the stored logs. Even with new regulations and improved practices, these effects will persist for many decades, for example, until trees in riparian areas grow to maturity, fall into streams and rivers and are replaced and roads are decommissioned and the area returned to natural conditions.

Although heavy urban development has been confined to a relatively small portion of SEWMU, it has had a disproportionately large impact. The development-related impacts summarized in Section 2.4.3.1, Tributary Habitat, Subsection ‘Snake River Basin’ occur to one degree or another in various portions of the SEWMU. The most damaging activity associated with urban development has been flood control projects and associated structures. Large portions of the Tucannon, Touchet and Walla Walla Rivers have been channelized and confined by levees and dikes intended to protect nearby roads, buildings, fields, and farms. The overall impact of these projects destabilized the rivers by increasing their erosive power (Hecht et al. 1982). As a consequence, the Tucannon River is now actively degrading its banks and bed and causing serious problems with regard to fine sediment deposition and habitat complexity. The Walla Walla River, and especially its Mill Creek tributary, has also been severely impacted by flood control projects. Fish passage is obstructed to varying degrees at numerous points, habitat complexity is virtually non-existent through the channelized section, and portions of Mill Creek are partially dewatered and subjected to excessive temperatures on an annual basis.

Habitat condition in the SEWMU for eight key limiting factors has been analyzed using the Ecosystem Diagnosis and Treatment (EDT) model (Mobrand et al. 1997). For this purpose, the streams in the management unit were divided into stream reaches. The percentage of stream reaches limited by each factor was as follows (SRSRB 2011, Table 5.2):

- Pools 100%
- Riparian function 96%
- Large wood 89%
- Confinement 86%
- Sedimentation 67%
- Flow 61%
- Temperature 61%
- Scour 46%

Typically, several factors were listed as limiting salmon and steelhead recovery in a particular stream reach and nineteen reaches were limited by six or more factors.

2.4.3.2 Mainstem (Exclusive of Estuary)

The mainstem habitat of the Columbia and Snake Rivers serves as a migration corridor for salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Important features of migration habitat include substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage. For fall-run Chinook salmon and, to a lesser extent chum salmon, mainstem habitat also serves as important spawning and rearing habitat. Important features of spawning and rearing habitat include accessibility, spawning gravel, water quality, water quantity, water temperature, food, and riparian vegetation.

The development of hydropower and water storage projects within the Columbia River Basin have resulted in the inundation of many mainstem spawning and shallow-water rearing areas, leading to loss of spawning gravels and access to spawning and rearing areas; altered water quality, leading to reduced spring turbidity levels; altered water quantity caused by seasonal changes in flows and consumptive losses from use of stored water for agricultural, industrial, or municipal purposes; altered water temperature, including generally warmer minimum winter temperatures and cooler maximum summer temperatures; altered water velocity, with reduced spring flows and increased cross-sectional areas of the river channel; altered food webs, including the type and availability of prey species; and lack of safe passage, with increased mortality rates of migrating juveniles (Ferguson et al. 2005; Williams et al. 2005).

The FCRPS is a series of 14 multipurpose, hydroelectric facilities constructed and operated by the USACE and the BOR. The BPA markets and transmits the power produced at FCRPS dams. NMFS has been consulting on the effects of the FCRPS since the first salmonid species in the basin was listed under the ESA in 1992 (Snake River sockeye salmon). Most recently, the 2008 FCRPS opinion (NMFS 2008e), which addressed effects on 13 salmon ESUs and steelhead DPSs and their designated critical habitat was supplemented in 2010 and 2014 (NMFS 2010b; 2014g). In 2016, the U.S. District Court for the District of Oregon directed NMFS and the FCRPS Action Agencies (USACE, BOR, and BPA) to keep the 2014 opinion and its incidental take statement in place and also directed the FCRPS Action Agencies to continue to fund and implement the 2014 opinion until a 2018 opinion is prepared and filed.

In addition, NMFS has completed consultation with the FERC on effects of the run-of-river hydroelectric projects in the middle reach of the Columbia River (upstream of the confluence with the Snake), operated by three public utility districts (PUDs). These are:

- Douglas PUD’s Wells Hydroelectric Project at Columbia RM 515 (NMFS 2003d);
- Chelan PUD’s Rocky Reach Hydroelectric Project at Columbia RM 453 (NMFS 2003c); and
- Grant PUD’s Priest Rapids Hydroelectric Project at Columbia RM 379 (NMFS 2008b).

In general, passage effects of these PUD projects are similar to those of the FCRPS run-of-river dams in the lower Snake and Columbia rivers.

As discussed in more detail below, dams and their associated reservoirs present fish-passage obstacles, causing passage delays and varying rates of injury and mortality. The altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators. These effects have been the subject of the ESA section 7 biological opinions cited above for the PUD dams and a series of opinions for the FCRPS projects

Migrating Juveniles

The hydropower system can affect migrating salmon and steelhead by delaying downstream juvenile passage and increasing direct and indirect mortality of juvenile migrants. The hydropower projects have converted much of the once free-flowing migratory river corridor into a stair-step series of slower pools (though juveniles do feed and rear in the reservoirs). Construction of the mainstem dams increased the time it took for smolts to migrate through the lower Snake and Columbia rivers with migration delays most pronounced in low flow years (Figure 5-1, Williams et al. 2005). However, the addition of surface spillway weirs at FCRPS dams and increased levels of spill during the last ten years has greatly reduced delay for yearling fish, particularly for steelhead (Smith 2014).

The extent of this impact compared to before hydropower system development, however, can only be estimated because the methods used to monitor the fish during the 1960s and 1970s (freeze brands, etc.) were radically different from those used presently (PIT tags). Based on recent detections of PIT-tagged smolts, average travel times from Lower Granite Dam on the Snake River to Bonneville Dam on the lower Columbia range from about 13 to 16 days for yearling Chinook salmon and 11 to 15 days for steelhead (2010-2015 migration years) with earlier migrants (April) generally taking longer to migrate through this reach than later migrants (late May). These travel times are faster than those measured in 2007 and reflect substantial improvements (especially for steelhead smolts) at each of the mainstem FCRPS dams. While migration times have been reduced, delays likely continue to impact smolts by: (1) increasing their exposure to predation, disease, and thermal stress in the reservoirs; (2) disrupting their arrival time in the estuary; (3) depleting their energy reserves; and (4) for steelhead, substantial delay has been shown to cause residualism (a loss of migratory behavior).

Juvenile salmon and steelhead can be killed while migrating through the dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation that leave fish more susceptible to predation and disease, resulting in delayed, or latent, mortality. A number of actions in recent years have improved these passage conditions for all listed Columbia River salmon and steelhead species. By 2009, each of the eight mainstem lower Snake and lower Columbia River dams was equipped with a surface passage structure (spill bay weirs, powerhouse corner collectors, or modified ice and trash sluiceways) to improve passage of smolts, which primarily migrate in the upper 20 feet of the water column in the lower Snake and Columbia Rivers. Other improvements include the relocation of juvenile bypass system outfalls to avoid areas where predators collect, changes to spill operations, installation of avian wires to reduce juvenile losses to avian predators, and structures that reduce dissolved gas concentrations that might otherwise limit spill operations. Nevertheless, while these and other changes have improved smolt survival in recent years, dam passage impacts remain.

As recommended in NMFS' 2016 status review, continued monitoring is needed to gain a better understanding of smolt migration timing and mortality rates through the lower Snake and Columbia Rivers, including the effects of spring and summer spill operations on juvenile migrants. We also need a better understanding of juvenile mortality that occurs before the fish reach the head of Lower Granite Reservoir and the FCRPS system. As discussed earlier, substantial mortality of in-river migrating juveniles occurs between natal streams and the hydropower system (Faulkner et al. 2016a).

The degree to which mortality in the estuary and ocean is caused by the prior experience of juveniles passing through the FCRPS (i.e., delayed or latent mortality) is unknown, and hypotheses regarding the magnitude of this effect vary greatly (ISAB 2007; 2012). Yearling smolts detected in bypass systems are less likely to return as adults than those migrating over a spillway. However, it is unclear whether this mortality reflects injury during passage through the bypass systems, or if fish that were already sick or injured are more likely to use these routes. The relative magnitude of delayed or latent effects, the specific mechanisms causing these effects, and the potential for interactions with other factors (ocean conditions, toxic pollutants, habitat modification or predation below Bonneville Dam, etc.) remain critical uncertainties. Answering these questions could improve the ability of hydropower system managers to improve survival (and potentially SARs (smolt-to-adult return)[19]) through additional structural improvements or operational modifications at the mainstem dams in future years (NMFS 2014g).

Additional information is needed on differential survival between populations of Snake River spring/summer-run Chinook salmon and steelhead migrating through the FCRPS. Research suggests that populations that spawn and rear at high elevations and produce relatively small yearling and subyearling smolts that migrate during June and July could be experiencing higher mortality rates in the mainstem portion of the migration corridor than populations that spawn at lower elevations and produce relatively large yearling smolts that migrate during the spring (NMFS 2016b).

Migrating Adults

Except during recent years with high summer water temperatures, the migration rates of adults through the mainstem FCRPS projects is similar to that before the dams were built (Ferguson et al. 2005). Any delay that adults experience as they search for and navigate through fish ladder entrances is balanced by the faster rate of migration through the lower velocity reservoir

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[19] An SAR is an estimate of survival rate from the smolt to adult stage for salmonids.

environments.

Water management operations at large upstream flood control storage projects in the United States and Canada and the mainstem run-of-river reservoirs have combined with changing climate patterns to alter the thermal regime of the Snake and Columbia Rivers compared to the predevelopment period. In general, the mainstem Snake and Columbia Rivers now have higher minimum winter temperatures and are cooler later in the spring and warmer later in the fall (Perkins and Richmond 2001). The combined effects of these changes appear to benefit spring and summer Chinook salmon and early migrating sockeye salmon and steelhead, which migrate during the spring and much of the summer. However, late summer and fall migrating sockeye salmon and steelhead are exposed to elevated temperatures compared to the predevelopment period. The USACE operates Dworshak Dam on the North Fork Clearwater River during July, August, and September to maintain cooler summer temperatures in the lower Snake River in an effort to mitigate these effects of reservoir operations and warmer climate conditions.
Adult salmon and steelhead can pass each of the eight mainstem dams in the lower Snake and Columbia rivers volitionally at fish ladders, which in general are highly effective. For example, the current estimate of average adult Snake River spring/summer-run Chinook salmon survival (conversion rate estimates using known-origin adult fish after accounting for “natural straying” and mainstem harvest) between Bonneville and Lower Granite Dams (2012-2016) is about 87.3% (See Table 5-5 in NMFS 2017n).

Some adult fall Chinook salmon–especially those migrating past Lower Granite Dam in late August and early September when water temperatures are highest–probably hold downstream of the Clearwater River confluence, which is typically cooled below historical temperatures by the releases of cold water from Dworshak Dam. These fish probably also hold temporarily downstream of the confluence with the Salmon River, which cools more rapidly in the fall than the Snake River (primarily because of Brownlee Reservoir), and near other small tributaries. The Snake River fall-run Chinook salmon recovery plan recommends that studies and monitoring be conducted to assess if future temperatures are likely to limit the productivity of the mainstem Snake River population (NMFS 2017m).

Factors Contributing to Interdam Loss
Interdam loss is the unaccounted for loss of migrating salmon between counting stations, positioned at dams, on the mainstem of the Columbia River. Fish are counted as they move upriver at each of the sequence of dams in the Columbia River. If, for example, 1,000 fish are counted at Bonneville Dam and 700 at McNary Dam, the interdam loss is 300 fish. If 200 fish are caught in the intervening authorized fishery, there are still 100 fish that are unaccounted at the next dam. This loss is well documented as dam counts since 1938 exhibit this pattern and is part of the baseline for the proposed action.

Interdam loss is sometime expressed as a mortality rate, and sometimes as a rate of survival. Since much of the recent literature focuses on survival rate, we generally use that convention here as well. For purposes of this discussion, we distinguish between unadjusted and adjusted survival rates. The unadjusted survival rate refers to the proportion of fish that survive from one counting station to the next. Authorized harvest accounts for some of the intervening mortality. The survival rate is therefore “adjusted” for authorized harvest. So, from the simple example above, the unadjusted survival rate is 70% and the adjusted survival rate is 90%.

The use of PIT tags has provided a more sophisticated accounting system in recent years since individual fish that are representative of a stock can be tracked from one counting station to the next which allows for better tracking of things like fallback (fish that pass above a dam, but then fall back below the dam one or more times) and straying. As a result, survival can be estimated with greater precision and for a more diverse set of discrete stocks. Two recent reports examine the PIT tag data available for upriver spring Chinook salmon. Crozier et al. (2016) reported on an analysis of PIT tag data to estimate survival rates for UCR spring-run Chinook and Snake River spring/summer-run Chinook salmon. They also conducted a covariate analysis to identify the factors that contributed to the loss of fish that did not survive (Crozier et al. 2017).

Results from the Crozier papers are discussed in more detail in the upcoming Effects section in this opinion (Section 2.5.1). The factors that affect survival are complex, but for purposes of the discussion on unauthorized harvest, which is part of interdam loss, it is sufficient to focus on result summaries. From 2005 to 2015 unadjusted survival rates from Bonneville Dam to McNary Dam for the Snake River and UCR components of the Upriver stock averaged 80.5% and 81.0%, respectively (Crozier et al. 2016). The average harvest rate during these years was 8.9% so the average adjusted survival rate was approximately 90%.

Crozier reported several factors that significantly affected survival rates. Natural-origin fish had higher unadjusted survival rates than hatchery fish (84% vs 79% for Snake River fish). Fish that migrated inriver had higher unadjusted survival rates than fish that were barged during downstream migration (81% vs. 79% for Snake River fish) (Crozier et al. 2016). Temperature and spill had the greatest influence on survival across all stocks. The survival rate from Bonneville to Lower Granite Dam varied from a low of 20% for fish migrating when temperatures were over 20°C to a high of 80% when temperatures were optimal (13-16°C). The year of lowest annual unadjusted survival for all stocks, 2015, was also the warmest year, with a mean temperature of 17.9°C during the summer portion of the run. The unadjusted survival rate from Bonneville to Lower Granite Dam in 2015 was 65%. Survival was also adversely affected by high spill. The year of second lowest survival was 2011 when flows were 50% above normal (Crozier et al. 2017) .

Bellerud conducted a similar analysis of the survival rates for a broader range of stocks using the available PIT tag data sets (pers. comm. 2017). The analysis showed similar results for Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon – the unadjusted survival rates in the Bonneville to McNary reach from 2008 to 2016 were 79% to 81%, respectively (Table 2-77). The harvest rate in that reach averaged about 11% so the pool of missing fish after authorized harvest was accounted for ranged from 8.1% to 10.3%. The adjusted survival rates for Snake River fall-run Chinook salmon and Snake River Basin steelhead were less, averaging 92.7% and 89.1%, respectively (Table 2-77).

Table 2-77. Average unadjusted and adjusted survival rates, harvest rates, and unexplained interdam loss from Bonneville to McNary Dam from 2008 to 2016 (Bellerud pers. comm. 2017).

	Unadjusted Survival	Harvest Rate*	Adjusted Survival	Unexplained Interdam

	Rate		Rate	Loss
Snake River spring/summer-run Chinook salmon	78.9	10.8	89.7	10.3
UCR spring-run Chinook salmon	81.0	10.9	91.9	8.1
Snake River fall-run Chinook salmon	68.8	23.9	92.7	7.3
Snake River Basin steelhead	77.8	11.3	89.1	10.9

*These harvest rates are for fisheries that occurred between Bonneville and McNary dams. For steelhead this includes recreational dip in fisheries in Drano Lake, and the lower portion of the Deschutes, John Day, and Umatilla Rivers.

The fact that fish die during upstream migration is not surprising. Fish returning to the Snake River or upper Columbia River are migrating hundreds of miles at times when conditions can be quite challenging. The Crozier et al. (2016) analysis and others like it allow us to quantify survival rates and identify which factors (natural conditions versus various human activities) affect survival. It was apparent that natural-origin fish had higher survival rates than hatchery-origin fish as did the fish that migrated downstream inriver, and it is likely a higher proportion of interdam loss is therefore hatchery-origin fish. Temperature and spill can dramatically affect survival during migration and factors like temperature can affect fallback at mainstem dams, which can then re-expose fish stressors they have already passed by such as a fishery or re-ascension of a dam. Environmental conditions are dynamic and can change weekly during migration so that groups of fish with different migration timing can be subject to very different conditions. Straying is an additional source that contributes to the pool of fish that are lost during upstream migration. Straying is a natural phenomenon for salmon and steelhead. Stray fish do not necessary die, but rather pull off into tributaries before they reach their native stream. Stray rates for these fish are difficult to estimate, but available information suggests that stray rates are typically on the order of 2 to 4%.

Table 2-78. Average runsize for upriver stocks at Bonneville Dam from 2008 to 2016.

Stock	Runsize
Upriver spring Chinook salmon	193,856
UCR summer Chinook salmon	69,569
Upriver fall Chinook salmon	659,882
A-Index and B-Index steelhead	315,513
Sockeye salmon	348,015
Total	1,586,853

As discussed above, the interdam loss that we seek to explain averages on the order of 7 to 11% depending on the stock. For reference, runsizes for the upriver stocks are typically a few to several hundred thousand fish (Table 2-78). We know from enforcement reports that there are occasions and events where just one or a few fish are caught and other occasions where substantial numbers of fish are caught unauthorized. There are likely multiple unauthorized actions each year so they are additive. Some stocks may be subject to more unauthorized harvest than others, but even so unauthorized harvest is more likely to be small relative to stock run sizes, occasional and opportunistic rather than large scale (on the order of thousands), pervasive, and systematic across all years.

Unauthorized harvest certainly contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial certainty what the total adult survival rates are, we are still not able to apportion the mortality to the contributing factors that include:

- stresses that occur during upstream migration that are influenced by temperature, spill, and a variety of other factors,
- fallback which can then re-expose fish to stressors such as a fishery or re-ascension of a dam they previously survived,
- straying,
- unauthorized harvest,
- indirect effects of harvest such as injury and subsequent delayed mortality from contact with fishing gear,
- injuries related pinniped or avian interactions,
- and interactions between all of these factors.

However, we continue to measure and account for interdam loss and incorporate its effect in the environmental baseline. Through monitoring if we determine interdam loss is significantly higher than analyzed here NMFS would reinitiate consultation.

Mainstem Spawning Habitat

Columbia River chum salmon spawn in the mainstem below Bonneville Dam and some productive historical spawning habitat was inundated by Bonneville pool. FCRPS flow management affects the amount of submerged spawning habitat for the mainstem component of the Lower Gorge population and whether adults can enter (and fry can emerge from) Hardy and Hamilton creeks. The functioning of mainstem spawning habitat has improved with FCRPS biological opinion operations that provide fall and winter tailwater elevations and flows for spawning, incubation, and emergence just downstream from Bonneville Dam and support access to spawning habitat in Hamilton and Hardy creeks.

Altered Seasonal Flow and Temperature Regimes

Water impoundment and dam operations in Canada and the upper Columbia and Snake River basins in the United States affect downstream hydrologic conditions and water quality characteristics that are important for salmonid survival. Today, average flows during the annual spring freshet are roughly the same in April, but about 35 to 40% lower than estimated unregulated flows in May and June when the great majority of steelhead and yearling Chinook salmon smolts migrate (Figure 5-3 from NMFS 2008g). These flow reductions also contribute to the slower travel times noted above.

The effect of hydropower and water storage project operations on river temperatures is complicated. Large storage projects like Brownlee or Grand Coulee dams, because of their thermal inertia, generally increase winter minimum temperatures, delay spring warming and delay fall cooling, resulting in higher late summer and fall water temperatures. Hydropower and water storage development, water management operations, and climate change have generally increased the frequency of high water temperatures (20 °C) occurring while summer Chinook salmon and steelhead are migrating through the lower Snake River during late summer and fall (EPA 2003). Crozier et al. (2011) showed a rise of 2.6 °C in mean July water temperature in the lower Columbia River at Bonneville Dam between 1949 and 2010 (NMFS 2014g); however, high water temperatures (>20 °C) often occurred in the lower Snake River from July to mid-September before hydropower and water storage development (Peery and Bjornn 2002). The high water temperatures can cause migrating adult salmon to stop or delay their migrations, or increase fallback at a dam. Warm temperatures can also increase the fishes' susceptibility to disease. Warmer water temperatures can increase the foraging rate of predatory fish, thereby increasing smolt consumption.

Direct effects of high water temperatures on salmon and steelhead depend on the coincidence of sensitive life stages with the shifts in water temperature. Since 1993, the U.S. Army Corps of Engineers has cooled rising water temperatures in the lower mainstem Snake River for migrating juvenile fish by drafting colder water from Dworshak Reservoir during summer months. The U.S. Bureau of Reclamation also provides flow augmentation from the upper Snake River Basin that enhances flows (water quantity) in the lower Snake and Columbia rivers. The agency seeks to release 487,000 acre feet of flow from the upper Snake River Basin, but water availability during drier years limits releases to 427,000 acre feet or less. Most of the water from the upper Snake River Basin is released to improve mainstem flows during July and August; however, since 2008 a portion of the upper Snake River water has been released in May and June to benefit spring migrants.

Mainstem Effects of Bureau of Reclamation Irrigation Projects in the Columbia River Basin

In total, BOR's 23 irrigation projects in the Columbia River Basin reduce the annual runoff volume at Bonneville Dam by about 5.5 million acre feet. These depletions occur primarily during the spring and summer as the reservoirs are refilled and as water is diverted for irrigation purposes.

Spring flow reductions have both beneficial and adverse effects on fish survival. During above average water years, flow reduction during reservoir refill reduces involuntary spills, which are known to cause undesirable total dissolved gas conditions in the migratory corridor. However, this beneficial effect is small because the amount of flow attenuation provided by Reclamation is generally too small to greatly affect involuntary spill events below Hells Canyon and Chief Joseph Dams. Flow depletions associated with Reclamation's projects contribute to juvenile migration delay and decrease juvenile migrant survival. In addition to these mainstem flow effects, several of the projects below Hells Canyon and Chief Joseph Dams affect listed salmonids in the tributary streams where the project is located or where Reclamation's irrigation return flows occur.

Mainstem Water Quality

Water quality in the mainstem Snake and Columbia Rivers is affected by an array of land and water use development activities in addition to the temperature effects of hydrosystem operations discussed above. Water quality characteristics of particular concern are temperature, turbidity, total dissolved gas, and pollutants.

Temperature

High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmonids to stop or delay their migrations. High temperatures also increase the metabolism and foraging by predatory fish. The impacts of high summer water temperatures on juvenile salmonid health may be reduced by the availability of thermal refugia, areas where localized shade, springs, or tributary inflows provide lower water temperatures (Kock et al. 2007). The Snake River spring/summer-run Chinook salmon recovery plan (NMFS 2017n) identifies elevated summer water temperatures in many tributary stream reaches across the Snake River Basin as a limiting factor for this ESU. Tributary temperatures, driven by low precipitation and high air temperatures, interacted with effects of the hydrosystem in 2015 to produce temperatures were often 4 or 5°C warmer than average in the lower Snake River reservoirs between mid-June and mid-July (NMFS 2016a).

Turbidity

Flow regulation and reservoir existence reduce turbidity in the Columbia and Snake Rivers. Reduced turbidity is thought to increase predator success through improved prey detection, increasing the susceptibility of smolts to predation. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia River and Snake River migratory corridors.

Total Dissolved Gas

Spill at mainstem dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses, notably nitrogen. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury or death (this is also known as decompression sickness, or the bends, which is a condition arising from dissolved gases coming out of solution into bubbles inside the body on depressurization). The incidence of GBT in both migrating smolts and adults remains low (1-2%) when TDG concentrations in the upper water column do not exceed 120% of saturation in FCRPS project tailraces and 115% in project forebays. When those levels are exceeded, the incidence of GBT increases. However, the effects of TDG supersaturation are moderated by depth, where each meter of depth compensates for 10% of gas supersaturation at the water surface. That is, water that is at 120% of saturation at the surface would be at 110% of saturation one meter below surface, at 100% of saturation two meters below the surface, and so on.

Recent reservoir operations have limited gas-generating, high-spill events to a few days or weeks during high-flow years. Historically, TDG supersaturation was a major contributor to juvenile salmon mortality, and TDG abatement is a focus of efforts to improve salmon survival. The 115-120% guideline is generally exceeded only during the peak of the annual runoff hydrograph. The USACE has invested heavily in controlling TDG at its projects in the migratory corridor.

Toxic Contaminants

Toxic contaminants in inflows carry cumulative loads from upstream areas in variable and generally unknown amounts. Growing population centers throughout the Columbia and Snake

River Basins, and numerous smaller communities contribute municipal and industrial waste discharges to the rivers. Industrial and municipal wastes from the Portland-Vancouver metropolitan areas affect the LCR and estuary. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. While the effects are not well understood, the different compounds appear to pose risks to salmonid development, health, and fitness through endocrine disruption, bioaccumulative toxicity, or other means. Exposure to the chemical contaminants may disrupt behavior and growth, reduce disease resistance, and potentially cause mortality.

NMFS has performed a series of consultations on the effects of commonly applied chemical insecticides, herbicides, and fungicides which are authorized for use per EPA label criteria. All West Coast salmonids are identified as jeopardized by at least one of the analyzed chemicals; most are identified as being jeopardized by many of the chemicals. NMFS issued jeopardy biological opinions for Idaho (NMFS 2014d) and Oregon (NMFS 2012e) for water quality standards for toxic substances. These consultations and biological opinions will result in promulgation of new standards for mercury, selenium, arsenic, copper, and cyanide in Idaho; and for cadmium, copper, ammonia, and aluminum in Oregon.

2.4.3.3 Columbia River Estuary

The estuary provides important habitat where juvenile Snake River fall-run Chinook salmon feed and complete the process of acclimating to salt water while avoiding predators. Juveniles from this ESU enter the estuary in two timing peaks each year. The first, likely made up of yearling migrants, passes Bonneville Dam during early to mid-May; the second (subyearlings) between late June and early July. Individuals of both life-history types generally spend less than a week in the estuary (McMichael et al. 2011). Subyearling Chinook salmon including small numbers of individuals from interior ESUs have been caught or detected in shallow water habitat along the margins of the estuary, including the channels that provide access to floodplain wetlands (Roegner and Teel 2014).

Estuarine floodplain habitats have undergone significant change in the last 100 years as a result of human development. Most of the marshes, wetlands, and floodplain channels that provided food and refuge have been diked off from the river and converted to agriculture and industrial and urban use. Corbett (2013) estimated losses of 70% for vegetated tidal wetlands and 55% for forested uplands between the late 1880s and 2010. Marcoe and Pilson (2017) conducted a spatial analysis of long term land cover change for the estuary and its floodplain by comparing GIS representations of late 1800s maps with recent, high resolution land cover data from 2009. They calculated that 68–70% of the vegetated tidal wetlands, important habitats for juvenile salmonids, were lost over that 100-year plus period. Most of this loss was due to conversion of land for agriculture and urban development, but wetlands in the upper reaches of the estuary were converted to industrial and urban use (especially in the Portland/Vancouver area). Furthermore, water storage and release patterns from reservoirs upstream of the estuary have reduced peak spring and early summer flows. Jay and Kukulka (2003) estimated that diking combined with a more than 40% reduction in spring flows has reduced shallow water habitat area by 62% during the crucial spring period when juvenile salmon use of the estuary is highest. Taken individually, diking and alteration of the hydrograph reduced shallow water habitat area by 52% and 29%, respectively.

The estuary and plume provide salmonids with a food-rich environment where they can complete the transition from freshwater to saltwater and from invertebrate to juvenile fish prey. Every anadromous fish that spawns in the Columbia River Basin undergoes this transformation at least twice in its lifetime—the first time while migrating out to sea during or soon after its first year of life and the second, 1 to 3 years later, when returning to spawn.

Use of the estuary and plume, and thus the impacts on salmonids because of changes to these areas, vary by species and major life history type. As discussed in Section 2.2.1, Status of Listed Species, anadromous salmonids have two major juvenile rearing strategies: ocean-type and stream-type (Fresh et al. 2005). Ocean type fish migrate to sea early in their first year of life after rearing for only a short period (or no time) in freshwater, but may feed and continue to grow in the estuary for weeks or months before ocean entry (Fresh et al. 2005). These fish make extensive use of shallow, vegetated floodplain habitats where the significant changes in flow and thus habitat access and quality described above have occurred. Conversely, stream-type fish rear in freshwater for a longer period, usually at least one year, before migrating to sea (Fresh et al. 2005). In terms of ESA-listed fish, LCR coho salmon, all five DPSs of Columbia basin steelhead, Snake River sockeye salmon, UCR spring-run Chinook salmon, and Snake River spring/summer-run Chinook salmon produce stream-type juveniles. Fall-run populations of LCR Chinook salmon, Snake River fall-run Chinook salmon, and Columbia River chum salmon are ocean-type fish. Spring-run populations of LCR Chinook salmon and UWR spring-run Chinook salmon are technically ocean-type fish but naturally represent a mixture of the two types. Ocean-type Chinook salmon in particular used the estuary as fry, fingerlings, subyearlings, and yearlings (Fresh et al. 2005); however, many previously common patterns are now considered rare.

Both ocean- and stream-type salmonids experience significant mortality in the estuary. However, because they spend different amounts of time in the estuary environments and use different habitats, they are subject to somewhat different combinations of threats and opportunities. For ocean-type juveniles, mortality is believed to be related most closely to lack of habitat, changes in food availability, and the presence of contaminants, including persistent, bio accumulative contaminants present in sediments in the shallow-water habitats where ocean-type juveniles rear Table 2-79. Stream-types are affected by these same factors, although presumably to a lesser degree because of their shorter residency times in the estuary. The influence of these factors on survival from Bonneville Dam to the ocean is summarized in the following sections.

Table 2-79. Relative importance to ocean- and stream-type salmonids of limiting factors in the Columbia River estuary, for factors rated as significant or higher in one of the two life-history types. Adapted from Table 3-1 of NMFS (2011b).

Factor	**Level of Impact[1]**	
	Ocean-type	**Stream-type**
Flow-related habitat changes	Major	Moderate
Sediment-related habitat changes	Significant	Moderate

Flow-related changes to access to off-channel habitat	Major	Moderate
Bank elevation changes	Major	Minor
Flow-related plume changes	Moderate	Major
Water temperature	Major	Moderate
Reduced macrodetrital inputs	Major	Moderate
Avian and pinniped predation	Minor	Major
Toxicants	Significant	Minor-Moderate

[1] Level of impact ratings: No likely effects, minor effects, moderate effects, significant effects, and major effects on populations.

Limiting Factors Related to Changes in the Food Web

As described above, spring freshets have been reduced and coupled with the effects of revetments, have separated much of the historical floodplain from the mainstem, reducing the availability of food and refugia for ocean-type juveniles rearing in the estuary. Stream-type juveniles have reduced access to insect prey that move from the floodplain wetlands into the mainstem migration corridor (Diefenderfer et al. 2016). Predation and competition for habitat and prey resources in the estuary has the potential to limit the success of juveniles entering the plume and nearshore ocean.

The introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitism, and alterations in the food web (NPCC 2004; Sytsma et al. 2004). Numbers of one of these introduced species, the American shad, now exceed 4 million annually (NPCC 2004). Planktivorous shad exert tremendous pressure on the estuarine food web because of the sheer weight of their biomass and energetic requirements. Some evidence suggests they reduce the abundance and size of *Daphnia* in the mainstem reservoirs, reducing this food resource for subyearling fall-run Chinook salmon. However, Haskell et al. (2017) found that juvenile shad were eaten by subyearling Chinook salmon in John Day Reservoir, especially in late July and early August when *Daphnia* populations diminish, so there is uncertainty regarding their net effect on the growth and survival of listed salmonids.

Limiting Factors Related to Toxic Contaminants

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007), from both estuary and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoffs (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare, but some researchers have described direct mortality of salmonids including high levels of prespawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2007), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2005).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects can interact with other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life history types.

Limiting Factors Related to Avian, Pinniped, and Piscivorous Fish Predation

Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on survival of juvenile salmonids in the Columbia River. Caspian terns (*Hydroprogne caspia*) on Rice Island, an artificial dredged material disposal island in the estuary, consumed about 5.4 - 14.2 million juveniles per year in 1997 and 1998, 5% to 15% of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-2015, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59% reduction compared to when the colony was on Rice Island 1998. Management efforts are ongoing to further reduce salmonid consumption by terns in the LCR as well as inland sites on the Columbia plateau. Similar efforts are in progress to reduce the nesting population of double-crested cormorants (*Phalacrocorax auritus*) in the Columbia River estuary to between 5,380 and 5,939 nesting pairs by the end of 2018 with the objective of increasing the survival of juvenile steelhead by 3.5% (USACE 2016). However, substantial numbers of cormorants have relocated to the Astoria-Megler Bridge in recent years (observers counted up to 11,000 on June 8, 2016), which is 13 miles upstream from the ocean so that smolts may constitute a larger proportion of the diet than if the birds were foraging from East Sand Island (Anchor QEA et al. 2017).

Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River Basin, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011; ISAB 2015). Prior to the start of the Northern Pikeminnow Management Program in 1990, this species was estimated to eat about 8% of the 200 million juvenile salmonids that migrated downstream in the Columbia River Basin each year. The sport fishery reward program, which pays recreational fishermen to harvest these predatory fish, appears to have reduced that rate to about 5% (CBFWA 2010; ISAB 2015). Juvenile salmonids are also consumed by non-native fishes including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

Pinniped Predation

California (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) aggregate each spring at the base of Bonneville Dam (and below Willamette Falls on the lower Willamette River), where they feed on adult salmon and steelhead. In 2016, the Corps documented the second largest number of pinnipeds at Bonneville Dam and the second largest estimate of salmonid predation since observations began in 2002 -- 9,525 fish or 5.8% of adult salmonid passage between January 1st and May 31st (USACE 2017). In addition, numbers of Steller sea lions have been increasing between August and December in recent years (from an average of 3 per day in October 2011 to 22 per day in 2015; USACE 2016) and are assumed to intercept adult Snake River fall-run Chinook salmon as well as spring and summer run fish from the Upper Columbia and Snake River ESUs.

NMFS' Northwest Fisheries Science Center began studying the losses of adult spring- and summer-run Chinook salmon to sea lions between the mouth of the river and Bonneville dam in 2010. Average annual survival through this reach has ranged from 58% to 91%, generally decreasing through 2015 (M. Rub, NWFSC, pers. comm., 2017). Preliminary estimates indicate that survival was higher during 2016. Up to 50% of the mortality of adult spring- and summer-run Chinook salmon destined for tributaries above Bonneville occurred within the 10-mile reach just below the dam.

Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Most estimates of the benefits of predator control projects in the Columbia Basin do not address compensation. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time. Therefore, they may best be addressed in a sensitivity analysis.

2.4.3.4 Columbia River Plume

Historically the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005). Juvenile spring Chinook and sockeye salmon that enter the plume move northward along the coast, continuing past the Strait of Juan de Fuca toward the Gulf of Alaska. Fall Chinook salmon and some coho salmon, which display a hybrid pattern remain in closer to the mouth of the Columbia River during the first summer before moving north while other coho move toward the Gulf of Alaska during that period (Burke et al. 2013; Fisher et al. 2014; Teel et al. 2015).

Variations in marine survival often correspond with periods of alternating cold and warm conditions within the plume and coastal ocean. For example, cold conditions during the first months at sea generally correspond with good adult returns for Chinook and coho salmon, whereas warm conditions do not. Using data from research cruises in the plume and the coastal waters of the Northern California Current off Oregon and Washington, NOAA's Northwest Fisheries Science Center rates each physical and biological parameter (1998-2017) in terms of its relative impact ("good," "bad," or "neutral") on salmon marine survival (https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/figures/2017/Table_SF-02.JPG). Biological indicators are directly linked to the success of salmon during their first year at sea through food–chain processes:

Upwelling → Nutrients → Plankton → Forage Fish → Salmon

The same physical processes that affect Pacific salmon also affect the migration of Pacific hake and numbers of marine birds in the plume and coastal waters, both of which prey on migrating juvenile salmon. That is, oceanographic variability can also have "top down" impacts on salmon through predation by hake and marine birds.

Anomalous warm ocean conditions (known in the popular press as "The Blob") moved into coastal areas occupied by Columbia River salmon during September, 2014, and appeared to be dissipating during summer, 2017 (Peterson et al. 2017). While ocean ecosystem indicators in 2015 and 2016 suggested some of the poorest outmigration years for juvenile salmon survival in the 20-year time series, some of the indicators in 2017 were fair, indicating that the ecosystem might be returning to normal. For example, the seasonal shift from a warm winter copepod community to a cold, lipid rich summer community did not occur in 2015 or 2016 because of the extended period of warm ocean conditions. However, the copepod community transitioned to a cold water community in June, 2017, signaling that the marine ecosystem might be transitioning back to a salmon-favorable environment.

Corresponding with ocean ecosystem indicators in 2015 and 2016 that suggested poor outmigration years for juvenile salmon survival, adult Chinook and coho returns to Bonneville Dam were below their preceding 10-year averages in 2016 and 2017 and sockeye returns were low in 2017 (Table 2-80).

Table 2-80. Chinook, coho, and sockeye salmon returns to Bonneville Dam in 2016 and 2017 and preceding 10-year averages*.

Species	2016 Adult Return (2006-2015 Average)	2017 Adult Return (2007-2017 Average)
Chinook salmon	697,987 (746,520)	488,981 (766,947)
Coho salmon	42,025 (125,648)	75,936 (119,675)
Sockeye salmon	342,498 (285,125)	87,693 (315,668)

*Source: Columbia River DART, Columbia Basin Research (2018).
Available at: http://www.cbr.washington.edu/dart/query/adult_graph_text

Less is known about the marine distribution and ecology of juvenile Columbia basin steelhead, which move rapidly through the plume and can disperse in all directions after leaving the estuary (McMichael et al. 2013). Information from ocean trawl catches indicate that steelhead migrate beyond the continental shelf in a matter of days (Daly et al. 2014). Because they move so rapidly out of the coastal area, relatively little is known about their ocean ecology or requirements.

2.4.4 Hatchery Effects

This Section includes the effects of hatchery operations in the Columbia River Basin for the operation of hatcheries prior to this consultation, as well as the continued operation of hatchery programs that have already undergone a separate ESA section 7 consultation. The effects of future operations of hatchery programs with expired ESA section 7 consultation and those programs yet to undergo ESA section 7 consultation are not included in the environmental baseline, except when effects are ongoing (e.g., returning adults from past hatchery releases for programs with expired ESA permits).

Because most hatchery programs are ongoing, the effects of each program are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion. In addition, because NMFS has completed section 7 consultation on all of the hatchery programs included in the 2018 Agreement, their effects are included in the environmental baseline. Table 2-81 provides a summary of the ESA consultations that have been completed for hatchery programs affecting each of the ESUs and/or DPSs in the action area. For each consultation, Table 2-81 specifies whether aspects of the hatchery program are included in the 2018 Agreement.

The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. To ensure compliance with the ESA, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in Table 2-81. Those analyses are incorporated, and an overview of effects are summarized in the following sections. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. For example, hatchery programs can affect ESA-listed salmon and steelhead through competition with natural-origin fish for spawning sites and food, outbreeding depression, and hatchery-influenced selection.

The history and evolution of hatcheries are important factors in analyzing their past and present effects. From their origin more than 100 years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability. The first hatcheries, beginning in the late 19^{th} century, provided fish to supplement harvest levels, as human development and harvest impacted naturally produced salmon and steelhead populations. As development of the Columbia River Basin proceeded (e.g., dam construction as part of the FCRPS between 1939 and 1975), hatcheries were used to mitigate for lost salmon and steelhead harvest attributable to reduced salmon and steelhead survival and habitat degradation. Since that time, most hatchery programs have been tasked to maintain fishable returns of adult salmon and steelhead, usually for cultural, social, recreational, or economic purposes, as the capacity of natural habitat to produce salmon and steelhead has been reduced.

A new role for hatcheries emerged during the 1980s and 1990s after naturally produced salmon and steelhead populations declined to unprecedented low levels. Because genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery, as well as in fish that spawn in the wild, hatcheries began to be used for conservation purposes (e.g., Snake River sockeye salmon). Such hatchery programs are designed to preserve the salmonid genetic resources until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs reduce the risk of extinction (NMFS 2005d; Ford 2011). However, hatchery programs that conserve vital genetic resources are not without risk to the natural salmonid populations because the manner in which these programs are implemented can affect the genetic structure and evolutionary trajectory of the target population (i.e., natural population that the hatchery program aims to conserve) by reducing genetic and phenotypic variability and patterns of local adaptation (HSRG 2014; NMFS 2014h). A full description how hatchery programs can affect ESA-listed salmon and steelhead can be found in Appendix C.

Population viability and reductions in threats are key measures for salmon and steelhead recovery (NMFS 2013e). Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., supplementation of natural population abundance through hatchery production). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish by increasing the natural production with returning hatchery adults. These programs are not, however, a proven technology for achieving sustained increases in adult production (ISAB 2003), and the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014).

Consultations for various production programs addressed by the 2018 Agreement have occurred since the late 1990s as salmon and steelhead listing decisions were finalized. Since the time of the 2008 Agreement, there has been a concerted effort to ensure all programs included in any Management Agreement's production tables have undergone ESA compliance processes. A final push to complete and update consultations for these hatchery programs occurred in the last several years. At the same time, NMFS completed a section 7 consultation on its funding of hatchery programs via the Mitchell Act. At this time, NMFS has completed section 7 consultations on the vast majority of hatchery programs in the Columbia River Basin.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). The following sections describe the past and present effects of all hatchery programs affecting the ESUs and DPSs in the action area. The following sections also describe the anticipated effects of hatchery programs that have completed ESA section 7 consultation.

Table 2-81. Columbia River Basin hatchery programs that have been addressed in previously completed ESA section 7 consultations.

Biological Opinion	Programs Authorized in Opinion	Proposed 2018 *U.S.* versus *Oregon* Management Agreement (Y/N)	Signature Date	Citation
USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River	Little White Salmon/Willard National Fish Hatchery Complex Coho	Y	November 27, 2007	NMFS (2007b), NMFS (2016g)
	Little White Salmon/Willard National Fish Hatchery Complex spring Chinook			
	Little White Salmon/Willard National Fish Hatchery Complex URB fall Chinook			
	Carson National Fish Hatchery spring Chinook			
	Spring Creek National Fish Hatchery fall Chinook (tule)			
	Eagle Creek National Fish Hatchery coho			
	Eagle Creek National Fish Hatchery winter steelhead			
	Warm Springs National Fish Hatchery Warm Springs River spring Chinook			
Consultation on Remand for Operation of the Federal Columbia River Hydropower System	Yakima River kelt reconditioning program	Y	May 5, 2008	NMFS (2008e); NMFS (2014g)
	Upper Columbia River kelt reconditioning program			
Consultation on the "Willamette	North Santiam spring Chinook	N	July 11, 2008	NMFS (2008c)

River Basin Flood Control Project"	South Santiam spring Chinook McKenzie spring Chinook Middle Fork spring Chinook Upper Willamette summer steelhead			
Letter: Request for Concurrence with the Yakima Nation Fisheries' assessment of potential impacts	Lake Cle Elum/ Yakima Basin Lakes	Y	July 1, 2009	Turner (2009)
Umatilla River Spring Chinook Salmon, Fall Chinook Salmon, and Coho Salmon Hatchery Programs	Umatilla spring Chinook Umatilla fall Chinook Umatilla coho	Y	April 19, 2011	NMFS (2011c; 2016f)
Snake River Fall Chinook Salmon Hatchery Programs, ESA Section 10(a)(1)(A) permits, numbers 16607 and 16615	Lyons Ferry Hatchery Snake River fall Chinook Fall Chinook salmon Acclimation program Idaho Power Company fall Chinook Nez Perce Tribal Hatchery Snake River fall Chinook	Y	October 9, 2012	NMFS (2012d)
Entiat National Fish Hatchery Summer Chinook Salmon Hatchery Program	Entiat summer Chinook	Y	April 18, 2013	NMFS (2013c)
Snake River Sockeye Salmon Hatchery Program	Snake River sockeye	Y	September 28, 2013	NMFS (2013d)
Yakima River Spring Chinook	Upper Yakima River spring Chinook/Cle Elum	Y	November 25,	NMFS (2013a)

Salmon, Summer/Fall Chinook Salmon, and Coho Salmon Hatchery Programs	Supplementation and Research Facility (CESRF)		2013	
	Yakima River summer and fall run Chinook production program			
	Yakima River coho Reintroduction program			
Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead Programs	Sandy River spring Chinook	N	August 7, 2014	NMFS (2014f)
	Sandy River coho			
	Sandy River winter steelhead			
	Sandy River summer steelhead			
Issuance of Section 10(a)(1)(A) Permit 18928 for the Chief Joseph Hatchery Okanogan Spring Chinook Salmon Program	Chief Joseph Hatchery Okanogan spring Chinook	Y	October 27, 2014	NMFS (2014c)
Reinitiation of the Issuance of Three Section 10(a)(1)(A) Permits for the Upper Columbia River Chiwawa River, Nason Creek, and White River Spring Chinook Salmon Hatchery Programs	Chiwawa spring Chinook	Y	May 29, 2015 (original signed July 3, 2013)	NMFS (2015a)
	Nason Creek spring Chinook			
Six Lower Snake River Spring/Summer Chinook Salmon Hatchery Programs	Catherine Creek spring/summer Chinook	Y	June 24, 2016	NMFS (2016c)
	Upper Grande Ronde spring/summer Chinook			
	Imnaha River spring/summer Chinook			

	Lookingglass Creek spring Chinook			
	Lostine spring/summer Chinook			
	Tucannon River Endemic spring Chinook			
Issuance of a Section 10(a)(1)(A) Permit 18583 for the Upper Columbia Wenatchee River Summer Steelhead Hatchery Program	Wenatchee summer steelhead	Y	July 20, 2016	NMFS (2016d)
Issuance of Four Section 10(a)(1)(A) Permits for Spring Chinook Salmon Hatchery Programs in the Methow Subbasin	Methow Hatchery spring Chinook	Y	October 13, 2016	NMFS (2016e)
	Winthrop National Fish Hatchery spring Chinook			
Mitchell Act	Bonneville coho	N	January 15, 2017	NMFS (2017a)
	Bonneville fall Chinook (tule)			
	Big Creek Chinook (tule)			
	Big Creek coho			
	Big Creek chum			
	Big Creek winter steelhead			
	Gnat Creek winter steelhead			
	Klaskanine winter steelhead			
	Klaskanine coho			

Mitchell Act (cont.)	Klaskanine fall Chinook (tule)			
	Clackamas summer steelhead			
	Clackamas winter steelhead			
	Clackamas spring Chinook			
	Grays River coho			
	N. F. Toutle fall Chinook (tule)			
	N. F. Toutle coho			
	Kalama fall Chinook (tule)			
	Kalama coho (type N)			
	Kalama summer steelhead			
	Kalama winter steelhead			
	Washougal fall Chinook (tule)			
	Washougal coho	Y		
	Walla Walla spring Chinook			
	Ringold Springs steelhead			
	Ringold Springs coho[1]	N		
	Clearwater River coho restoration project	Y		
	Lostine River coho restoration project;	N		
	Deep River coho (MA/SAFE)			

Mitchell Act (cont.)	Deep River fall Chinook			
	Klickitat coho	Y		
	Klickitat URB fall Chinook			
	Klickitat spring Chinook			
	Klickitat (Skamania) summer steelhead			
	Beaver Creek summer steelhead	N		
	Beaver Creek winter steelhead			
	Beaver Creek (Elochoman) coho[1]			
	South Toutle summer steelhead			
	Coweeman winter steelhead			
	Cathlamet Channel Net-pen spring Chinook			
	Klineline winter steelhead (Salmon Cr.)			
	Washougal summer steelhead (Skamania Hatchery)			
	Washougal winter steelhead (Skamania Hatchery)			
	Rock Creek winter steelhead			
	Kalama spring Chinook			
	Umatilla River coho			
	Sandy River spring Chinook			
	Sandy River winter steelhead			

	Sandy River summer steelhead			
	Sandy River coho			
	Carson National Fish Hatchery spring Chinook	Y		
	Little White Salmon National Fish Hatchery spring Chinook			
	Willard National Fish Hatchery fall Chinook			
	Eagle Creek National Fish Hatchery winter steelhead	N		
	Eagle Creek National Fish Hatchery coho			
Issuance of a Tribal 4(d) Rule Determination for a Tribal Resource Management Plan (TRMP) submitted by the Confederated Tribes of the Colville Reservation (CTCR), and Funding and Carrying out Activities Pursuant to that TRMP	CTCR summer/fall Chinook	Y (only 636,239 out of 2,000,000 is in agreement)	February 24, 2017	NMFS (2017i)
	CTCR spring Chinook	N		
	CTCR steelhead	Y		
Mid-Columbia Coho Salmon Restoration Program: Operation and Construction	Mid-Columbia Coho Restoration Program	Y	February 28, 2017	NMFS (2017g)
Four Lower Snake River Steelhead Hatchery Programs	Grande Ronde Basin summer steelhead	Y (except for 800,000)	July 11, 2017	NMFS (2017h)
	Little Sheep Creek summer steelhead	Y		
	Lyons Ferry summer steelhead			

	Tucannon River summer steelhead			
Leavenworth National Fish Hatchery Spring Chinook Salmon Program (Reinitiation 2016)	Leavenworth National Fish Hatchery Spring Chinook	Y	September 29, 2017	NMFS (2017b)
Little White Salmon National Fish Hatchery Upriver Bright Fall Chinook Salmon Program	Little White Salmon National Fish Hatchery URB fall Chinook (Corps)	Y	October 5, 2017	NMFS (2017l)
Two Steelhead Hatchery Programs in the Methow River	Wells Complex summer steelhead	Y	October 10, 2017	NMFS (2017k)
	Winthrop National Fish Hatchery			
Five Snake River Basin Spring/Summer Chinook Salmon Hatchery Programs	Rapid River spring Chinook	Y	November 27, 2017	NMFS (2017o)
	Hells Canyon spring Chinook			
	South Fork Salmon River (SFSR) summer Chinook			
	Johnson Creek Artificial Propagation and Enhancement Project summer Chinook			
	South Fork Chinook Eggbox Project summer Chinook			
Five Clearwater River Basin Spring/Summer Chinook Salmon and Coho Salmon Hatchery Programs	Kooskia spring Chinook	Y	December 12, 2017	NMFS (2017p)
	Clearwater Fish Hatchery spring/summer Chinook	Y (all except for 1,615,000)		
	Nez Perce Tribal Hatchery spring/summer Chinook	Y (all except for 180,000)		

	Dworshak spring Chinook	Y (all except for 600,000)		
	Clearwater River coho (at Dworshak and Kooskia)	Y		
Nine Snake River Steelhead Hatchery Programs and one Kelt Reconditioning Program in Idaho	Steelhead Streamside Incubator (SSI) Project	Y	December 12, 2017	NMFS (2017q)
	Dworshak National Fish Hatchery B-Run Steelhead			
	East Fork Salmon Natural A-run Steelhead			
	Hells Canyon Snake River A-run Summer Steelhead			
	Little Salmon River A-run Summer Steelhead			
	Pahsimeroi A-run Summer Steelhead	N		
	South Fork Clearwater (Clearwater Hatchery) B-Run Steelhead	Y		
	Upper Salmon River A-Run Steelhead	N		
	Salmon River B-Run	N (except for 440,000 out of 1,085,000)		
	Snake River Kelt Reconditioning	N		
Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin	Chelan Falls summer/fall Chinook	Y	December 26, 2017	NMFS and USACE (2017)
	Wenatchee summer/fall Chinook			
	Methow summer/fall Chinook			
	Wells summer/fall Chinook			

	Priest Rapids fall Chinook			
	Ringold Springs fall Chinook			
Four Salmon River Basin Spring/Summer Chinook Salmon Hatchery Programs in the Upper Salmon River Basin	Yankee Fork spring Chinook	Y (only 300,000 out of 600,000 is in agreement)	December 26, 2017	NMFS (2017d)
	Panther Creek summer Chinook	Y		
	Panther Creek summer Chinook egg box	N		
	Upper Salmon River spring Chinook	Y		
	Pahsimeroi summer Chinook	Y		
Hood River Spring Chinook Salmon and Winter Steelhead Programs	Hood River spring Chinook	Y	February 13, 2018	NMFS (2017e)
	Hood River winter steelhead	Y		
Middle Columbia River Summer Steelhead and Spring Chinook Programs	Touchet endemic summer steelhead	Y	February 13, 2018	NMFS (2017f)
	Umatilla summer steelhead			
	Round Butte spring Chinook	Y (all except 500,000)		
	Walla Walla spring Chinook	Y		

[1]Proposed future program.

As discussed in detail in the site-specific consultations for each hatchery program as well as the Mitchell Act consultation (NMFS 2017j), hatcheries generally pose risks to the naturally-spawning salmon and steelhead populations wherever they come into contact. This is the case, generally, with the hatchery programs included in the baseline, and those effects and risks will be perpetuated by the ongoing operation of the programs. These risks are fully described in the site-specific consultations, the effects section and in Appendix C. These risks include genetic risks, completion and predation on natural-origin fish, disease, and broodstock collection and facility effects. However, as described below and in the referenced hatchery program consultations, in many cases steps are being taken to reduce the associated impacts and risks. Thus, while in our assessment of effects we include the continued negative impacts of the hatcheries included in the 2018 Agreement, we also consider the extent to which those operations are reducing their effects.

2.4.4.1 Lower Columbia River ESUs/DPSs

NMFS directs Federal funding to many of the hatchery programs that affect Lower River ESUs/DPSs through the Mitchell Act. NMFS first completed ESA consultation on the Mitchell Act program in 1999 (NMFS 1999e). Since that time, operators have carried out reforms including: improved monitoring of the status of salmon and steelhead populations; changes in the use of local broodstock; changes in production levels; use of weirs to selectively remove hatchery fish from the spawning grounds; and use of alternative release locations. These measures helped reduce adverse impact to ESA-listed species.

In 2017, NMFS completed an environmental impact statement (EIS) and new biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production level changes will reduce the pHOS as described in Table 2-82, Table 2-83, and Table 2-84 and reduce genetic and ecological risk.
- Elimination of the release of Chambers Creek steelhead, a hatchery stock that does not originate from within the Columbia River Basin. This change will reduce genetic risk to the ESA-listed LCR steelhead DPS.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Table 2-82. Expected genetic effect levels on ESA-listed Chinook salmon populations potentially affected by Mitchell Act-funded hatchery programs.

Chinook Salmon ESU	Major Population Group (MPG)	Population	Recovery Designation	Recent Avg pHOS (2010-2015)	Expected pHOS levels* once Mitchell Act reforms are fully Implemented
LCR	Coast	Elochoman/Skamokawa	Primary	79%	<u><</u>50.0%
		Mill/Germany/Abernathy	Primary	89%	<u><</u>50.0%
		Grays/Chinook	Contributing	73%	<u><</u>50.0%
	Cascade	Coweeman	Primary	15%	<u><</u>10.0%
		Lower Cowlitz	Contributing	27%	<u><</u>30.0%
		Toutle	Primary	64%	<u><</u>30.0%
		Kalama (fall)	Contributing	84%	<u><</u>10.0%
		Kalama (spring)	Contributing	~0%	<u><</u>10.0%
		Lewis	Primary	34%	<u><</u>10.0%
		Washougal	Primary	65%	<u><</u>30.0%
UWR	Western Cascade	Clackamas	Primary	<10%	<u><</u>10.0%

*Expected pHOS levels are based on a 4-year average

Table 2-83. Expected genetic effect levels on ESA-listed LCR coho salmon populations potentially affected by Mitchell Act-funded hatchery programs.

LCR Major Population Group (MPG)	Population	Recovery Designation	Recent Avg. pHOS (2011-2015)	Expected pHOS levels* once fully Implemented
Coast	Grays/Chinook	Primary	59%	<u><</u>30.0%
	Elochoman/Skamokawa	Primary	42%	<u><</u>30.0%
	Clatskanie	Primary	6%	<u><</u>10.0%
	Scappoose	Primary	0%	<u><</u>10.0%
Cascade	Lower Cowlitz	Primary	7%	<u><</u>30.0%
	Coweeman	Primary	13%	<u><</u>10.0%
	SF Toutle	Primary	25%	<u><</u>10.0%
	NF Toutle	Primary	33%	<u><</u>30.0%
	EF Lewis	Primary	12%	<u><</u>10.0%
	Washougal	Contributing	37%	<u><</u>30.0%
	Sandy	Primary	6%	<u><</u>10.0%
	Clackamas	Primary	9%	<u><</u>10.0%

*Expected pHOS levels are based on a 4-year average

Table 2-84. Expected genetic effect levels on ESA-listed steelhead populations potentially affected by Mitchell Act-funded hatchery programs.

Steelhead DPS	Major Population Group (MPG)	Population	Recovery Designation	Expected Maximum Gene flow level from MA programs once fully Implemented	Expected Census pHOS levels* from MA programs once fully Implemented
LCR DPS	Cascade (W)	Coweeman	Primary	≤2.0%	≤5.0%
		SF Toutle	Primary	≤2.0%	≤5.0%
		Kalama	Primary	≤2.0%*	≤5.0%**
		Salmon Cr	Stabilizing	≤2.0%	≤5.0%
		Clackamas	Primary	N/A	Winter program: ≤10.0%; Summer program: ≤5.0%
		Washougal	Contributing	≤2.0%	≤5.0%
		Sandy	Primary	N/A	Winter program: ≤10.0%; Summer program: ≤5.0%
	Cascade (S)	Kalama	Primary	≤2.0%*	≤5.0%**
		Washougal	Primary	≤2.0%	≤5.0%
	Gorge (W)	Upper Gorge	Stabilizing	≤2.0%	≤5.0%

* Expected pHOS levels are based on a 3-year average
**Expected outcome from the isolated component of the Kalama steelhead programs.

2.4.4.2 Middle and Upper Columbia River ESU/DPS

The hatchery programs that affect the Middle and Upper Columbia River ESUs and DPS have changed over time and reduced adverse effects on ESA-listed species. Specifically, the hatchery programs funded by the public utility districts were reduced in size starting in 2014 because of a revised calculation of their mitigation responsibility bases on increased survivals through the Upper Columbia River dams. Reducing hatchery production has reduced pHOS and associated genetic risk. It has also reduced the number of natural-origin fish removed for the hatchery broodstocks.

In addition, several reform measures have been incorporated into hatchery programs affecting Middle Columbia River steelhead and Upper Columbia River spring-run Chinook salmon including the following:

- The Winthrop National Fish hatchery spring Chinook salmon program made changes in their broodstock (i.e., developed a “stepping stone” program) to better link their hatchery fish genetically to natural-origin Chinook salmon.
- There has been continued improvement of spring and summer/fall Chinook salmon hatchery rearing practices to minimize early maturation, which could contribute to residualization.
- There has been a change in the use of water at Leavenworth National Fish Hatchery, which has provided more stream flow in Icicle Creek in summer months, which has

reduced the potential for dewatering; therefore, reducing risks to the UCR spring-run Chinook Salmon ESU and UCR Steelhead DPS.

- The Methow component of the Wells Complex steelhead program made changes in their broodstock (i.e., developed a "stepping stone" program) to better link their hatchery fish genetically to natural-origin steelhead.
- Changes were made in the management of adult hatchery-origin steelhead returning to the Wenatchee River Basin, which reduced pHOS and genetic risk to the UCR Steelhead DPS.
- The Walla Walla summer steelhead hatchery program (Wallowa stock) has been modified over time to reduce the genetic effects of releasing a non-endemic stock. In addition, the operators are evaluating the feasibility of using an endemic summer steelhead broodstock (Touchet stock), which would further reduce genetic risk of the hatchery program on the MCR Steelhead DPS.

2.4.4.3 Snake River ESUs/DPS

Snake River fall-run Chinook Salmon ESU

NMFS completed a consultation on the Snake River fall-run Chinook salmon hatchery programs in 2012 (NMFS 2012d). Under that proposed action at that time, we concluded that the pHOS, coupled with the presumed proportion of natural-origin fish in the broodstocks (pNOB), led to a PNI that was considerably lower the 67% that would be recommended for a population of high conservation concern. Thus, this posed a fitness risk through hatchery-influenced selection. In addition the broodstock collection protocol, typically collection only at Lower Granite Dam, would limit conservation or development of subpopulation structure, posing a diversity risk.

While recognizing these risks, we also considered that although in theory the presence of so many hatchery-origin fish on the spawning grounds should cause fitness to decline, natural production in the population was increasing. Given that the hatchery program was also increasing in size, it was possible that the increase in natural production was caused by spawning of an increasing number of hatchery-origin fish, but it could not be ruled out that this was a supplementation response. Based on this, and the relatively short number of generations the population had been subjected to hatchery influence, NMFS concluded that issuing an ESA Section 10 permit to continue operation of the programs through broodstock collection in 2017 (NMFS 2012d), without attempting to reduce hatchery influence, posed low risk to the survival or recovery of the population and thus the Snake River fall-run Chinook Salmon ESU.

In 2012, it was also clear that there were important information gaps that made it difficult to recommend actions to reduce genetic risk. A key part of that proposed action was a supplemental research, monitoring, and evaluation (RM&E) package to allow more precise estimates hatchery-natural composition, homing fidelity of hatchery fish, and area of origin of naturally produced fish. Results of these RM&E efforts were presented at a 2017 symposium (USFWS 2017).

Snake River spring/summer-run Chinook Salmon ESU

There are 18 spring/summer-run Chinook salmon hatchery programs in the Snake River Basin. Most of these programs release hatchery fish into rivers with ESA-listed natural-origin spring/summer-run Chinook salmon. However, some of these hatchery programs release fish into the Clearwater River, where spring/summer-run Chinook salmon are not listed under the ESA.

Over the years, hatchery programs in the Salmon River have made improvements to their hatchery programs. In particular, program managers have better integrated natural-origin fish into their broodstock, thereby creating integrated components of their hatchery programs. The South Fork Salmon River summer Chinook salmon hatchery program out of McCall Fish Hatchery created an integrated component and now has two components (segregated and integrated) with a recently implemented genetic relationship between them. In other words, a percentage of returning fish from the integrated component will be used as broodstock in the segregated component. This type of genetic linkage is sometimes referred to as a “stepping stone” system (HSRG 2014). Initial analysis by NMFS of programs connected this way shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs because they maintain a genetic linkage with the naturally spawning population (Busack 2015).

In this case, the presence of returning segregated hatchery-origin adults on the South Fork Salmon River spawning grounds poses little additional risk compared to integrated hatchery-origin adults. The South Fork Salmon River summer Chinook salmon hatchery program also contributes eyed-eggs to the South Fork Chinook salmon eggbox program, meaning segregated hatchery fish produced with this program are also genetically linked, which is an improvement from when this program operated as the “Dollar Creek Eggbox Program”. According to NMFS’ site-specific biological opinion (NMFS 2017o), genetic analyses using a PNI model indicate that, depending on natural-origin returns, the PNI will range from 5% to 67% on any given year in the South Fork Salmon River population. NMFS considers this to be a considerable improvement to the genetic structure of the population, compared to when these components were not genetically linked.

The Rapid River and Hells Canyon programs are segregated and for harvest purposes. In the most recent biological opinion, these programs have developed new strategies to limit straying and ecological interactions between hatchery and ESA-listed natural-origin fish (NMFS 2017o). The Johnson Creek Artificial Propagation Enhancement program has always used 100% natural-origin fish in their broodstock, so there are only minor genetic risks associated with this program, and this program will continue to operate with these same conservation considerations and standards. The Sawtooth hatchery program in the Upper Salmon River has also recently employed a genetically linked aspect to their integrated and segregated program components. This reduced genetic risk to the ESU. In addition, the proposed Panther Creek hatchery program may reduce risk to the ESU by re-establishing a natural-origin population. There is also a commitment for this future hatchery program to adhere to PNI values according to the sliding scale management objectives described in the biological opinion (NMFS 2017d). The Pahsimeroi and Yankee Fork hatchery programs have implemented sliding scale management strategies to manage genetic interactions between hatchery-origin fish with natural-origin fish on spawning grounds. The hatchery programs in the Upper Salmon River have also committed to strategies to limit hatchery straying and ecological interactions with ESA-listed natural-origin fish.

There have also been some improvements in recent years to hatchery programs located in northeast Oregon. The Catherine Creek, Imnaha, and Lostine hatchery programs use sliding scales sensitive to population abundance (NMFS 2016c). Under the sliding scales, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels, but reduce proportions as natural-origin abundance increases. Outplanting of adults is in addition to the pHOS determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

The Clearwater hatchery programs operate where ESA-listed Snake River spring/summer-run Chinook salmon are not present. Furthermore, according to NMFS site-specific biological opinion (NMFS 2017p) these hatchery programs have implemented new strategies to limit straying of program fish into areas where ESA-listed fish are present.

Snake River Sockeye Salmon ESU

The purpose of the Snake River sockeye hatchery program is to restore sockeye salmon runs to Stanley Basin waters leading, eventually, to sockeye salmon recovery and Indian and non-Indian harvest opportunity. The hatchery program was initiated in 1991, and the Snake River Sockeye Salmon ESU might now be extinct if not for the hatchery program (NMFS 2013d). The hatchery program is expected to accelerate recovery of the Snake River Sockeye Salmon ESU by increasing the number of natural-origin spawners faster than what may occur naturally (NMFS 2013d). In addition, the sockeye salmon hatchery program will continue to provide a genetic reserve for the Snake River Sockeye Salmon ESU to prevent the loss of unique traits due to catastrophes.

The Snake River sockeye salmon hatchery program is using a three-phase approach:

- Phase 1: increase genetic resources and the number of adult sockeye returns (captive brood phase)
- Phase 2: incorporate more natural-origin returns into hatchery spawning designs and increase natural spawning escapement (population re-colonization phase)
- Phase 3: move towards the development of an integrated program that meets proportionate natural influence (PNI) goals established by the Columbia River Hatchery Scientific Review Group (HSRG) (local adaptation phase). During Phase 3, no hatchery-origin sockeye salmon would be released into Pettit or Alturas Lake.

Growth of sockeye salmon in the Stanley Basin lakes is often density-dependent and related to zooplankton density (NMFS 2013d). Juvenile sockeye salmon rear one or two years in the lakes before emigrating to the ocean, and, during their stay in the lakes, sockeye juveniles feed almost entirely on certain assemblages of zooplankton (Burgner 1987). The Stanley Basin lakes' zooplankton communities declined drastically after the sockeye populations declined and other fish (e.g., trout and non-native kokanee) were introduced (NMFS 2013d), and the types of zooplankton available changed to assemblages less supportive of sockeye salmon (Koenings and Kyle 1997). The Snake River sockeye salmon hatchery program is expected to help sockeye salmon reestablish their biological niche and may result in an increase in zooplankton levels as kokanee abundance declines. This change would be expected to increase the growth rate of juvenile sockeye salmon and improve their survival during the long seaward migration from their nursery lakes. However, in the short-term, increasing the number of juvenile sockeye salmon in the lakes may increase competition for food. Therefore, ongoing studies to determine the carrying capacity of the lakes will continue and allow permit holders to adjust release levels if needed.

Snake River Basin Steelhead DPS

There are 14 steelhead hatchery programs in the Snake River Basin and one kelt reconditioning program. Typically, shortly after spawning, a kelt is in fairly poor condition, and its chances of surviving the downstream migration may be low. The objective of kelt reconditioning is to improve the condition of kelts by feeding and treating any disease in a hatchery environment, so that the kelts can be returned to the river in a healthier state (Hatch et al. 2017).

The kelt reconditioning program consists of the collection of up to 700 post-spawned steelhead greater than 60 cm, and the administration of disease-preventative medications and feed for the purpose of improving survival over what would be expected in the wild. Upon release, these fish are intended to return to natal populations, thereby increasing spawner escapement and productivity if reconditioned individuals successfully spawn.

Most of the steelhead hatchery programs are operated to augment harvest or A-Index and B-Index steelhead, but one program is for supplementation. NMFS concluded in its 2017 site-specific biological opinion that straying is low for all of the segregated harvest steelhead programs in the Snake River Basin, and is not expected to affect the abundance, productivity, diversity or spatial structure of the DPS because of the low potential for interbreeding and competition for spawning space between hatchery and natural-origin steelhead (NMFS 2017h). The East Fork Salmon River Natural program is the only integrated program. Genetic effects on the East Fork population are limited by the use of natural-origin broodstock, and an expected PNI of < 0.5 on average is a reasonable target for a population targeted for "maintained" in the recovery scenario (NMFS 2017n) and is likely to benefit the DPS through increased abundance and productivity for the East Fork population.

2.4.5 Harvest Effects

The following Section describes the effects of harvest of the ESUs and DPSs that are the subject of this consultation. For many of these salmonid populations, NMFS calculates cumulative exploitation rates that account for impacts of all fisheries coastwise. While many of these fisheries may occur outside the action area, the information is included in the environmental baseline section as the most relevant portion of the document for such a discussion.

2.4.5.1 Ocean Harvest

NMFS has previously considered the effects of ocean salmon fisheries on ESA-listed species under its jurisdiction for ESA compliance through completion of biological opinions and the ESA 4(d) Rule evaluation and determination processes. In general, each opinion provides a review of the record of harvest effects on natural-origin salmon species in the Columbia River Basin (Table 2-85). These opinions and determinations are still in effect and address harvest effects to species that are affected by the proposed action considered in this opinion (see Table 1-1 for the species list).

Since 1991, twenty eight salmon ESUs and steelhead DPSs have been listed under the ESA on the west coast of the United States. Beginning in 1991, NMFS considered the effects of Pacific Fishery Management Council fisheries, hereafter "PFMC Fisheries", on salmon and other species listed under the ESA and issued Opinions based on the regulations implemented each year or on the underlying Pacific Coast Salmon Fishery Management Plan (FMP) itself. In an Opinion dated March 8, 1996, NMFS considered the impacts of implementing the FMP on all salmon species then listed under the ESA, including spring/summer-run Chinook salmon, fall Chinook salmon, and sockeye salmon from the Snake River (NMFS 1996b). Subsequent Opinions, beginning in 1997, considered the effects of PFMC Fisheries on the growing catalogue of ESA-listed species (Table 2-85). NMFS has developed new consultations or reinitiated consultation when new information became available on the status of the ESUs or the impacts of the FMP on the ESUs, or when new ESUs were listed.

Table 2-85. NMFS ESA determinations regarding ESUs and DPS affected by PFMC Fisheries operating pursuant to Pacific Coast Salmon FMP and the duration of the Opinion. (Only those decisions currently in effect are included).

Date (Decision type)	**Duration**	**Citation**	**Species Considered**
Salmonid Species			
March 8, 1996 (Opinion)	until reinitiated	(NMFS 1996b)	Snake River spring/summer-run and fall-run Chinook salmon, and sockeye salmon
April 30, 2001 (Opinion)	until reinitiated	(NMFS 2001c)	UWR spring-run Chinook salmon Columbia River chum salmon UCR spring-run Chinook salmon UCR steelhead Snake River Basin steelhead LCR steelhead UWR steelhead MCR steelhead
April 27, 2012 (Opinion)	until reinitiated	(NMFS 2012c)	LCR Chinook salmon
April 9, 2014 (Opinion)	until reinitiated	(NMFS 2014b)	LCR coho salmon
Non Salmonid species			
April 30, 2011 (Opinion)	until reinitiated	(NMFS 2010a)	Pacific eulachon

Ocean fisheries in the offshore and near shore marine areas (defined as the area from zero to three miles offshore) of the U.S. Exclusive Economic Zone (EEZ) and the coastal and inland marine waters of the west coast states (Washington, Oregon, and California) are not directed at eulachon, chum salmon, or steelhead, all of which are rarely caught in PFMC-managed fisheries (PFMC 2013). The ocean distributions for ESA-listed steelhead are not known in detail, but steelhead are caught only rarely in ocean salmon fisheries, and consideration of the likely stock composition suggests that the catch of steelhead is less than 10 per year from all the steelhead DPSs combined (NMFS 2001c). Chum salmon catch levels in ocean fisheries are expected to be similar as steelhead. Ocean fisheries are directed at Chinook and coho salmon, therefore Snake River sockeye salmon are unlikely to be caught in ocean harvest, which has been verified through fishery sampling and post season reporting (PFMC 2016e). The harvest of upriver spring Chinook salmon, including those from the Upper Columbia River and Snake River ESUs, is assumed to be zero or close to it based on the timing for when ocean fisheries are prosecuted, allowing spring-run Chinook salmon to enter freshwater areas before ocean salmon fisheries begin. These low levels of catch of all spring-run Chinook salmon have similarly been verified from these same sampling activities. Spring Chinook from the LCR and UWR ESUs have different ocean distributions and are caught in ocean fisheries.

Four salmon ESUs experience measurable effects of harvest in the ocean. These include the LCR Chinook Salmon ESU, LCR Coho Salmon ESU, UWR Chinook Salmon, and Snake River fall-run Chinook Salmon ESUs.

LCR Chinook Salmon ESU

In 2000 and 2001, NMFS required that the total brood year exploitation rate (ER) for the Coweeman stock (representing the LCR fall-run (tule) component of the ESU), in all fisheries combined, not exceed 65% (NMFS 2012c). The exploitation rate limit was derived using the Viability Risk Assessment Procedure (VRAP), which provided an estimate of an associated Rebuilding Exploitation Rate (RER). An RER for a specific population is defined as the maximum exploitation rate that would result in a low probability of the population falling below a specified lower abundance threshold and in a high probability that the population would exceed an upper abundance threshold over a specific time period. RERs were used originally as part of the assessment in the 1999 Pacific Salmon Treaty (PST) Opinion (NMFS 1999d) and the 2000 Opinion on PFMC Fisheries (NMFS 2000b). (For a more detailed discussion of VRAP and the related RER calculations, see (NMFS 1999a). The 65% RER was subsequently reviewed and reduced substantially, in 2002, with an RER of 49%, which was used as the consultation standard for the tule component of the LCR Chinook Salmon ESU from 2002 to 2006 (NMFS 2012c).

In 2007, NMFS concluded that a periodic review was warranted. The Washington Management Unit Recovery Plan (LCRFRB) also called for a review of the 49% RER standard and the associated effects. NMFS organized an ad hoc workgroup that included staff from the NMFS NWFSC and WDFW. The general conclusion from the array of analytical results was that harvest impacts needed to be reduced further. In the 2007 Guidance Letter to the PFMC, NMFS recommended that the PFMC lower the exploitation rate in 2007 for the LCR tule Chinook salmon populations from 49% to 42%. In 2008, the exploitation rate was reduced again to 41% (NMFS 2012c). NMFS further indicated our intention to review the information that had accumulated over these years and conducted further analysis that would provide the basis for an opinion that would set harvest limits leading to reductions down to 37% by 2011.

At its November 2011 meeting, the PFMC considered, among other matters, new methodological approaches for use in the 2012 ocean salmon fishery management. The PFMC passed a motion to recommend that NMFS consider an abundance-based management (ABM) matrix for LCR tule Chinook salmon when formulating ESA section 7 biological opinion consultation standards for salmon fisheries in 2012 and beyond. In 2012, NMFS issued its current opinion, including an ABM matrix for the tule Chinook salmon populations. NMFS concluded in this opinion that the proposed fishing seasons were not likely to jeopardize the continued existence of the LCR Chinook Salmon ESU (NMFS 2012c). PFMC Fisheries have been operating using this ABM matrix since then and continue to do so.

The exploitation rate on LCR spring Chinook salmon populations based on an analysis of Cowlitz River hatchery fish in PFMC fisheries averaged 30% from 2000 to 2005, but has since been below 10% from 2005 on. For Sandy River spring Chinook salmon, represented by Willamette River hatchery fish, PFMC fisheries have averaged 1% or less since 2000 and account for 2% of the total exploitation rate (NMFS 2012c).

The exploitation rate on LCR bright populations averaged 5% in PFMC fisheries since 2000 and accounted for 12% of the total exploitation rate of LCR bright Chinook salmon (NMFS 2012c).

LCR Coho Salmon ESU

In 1997, the PFMC adopted a management plan (Amendment 13 to the Pacific Coast Ocean Plan) that constrained overall allowable fishery impacts on Oregon Coast natural-origin coho salmon. The management plan was built around a harvest matrix that allowed harvest impacts to vary depending on brood year escapement and marine survival. In 2000, after a review of Amendment 13, the PFMC adopted new changes to the FMP recommended by an ad hoc workgroup of fisheries experts; these changes included a lower range of harvest impacts when parental spawner abundance and marine survival were low.

LCR coho salmon were listed under Oregon’s Endangered Species Act in July 1999 (NMFS 2014b). An ODFW specific fishery management plan (Oregon Matrix), which was modeled after the one for Oregon Coast natural-origin coho salmon, was approved by the Oregon Fish and Wildlife Commission in July 2001. The plan defined the allowable harvest rate for both ocean and inriver fisheries depending on brood year escapement and marine survival indicators (NMFS 2015b). The resulting matrix was used by the states of Oregon and Washington for managing ocean and Columbia River fisheries for LCR coho salmon from 2002-2005.

In 2005, NMFS concluded in a conference Opinion that the exploitation rates anticipated in the 2005 PFMC Fisheries, based on the ocean component of the Oregon Matrix, were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU, which was then proposed for listing under the ESA as threatened (NMFS 2015b). The LCR Coho Salmon ESU was subsequently listed as threatened under the Federal ESA, effective August 29, 2005. Once the Federal listing became effective for this ESU, the conference Opinion was confirmed as the Opinion (NMFS 2015b).

Since the Federal listing of this ESU under the ESA in 2005, the states of Oregon and Washington have been working with NMFS to develop and evaluate a management plan that can be used as the basis for their long-term management. In 2006, NMFS concluded in an Opinion that a 15% total combined (ocean and in-river) exploitation rate was not likely to jeopardize the continued existence of the LCR Coho Salmon ESU. PFMC fisheries have generally accounted for about 60% of the LCR coho salmon harvest mortality since 1994 when harvest of coho was reduced. Exploitation rates for ocean fisheries averaged 80% from 1970-1983, 49% from 1984-1993, and 10% from 1994-2007. In 2008, NMFS completed a multi-year Opinion that used the ocean component of the Oregon Matrix to define the total harvest impact rate for ocean fisheries and Columbia River mainstem fisheries up to Bonneville Dam. The proposed action in the 2008 opinion limited the exploitation rate to 15%. This strategy has been used, in part, due to the limited amount of data on the status of natural-origin LCR coho salmon populations. In 2012, the PFMC brought together an ad hoc workgroup to facilitate the process of updating the harvest management strategies for the LCR Coho Salmon ESU. Based on the workgroup's recommendation, the PFMC proposed that NMFS manage ocean and inriver fisheries under a new harvest matrix, which identifies exploitation rate limits based on two levels of parental escapement and five levels of marine survival (i.e., a 2 x 5 matrix). NMFS evaluated this strategy in a 2015 Opinion and concluded that the proposed management framework was not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (NMFS 2014b).

Snake River Fall-run Salmon

Snake River fall-run Chinook salmon are broadly distributed and caught in fisheries from Alaska to California, but the center of their distribution and the majority of impacts occur in fisheries from the west coast of Vancouver Island to central Oregon. The total ocean fishery exploitation rate averaged 46% from 1986 to 1991. Following the listing of Snake River fall-run Chinook salmon under the ESA, the exploitation rate fell to 31% from 1992 to 2006 (NMFS 2008d). As a result of ESA consultation, ocean fisheries have been reduced since 1996 to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 base period (NMFS 2008d). Fisheries affecting Snake River fall-run Chinook salmon have been subject to ESA constraints since 1992. Since 1996, ocean fisheries have been subject to a total harvest rate limit of 31.29% annually. This represents a 30% reduction in the 1988 to 1993 base period harvest rate.

Council Groundfish Fisheries

PFMC groundfish fisheries historically catch salmon as bycatch while conducting fisheries pursuant to the Pacific Coast Groundfish FMP. Table 2-86 summarizes the bycatch of salmon by species and fishery managed by the PFMC under the Groundfish FMP from 2002 through 2015. Chinook salmon are the salmon species most typically taken as incidental catch by trawl fisheries. Yearly Chinook salmon bycatch ranged from 901 to 19,475 fish for non-tribal fisheries from 2002 to 2015. Coho and chum are caught in relatively low numbers, with an annual catch of tens to at most a few hundreds of fish over all fishery sectors coast-wide. Most of these fish are unlisted natural-origin or hatchery fish. Sockeye and steelhead are rarely encountered in the groundfish fishery. Available information suggests several ESUs (including UCR spring-run, and Snake River Spring/summer-run Chinook salmon) are not or have rarely been taken in the groundfish fisheries. During this period, Chinook salmon were primarily caught in the at-sea and shorebased whiting fisheries. Bycatch across fisheries averaged just over 9,200 Chinook salmon annually from 2002 to 2015. Bycatch consists of primarily subadult Chinook and coho salmon (i.e., two- and three-year-olds), with coho salmon averaging 2% of all salmon taken annually in the groundfish fisheries.

NMFS concluded in previous opinions on PFMC groundfish fishery implementation that the effects on ESA-listed Chinook salmon ESUs most likely to be subject to measurable impacts (Snake River fall-run Chinook, LCR Chinook, and UWR Chinook salmon) were very low. However, limited monitoring and low Chinook and coho salmon bycatch levels constrained the feasibility of making quantitative assessments for individual ESUs. Qualitative characterizations of the impacts ranged from rare to ERs that ranged from a "small fraction of 1% per year" to "less than 1% per year," depending on the ESU or populations being considered (NMFS 1999b; 2006). Since then, information regarding the stock composition of the Chinook salmon bycatch has become available from samples taken from 2009 to 2014 from the at-sea and shore side sectors of the whiting fishery. Bycatch in other sectors has been very low, with insufficient samples for either genetic or CTW-based analysis. The samples were analyzed by using genetic stock identification (GSI) techniques. Although listed and unlisted ESUs contributed to bycatch, the major contributors to Chinook salmon bycatch in the at-sea sector were from unlisted ESUs. They contributed, on average, Klamath/Trinity Chinook (28%) followed by south Oregon/north California (25%), Oregon Coast (10%), and northern British Columbia (11%) Chinook salmon. Samples from Chinook salmon bycatch in the shore side whiting sector showed a contribution from Central Valley Chinook (13%), similar to the Oregon Coast and very low contribution from British Columbia Chinook salmon. The remainder of stocks which included contributions from listed ESUs contributed 5% or less of the Chinook salmon bycatch in either fleet on average. In general, the shore side fishery is focused closer to shore. It does not extend as far south as the at-sea fishery.

The results demonstrate a strong regional pattern in contribution of Chinook salmon ESUs, with a greater proportion of southern Chinook salmon ESUs as bycatch when the fleets move south along the coast and similar patterns in the distribution of those salmon between the at-sea and shore side fleets. Samples from years when fisheries had more southerly distribution include more southern ESUs and vice versa. Moreover, some ESUs fit this pattern more closely than others (e.g., Puget Sound, Central Valley) due to different migration patterns (tending to migrate differentially north or south). This context is important for understanding Columbia River Chinook salmon ESUs were dominant in the Columbia River area. Catches further north included Columbia River and increasing percentages of Puget Sound and Fraser River Chinook salmon.

These low contribution rates to bycatch from the listed Chinook salmon ESUs (i.e., 5% or less) are consistent with the previous qualitative characterizations of likely ERs described by NMFS in its most recent opinion on PFMC's groundfish fisheries (NMFS 2017t). These genetic sampling results provide more specific information regarding the stock composition of the Chinook salmon bycatch in the whiting fishery, but the results support the more qualitative expectations in the 2006 supplemental opinion that impacts to listed ESUs are very low; i.e., less than 1% mortality per year for the most affected ESUs (NMFS 2017t).

Table 2-86. Salmon mortality (number of fish) by species and fishing sector in Pacific Coast Groundfish Fisheries, 2008 to 2015 (NMFS 2017t).

Fishery	Species	2008	2009	2010	2011	2012	2013	2014	2015
At-Sea whiting	Chinook	718	318	714	3,989	4,209	3,739	6,695	1,806
	Coho	21	12	0	5	17	6	104	4
	Chum	60	41	10	46	53	26	4	5
	Pink	0	2	0	12	22	37	0	23
	Sockeye	2	0	2	0	0	0	0	0
Shorebased whiting	Chinook	1,962	279	2,997	3,722	2,359	1,263	6,898	2,002
	Coho	141	10	37	16	136	16	33	167
	Chum	113	8	2	8	42	3	7	4
	Pink	7	26	0	6,113	0	2	0	0
	Sockeye	0	0	0	2	0	0	1	0
Tribal whiting[1]	Chinook	696	2,145	678	828	17	1,014	45	3
	Coho	21	57	5	28	0	78	0	0
	Chum	11	11	1	23	0	5	0	0
	Pink	9	129	0	1,087	0	5	0	0
	Sockeye	0	0	0	2	0	1	0	0
Bottom trawl	Chinook	449	304	282	175	304	323	984	996
	Coho	0	0	31	19	027	49	18	3
	Chum	0	0	0	0	00	0	0	0
	Pink	0	2	0	0	2	0	2	0
	Sockeye	0	0	0	1	0	0	0	0
Midwater non-whiting	Chinook	n/a	n/a	n/a	n/a	12	71	661	482
	Coho	n/a	n/a	n/a	n/a	0	0	12	7
	Chum	n/a	n/a	n/a	n/a	0	1	0	5
	Pink	n/a	n/a	n/a	n/a	0	0	0	0
	Sockeye	n/a	n/a	n/a	n/a	0	0	0	0
Non-trawl gear[2]	Chinook	0	22	16	8	63	124	36	40
	Coho	42	71	42	83	43	68	124	63
	Chum	0	0	0	0	0	0	0	0
	Pink	0	0	0	0	0	0	0	0
	Sockeye	0	0	0	0	0	0	0	0

[1] Includes only the Pacific whiting fishery. Tribal non-whiting fishery values were not available.

[2] Includes bycatch by vessels fishing under EFPs not already included in a sector count. The added Chinook bycatch by year under EFPs was 2002-22, 2003-51, 2004-3, 2014-1.

2.4.5.2 Columbia River Mainstem Harvest

Pre-European settlement fishing in the Columbia River Basin

Anadromous fish have been harvested in the Columbia River Basin as long as there have been people here. For thousands of years, Native Americans have fished for salmon and steelhead, as well as for other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls, to spears, weirs, and traps (usually in smaller streams and headwater areas).

Anthropological and archaeological evidence suggests that for more than 10,000 years Native Americans have fished for salmon and steelhead, as well as for other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes (Campbell and Butler 2010).

Native people utilized a variety of methods to catch salmon and steelhead, including weirs, gillnets, dipnets, spears, harpoons, and hook and line, occasionally even poison, which were decided largely by the river conditions (Barnett 1937; Hewes 1947; Johnson 1983; Taylor III 1999; Meengs and Lackey 2005). In the narrow channels near The Dalles prior to western development, tools used for harvest were limited to long handled spears and dipnets. In calmer waters, seines and gillnets were common. In smaller tributaries, many tribes used weirs, or 'salmon dams', to funnel fish into a net or basket (Taylor III 1999). And at falls, like Celilo and Kettle Falls, Native Americans employed large baskets, and long handled nets to harvest salmonids. In 1845, explorer Charles Wilkes describes what he records as the "Quiarlpi", or Basket People, who used basket nets to harvest salmon at Kettle Falls:

> "…the fishing apparatus consists of a large wicker basket, supported by long poles inserted into it, and fixed in the rocks. The lower part, which is of the basket form, is joined to a broad frame, spreading above, against which the fish, in attempting to jump the falls, strike, and are thrown back into the basket. This basket, during the fishing season, is raised three times in the day, (twenty-four hours,) and at each haul, not unfrequently, contains three hundred fine fish." (Wilkes 1845).

Harvested salmon were historically consumed fresh, dried, or jerked for tribal subsistence, cultural ceremonies, and trade, and were later harvested for salting and canning export. Because salmon and steelhead spawned as far inland as the headwaters of the Columbia River, 1,200 miles from the ocean, they were an important food to the indigenous people who lived along the river, and also to those who traveled far to trade for fish at established fisheries like those at Kettle Falls (located in the upper Columbia near the Canada–U.S. border, which was flooded in 1940, when the Grand Coulee Dam impounded the Columbia River to create Lake Roosevelt) or Celilo Falls (a series of cascades and waterfalls on the mainstem Columbia River near The Dalles, Oregon, until 1957, when the falls and nearby settlements were submerged by the construction of The Dalles Dam). Historical runs were estimated to be between 11-16 million salmon annually (Taylor III 1999; Harrison 2008).

Baselines for unrestrained Native American fish harvest and consumption helped elucidate the reservation of the treaty fishing right during treaty negotiations in the mid-1850s. The annual return of salmon and steelhead from the ocean had spiritual and cultural significance for tribes, and the fish had economic importance as both a trade and food item. Tribes developed elaborate rituals to celebrate the return of the first fish. These first-salmon ceremonies were intended to ensure that abundant runs and good harvests would follow. The health of Native Americans was heavily reliant on these resources whose diets traditionally included certain quantities and qualities of fish (Harper and Deward E. Walker 2015). Since we do not have reliable catch data for Indian fisheries prior to the 1800's, historical estimates are generally made by extrapolating per capita estimates to population estimates (Johnson 1983). Craig and Hacker (1940) first estimated that per capita salmon consumption by tribes in the Columbia River Basin in the 1800's was one pound (0.45 kg) per day, or 365 pounds (166 kg) annually. Multiplied by their approximation of 50,000 Native American people, they estimated Columbia River Basin harvest to be about 18,000,000 pounds (8,164,662 kg) per year. Not long after, Hewes (1947) updated the population estimate to 61,500 Native American people and modified their use assumptions, and after recalculating produced an estimate of 22,274,500 (10,023,525 kg) salmon harvested by Columbia River tribes, equivalent to approximately 2.3-3.4 million salmon annually Hewes (1947); (Taylor III 1999). The question of Native American harvest was revisited in the 1980's by demographer Robert Boyd, and anthropologist Randall Schalk. By reviewing the history of disease and epidemics in the region, (Boyd 1985) raised the population estimate to 87,000 Native American people within the Columbia River Basin prior to the epidemics of the 1770s (Swagerty 2012). Schalk examined the question from the usage perspective. Using more refined data on salmon biology and carbohydrate demands, as well as increasing the daily consumption estimate, Schalk estimated Native American harvest to be 41,754,800 pounds (18,939,658 kg) per year, or between 4.5 and 6.3 million salmon (Schalk 1986; Taylor III 1999; Meengs and Lackey 2005; Swagerty 2012). In a conservative approach (using an average per capita consumption estimate of less than 365 pounds per capita per year) combining the work of Hewes (1947), Walker Jr. (1967), and Schalk (1986), the Northwest Power Planning Council (NPCC 1986) estimates the average annual catch prior to the arrival of Euro Americans (circa 1780's) in the Columbia River Basin to be 44,126,900 pounds (20,015,625 kg). In their review, Harper and Deward E. Walker (2015) conclude that between 500 and 583 pounds (227-264 kg) per capita per year rather than 365 pounds is a more accurate historical, or heritage, consumption rate for the Columbia River Basin.

Early European historical fishing in the Columbia River Basin

While it is difficult to quantify the historical harvest made by tribes in the Columbia River Basin, even the most conservative of these estimates is sizeable, especially when compared to the industrial fishery maximum harvests between 1883 and 1919, which only surpassed 41 million pounds nine times in 36 years. Despite these high historical harvest rates among the tribes, the fisheries remained stable. Taylor III (1999) provides two explanations for this: First, Native American fishing pressure was generally adapted to the supply of the area, and unlike later developed non-Indian industrial fishing, was spread across the Basin rather than focused on the Lower Columbia River. In addition, before the advent of canning in the late 1800's and early 1900's, the demand for salmon was essentially limited. Second, due to the biology of salmon, thinning a run could increase the survival of young by lowering the frequency of aggressive mating behaviors that could lead to destruction of redds or of other potential spawners (Taylor III 1999).

Commercial fishing developed rapidly with the arrival of European settlers and the advent of preservation technologies in the 1800s. In the 1820's, the salting and export of salmon began, led by the Hudson's Bay Company. The packing industry initially relied heavily upon Native American-caught salmon. As demand grew, the non-Indian commercial fishery expanded as well (Johnson 1983). Even greater expansion was spurred by the opening of the first salmon cannery on the Columbia by Hapgood, Hume and Company in 1864 (Johnson 1983; Dietrich 1995). The canning industry reached its peak in 1883 with 55 canneries in operation packing 630,000 cases of salmon. The 1883 commercial harvest was 43 million pounds (Netboy 1974; Brown 1975). Fishing pressure, especially in the late nineteenth and early twentieth centuries has long been recognized as a key factor in the decline of Columbia River salmon runs (NRC 1996).

In 1855, Columbia River Basin Native Americans entered into the Treaties of 1855 with the United States government, ceding the majority of their land but expressly reserving, among other things, the right to fish: "the exclusive right of taking fish in the streams running through and bordering said reservation is hereby secured to said Indians; and at all other usual and accustomed stations, in common with citizens of the United States the exclusive right of taking fish… at all usual and accustomed places, in common with citizens of the Territory". The subsequent historical progression of legal interpretation of the Treaty Indian fishing right is described in Section 1.2.

Modern era fishing in the Columbia River Basin

As described in Section 1.2, aspects of treaty Indian fishing rights in the Columbia River Basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon* (Civil Case No. 68-513, Oregon 1968). In at least a half-dozen published Opinions and several unpublished Opinions in *US v Oregon*, as well as dozens of rulings in the parallel case of *U.S. v. Washington* (interpreting the same treaty language for Tribes in Western Washington), the courts have established a large body of case law setting forth the fundamental principles of treaty rights and the permissible limits of conservation regulation of treaty fisheries.

Since 1992 (NMFS 1992), NMFS has consulted under section 7 of the ESA on proposed *US v Oregon* fisheries in the Columbia River Basin. After the initial consultation (NMFS 1992), NMFS conducted a series of consultations to consider the effects of proposed fisheries as additional species were listed, as new information became available, and as fishery management provisions evolved to address the needs of ESA-listed species.

Harvest mortality has been reduced substantially in response to evolving conservation concerns. The effects of fisheries have been considered through a series of consultations since Snake River spring/summer-run Chinook salmon were listed in 1992. Other listings followed, including UCR spring-run Chinook salmon, and the effects of fisheries on these species were incorporated into subsequent opinions. Prior to 1992, the now expired CRFMP, used for management from 1986 to 1998, allowed for harvest rates up to 4.1% on upriver spring stocks in non-treaty fisheries and either 5% (for aggregate runs less than 50,000) or 7% (for runs between 50,000 and 128,800) in treaty C&S fisheries. For runs greater than 128,800, half the surplus greater than 128,800 was considered harvestable in mainstem fisheries. The CRFMP also provided that all fish in excess of 143,750 were harvestable. The CRFMP set an interim management goal of 25,000 natural-origin spring Chinook salmon as measured at Lower Granite Dam.

In 1992, when the Snake River spring/summer-run Chinook Salmon ESU was listed, new constraints were implemented. These were refined through a series of annual consultations that led to the development in 1996 of a three year Management Agreement that modified the CRFMP's original harvest management framework. The Plan's provisions were modified by reducing allowable impacts in the non-treaty fisheries. The alternative target harvest rates in the treaty fisheries (5-7%) were not changed as a result of the Agreement, but the Agreement did, for the first time, require that fisheries be managed in response to the status of listed natural-origin fish rather than an aggregate runsize that was now composed primarily of hatchery-origin fish. The 1996 Agreement provided that harvest rates would match those of the original CRFMP only if the anticipated return of natural-origin spring Chinook salmon from the Snake River exceeded 10,000 fish.

The CRFMP limited harvest rates on upriver summer Chinook salmon stocks in the non-treaty and treaty fisheries to 5% each. The three-year Agreement reduced the harvest rate limit for upriver summer Chinook salmon in the non-treaty fishery from 5% to 1% and clarified that all treaty fisheries were subject to the 5% harvest rate limit. At the time, the purpose of these further constraints was to limit the potential take of the summer component of the Snake River spring/summer-run Chinook Salmon ESU. These limits on summer Chinook salmon harvest were not particularly confining since both the states and tribes had been managing their fisheries well below these limits because of low returns and conservation concerns.

The 1996-1998 Management Agreement was extended through July 31, 1999 and therefore applied to the 1999 spring fisheries as well. By the time the 2000 season approached, additional listings had occurred, including the UCR spring-run Chinook Salmon ESU. In 2000, there was a preseason forecast for upriver spring Chinook salmon of 134,000 that was higher than it had been for some time. Based on the higher aggregate run size, the tribes proposed a harvest rate for spring Chinook salmon of 9% while the states proposed a harvest rate ranging from 1-2%. At the time, NMFS concluded that an increase in the harvest rate beyond 9%, no matter how small, was inappropriate given the status of the stock. NMFS issued a jeopardy opinion and limited the overall harvest rate to 9%. The 9% cap was then carried forward in subsequent analyses related to the 2000 FCRPS biological opinion and thus became one of the underlying assumptions related to its conclusions. This then provided the benchmark against which subsequent harvest proposals were compared.

In 2001, there was a preseason forecast for upriver spring Chinook salmon of 364,000 that was twice what it was in 2000 and three times what it had been in any year since 1979. The Parties reached an Interim Management Agreement for winter, spring, and summer fisheries that allowed for a variable harvest rate based on the aggregate upriver spring Chinook salmon runsize and the natural-origin Snake River spring/summer-run Chinook salmon runsize. This sequence of past consultations contributed to the evolution of the management framework contained in the 2005-2007 Interim Management Agreement, which was carried through into the 2008 Agreement.

Since 2008, actual harvest rates have ranged between 8.8-16.7% (Table 2-87). In 2010, the Parties implemented a "Catch Balance Agreement" for mainstem spring season fisheries. The two provisions of this agreement included (1) a provision that total non-treaty mainstem fishery mortality cannot exceed the total allowed treaty harvest and (2) provision that the states of Oregon and Washington will use a 30% buffer to manage early season fisheries. This buffer is a requirement that non-treaty fisheries occurring prior to the first TAC run size update must be managed for the impacts associated with a run size 30% less than the pre-season forecast.

In addition, recreational fisheries have been required to release unmarked, natural-origin spring Chinook salmon in the Columbia River. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries. This release mortality rate is the *US v Oregon* TAC's scientific recommendation which is developed, and updated whenever new information becomes available, through a combination of reviewing current scientific literature and incorporating Columbia River Basin specific studies examining natural-origin spring Chinook salmon captured and released from recreational gear used during spring fisheries, as seasonal temperature changes are known to affect release mortality rates differently (TAC 2017).

Harvest mortality has been reduced substantially in response to evolving conservation concerns. Steelhead impacts associated with fall season treaty fisheries were managed from 1986 to 1998 pursuant to the guidelines contained in the now expired CRFMP. That plan allowed for a tribal harvest rate on B-Index steelhead during the fall season of 32%. The 32% cap was itself a reduced fishing level designed at the time to provide necessary protection to B-Index steelhead. The average B-Index harvest rate from 1985 to 1997 was 26.0%. Since 1998, when ESA constraints specific to B-Index steelhead were first applied, the harvest rate in the tribal fall season fishery averaged 11.5%. The 15% harvest rate cap represented a 42% reduction from the long-term average harvest rate for the tribal fishery, and a 53% reduction from the CRFMP allowed harvest rate of 32%.

Significant management actions in non-treaty fisheries related to steelhead occurred 40 years ago. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Prior to efforts during the last few years to promote commercial selective fisheries, time, area, and gear restrictions limit handling and mortality of steelhead by the non-treaty fishery to less than 2% of the run. In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries. This release mortality rate is the *US v Oregon* TAC's scientific recommendation which is developed, and updated whenever new information becomes available, through a combination of reviewing current scientific literature and incorporating Columbia River Basin specific studies examining natural-origin steelhead captured and released from recreational gear used during spring times of the year, as seasonal temperature changes are known to affect release mortality rates differently (TAC 2017).

Also as described in Section 1.2, the *US v Oregon* fisheries have been managed subject to the 2008-2017 *United States v. Oregon* Management Agreement ("2008 Agreement"). NMFS completed an opinion on the 2008 Agreement on May 5, 2008 (NMFS 2008d). The opinion concluded that fisheries management subject to the proposed agreement was not likely to jeopardize any of the affected ESA-listed species.

The incidental take limits and expected incidental take (as a proportion of total run size) of listed salmonids for treaty Indian and non-Indian fisheries under the 2008 Agreement are captured in Table 2-87. As mentioned above, NMFS hereby incorporates by reference the opinion (NMFS 2008d) analyzing the effects of this take into the environmental baseline.

Table 2-87. Authorized level of incidental take (as proportion of total run-size) of listed anadromous salmonids for non-Indian and treaty Indian fisheries included for the 2008 Agreement.

ESU or DPS	Take Limits from 2008-2017 (%)	Range of take observed from 2008-2017 (%)	Average annual take
Snake River fall-run Chinook Salmon	21.5 – 45.0 [1]	26.2 - 38.3	32.9%
Snake River spring/summer-run Chinook Salmon	5.5 – 17.0 [2]	8.8 -16.7 [2]	12.1%
LCR Chinook Salmon	Managed by components listed below		
spring-run component	Managed For Hatchery Escapement Goals	Hatchery escapements met all but 1 year	[3]
tule component (early-fall run)	30 – 41 [4]	33.0 - 44.5	37.2 % [4]
bright component (late-fall run)	Managed For 5,700 fish Escapement Goal	Escapement goal met every year	n/a
UWR Chinook Salmon	15.0	5.1 – 16.4	9.5%
Snake River Basin Steelhead	Managed by components listed below		
A-Index Component	4.0 [5]	1.1 -3.3	1.9%
B-Index Component	2.0 [7]	0.7 – 3.4 [7]	2.0%
B-Index unclipped component, non-treaty	15 -22 [1,7]	10.1 -21.5	17.9% [7]
LCR Steelhead	Managed by components listed below		
winter component	2.0 [5,6]	0.3 – 0.8	0.6%
summer component	4.0 [5]	0.2 – 0.7	0.6%
UWR Steelhead	2.0 [5,6]	0.3 – 0.8	0.6%
MCR Steelhead	Managed by components listed below		
winter component	2.0 [5,6]	0.3 – 0.8	0.6%
summer component	4.0 [5]	1.1 – 3.3	1.9%

UCR spring-run Chinook Salmon	5.5 – 17.0 [1,2]	8.8 – 16.7 [2]	12.1%
CR Chum Salmon	5.0	0.8 – 4.7	1.3%
UCR Steelhead, non-treaty	4.0 [5]	1.1 – 3.3	1.9%
Snake River Sockeye Salmon	6.0 – 8.0 [1]	4.6 – 9.7	6.2%
LCR Coho Salmon	10 – 30 [1,4]	7.3 - 24.4	14.3% [1,4]
Monitoring, Evaluation, and Research	0.1 - 0.5 [10]		

[1] Allowable take depends on run size.
[2] Impacts in treaty fisheries on listed wild fish can be up to 0.8% higher than the river mouth runsize harvest rates (indicated in table above) due to the potential for changes in the proportion wild between the river mouth and Bonneville Dam.
[3] NMFS (2012c) determined fisheries have ranged from exploitation rates of 2% to 28% over the last ten years, and are expected to remain within this range through managing for hatchery escapement until other actions concerning terminal fish passage in the LCR are addressed.
[4] Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2012c) evaluated the PFMC's harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.
[5] Applies to non-Indian fisheries only; 2% in winter/spring/summer seasons and 2% in fall season.
[6] There is no specific harvest rate limit proposed for treaty fisheries on winter steelhead above Bonneville Dam or on A-Index summer steelhead.
[7] For fall fisheries only.

The previous biological assessment (TAC 2008) assumed these fisheries were expected to also have an indirect effect on the amount of marine derived nutrients returning to spawning and rearing areas because the fisheries would reduce the number of adult fish that would otherwise return to spawn and die. Therefore the analysis in the 2008 BA (TAC 2008) extended from the fishery footprint upstream to include all accessible salmon spawning and rearing areas in the Columbia River Basin. The rates in Table 2-87 are variable based on tiered schedules in the 2008 Agreement that are stratified by returning adult abundances.

Table 2-87 summarizes the allowed rates for each ESU/DPS along with the observed annual average postseason performance after fisheries were implemented during the course of the 2008 Agreement.

While the general principles for quantifying treaty Indian fishing rights are well established, their application to individual runs during the annual fishing seasons is complicated. Annual calculations of allowable harvest rates depend on (among other things) estimated run sizes for the particular year, the mix of stocks that is present, application of the ESA to mixed-stock fisheries, application of the tenets of the "conservation necessity principle" for treaty Indian fisheries, and the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty Indian fishing rights during a particular fishing season often cannot be established by a rigid formula, the treaty fishing right itself continues to exist and must be accounted for in the environmental baseline.

2.4.5.3 Columbia River Tributary Harvest

Tributary fisheries target hatchery-origin steelhead, Chinook salmon and coho salmon, throughout the action area. These fisheries affect the status of ESA-listed fish by removing adults from the respective tributaries which may have otherwise contributed to the spawning population or to nutrient enhancement of the ecology. While they tend to target hatchery-origin fish it is important to review where NMFS has authorized tributary levels of fishing to evaluate where tributary levels of known incidental handling and mortality is occurring. Hatchery-origin fish are externally marked for easy identification (i.e., the adipose fin is clipped or removed), and in areas where natural-origin fish are present recreational fisheries are managed with the requirement that all unmarked adipose fin present adult salmon and steelhead be released. In areas where natural-origin fish are not ESA-listed, recreational fisheries may target them. They are managed to meet both hatchery broodstock needs, whereas unmarked fish may be included in hatchery broodstock needs, but are more often managed for natural production escapement goals. Commercial fisheries in these areas follow these general management guidelines but retain all fish regardless of external marking designation.

In one of its 2003 opinions (NMFS 2003e), NMFS determined that the WDFW and ODFW adequately addressed the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon and steelhead in the relevant five Fisheries Management and Evaluation Plans (FMEPs). These FMEPs limited tributary harvest levels of managed fisheries to achieve the 5,700 escapement goal for bright fall-run Chinook salmon. The plans also kept harvest impacts below the rate developed during the PFMC process described above in the Ocean Harvest Section for fall-run Chinook salmon, below 4% for chum salmon (NMFS 2008d), and 10% for steelhead, although the actual impacts are closer to 5%, on average, for steelhead in the action area (NMFS 2003e). While fisheries described in these FMEPs for spring-run Chinook salmon are selective for marked hatchery-origin fish, current tributary fisheries in the action area are managed to ensure hatchery escapement goals (those back to their respective release facilities) are met for spring-run Chinook salmon because of the limited amount of suitable habitat, as discussed above in Section 1.2. This management strategy using hatchery escapements has continued to ensure the extinction risk is low in the short-term until upstream and downstream passage issues can be resolved in the Cowlitz and Lewis basins.

Similarly in the Willamette River, another major tributary to the Columbia River, in 2001 NMFS evaluated an FMEP for UWR spring-run Chinook salmon (NMFS 2001a) and another FMEP for UWR winter-run steelhead (NMFS 2001a) submitted under Limit 4 of the final 4(d) rule. After evaluation of these FMEPs with respect to the criteria specified for Limit 4, NMFS determined that the plans adequately addressed all of the criteria. The FMEPs described that ODFW would implement selective fisheries for hatchery-origin spring-run Chinook salmon and steelhead in the Willamette River, meaning that all hatchery-origin spring-run Chinook salmon and steelhead would be ad clipped and that only fish that are ad clipped would be allowed to be retained in freshwater fisheries beginning in 2002 and thereafter. All unmarked, natural-origin fish were required to be released unharmed. The monitoring and evaluation measures identified in each FMEP assessed the encounter rate of natural-origin fish in the fisheries, fishery mortality, the abundance of hatchery-origin and natural-origin fish throughout the entire UWR Basin, and angler compliance. This information is used annually to assess whether impacts on ESA-listed fish are as expected. ODFW also conducts a comprehensive review of the FMEP at five year intervals to evaluate whether the objectives of the FMEP are being accomplished. Since implementation of the FMEPs the annual harvest rate on natural-origin UWR spring-run Chinook salmon has averaged 10.6% (ODFW 2015) which is below the levels analyzed in the FMEP for natural-origin Chinook salmon and for UWR winter steelhead over the same time period there have been no directed fisheries in the Willamette River Basin.

In the UCR Basin, for areas upstream of Priest Rapids Dam, the local salmon recovery board (the UCSRB) has committed to pursue and support fishing opportunities (recreational and tribal) in the UCR that are consistent with meeting ESA obligations for ESA-listed populations (UCSRB 2007). The harvest of UCR steelhead varies from year-to-year depending on a tiered harvest rate schedule. Similar to other geographic areas described above, harvest depends on the total abundance of externally marked hatchery-origin steelhead from the upriver Wenatchee steelhead hatchery program. Steelhead are harvested in tribal fisheries and in mainstem recreational fisheries, and there is incidental mortality associated with mark-selective recreational fisheries (i.e., catch and release mortality) while they target hatchery-origin steelhead. Harvest has negative impacts on the abundance, productivity, genetic and spatial diversity of natural-origin steelhead through the removal of natural-origin fish through incidental take and mortality. However, harvest of returning hatchery-origin fish can have beneficial impacts on the same parameters through removal of surplus hatchery-origin fish destined for spawning grounds.

WDFW regulates the harvest of hatchery-origin steelhead in the UCR Basin; there is no directed fishery on natural-origin steelhead in the basin (UCSRB 2007). NMFS (2003a) approved a tiered-approach to the harvest of hatchery-origin steelhead consistent with the UCR recovery plan through the ESA consultation and through the issuance of ESA Section 10(a)(1)(A) direct take enhancement permit (Permit No. 1395) for the Wenatchee steelhead hatchery program. The goal of the fishery is to reduce the number of hatchery-origin steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of natural-origin steelhead in the spawning populations. Hatchery-origin steelhead can be removed at dams and other trapping sites, or WDFW may allow recreational fisheries to selectively harvest hatchery-origin steelhead (i.e., ad clipped fish) subject to limits on the effects to natural-origin fish. Under the current ESA permit, steelhead fisheries targeting hatchery-origin steelhead may be implemented in the Wenatchee, Methow, and/or Okanogan subbasin when natural-origin steelhead run levels meet defined criteria. The current permit criteria (NMFS 2003a; UCSRB 2007) are:

- When the natural-origin (wild) steelhead run is predicted to exceed 1,300 fish at Priest Rapids Dam and the total steelhead run is predicted to exceed 9,550 steelhead, a harvest fishery may be considered as an option to remove excess adipose fin-clipped hatchery steelhead. For a fishery to commence, the predicted Wenatchee tributary escapement must meet the minimum Tier 1 criteria. The mortality impact on naturally produced steelhead must not exceed the specified limits for Tier 1 for the Wenatchee tributary (2 %).
- When the natural-origin steelhead run is predicted to exceed 2,500 fish at Priest Rapids Dam, the total steelhead run is predicted to exceed 10,035 steelhead, and the tributary escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 2 for the Wenatchee tributary (4%).
- When the natural-origin steelhead run is predicted to exceed 3,500 fish at Priest Rapids Dam, the total steelhead run is predicted to exceed 20,000 steelhead, and the tributary

escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 3 in the Wenatchee tributary (6%).

- The WDFW may remove artificially propagated steelhead at dams or other trapping sites to reduce the number of artificially propagated steelhead in the spawning areas in excess of full habitat seeding levels to increase the proportion of naturally produced steelhead in the spawning population.

Under each fishery criterion, catch and release mortality of natural-origin steelhead is calculated at 5% (NMFS 2003a). This release mortality rate is the *US v Oregon* TAC's scientific recommendation which is developed, and updated whenever new information becomes available, through a combination of reviewing current scientific literature and incorporating Columbia River Basin specific studies examining natural-origin steelhead captured and released from recreational gear used during these tributary fisheries, as seasonal temperature changes are known to affect release mortality rates differently and tributary fisheries have generally lower water temperatures (TAC 2017).

Incidental take of steelhead occurs in UCR spring-run Chinook salmon fisheries; spring-run Chinook salmon fisheries are strictly regulated and limited to no more than 1% incidental mortality (natural-origin and hatchery-origin combined) of UCR steelhead. Current estimates, based on observed steelhead encounters during the Icicle River recreational spring-run Chinook salmon fishery and the lower Wenatchee River fishery, indicate an annual estimated encounter rate of 53% (using a 10-year geometric mean of encounters). This encounter rate would provide a range of adult encounters from zero to ten steelhead (hatchery and natural-origin combined) during the fishery. With a 5% incidental catch-and-release hooking mortality rate, this fishery would result in the maximum incidental mortality of 0.8 fish or the take of one ESA-listed UCR steelhead annually (NMFS 2013b). Annual monitoring and reporting is required to ensure that these performance standards are met.

Spring-run Chinook salmon harvest in this geographic area targets unlisted spring-run Chinook salmon produced by the LNFH and surplus hatchery-origin UCR spring-run Chinook salmon produced by the safety-net components of the Chiwawa River and Nason Creek hatchery programs. In 2013, NMFS approved a new spring-run Chinook salmon fishery in the Wenatchee River below Tumwater Dam to the confluence of the Wenatchee and Columbia Rivers for the purpose of removing hatchery-origin fish that were excess to natural spawning needs while achieving criteria for protecting spring-run Chinook salmon diversity (proportionate natural influence (PNI) criteria) (NMFS 2013b; 2013i; 2013h). The incidental take of ESA-listed natural-origin spring Chinook salmon in the fishery is strictly limited based on the abundance of natural-origin spring Chinook salmon returning to the Wenatchee River to spawn. Maximum incidental mortality (including catch-and-release hooking mortality) is 2% (i.e., 2% of the annual natural-origin spring Chinook salmon run). In recent years, Wenatchee River spring-run Chinook salmon abundance has averaged between 500 and 600 fish meaning fisheries targeting hatchery-origin fish could continue annually until the incidental take of natural-origin spring Chinook salmon has reached 10 to 12 fish for the season in the Wenatchee River subbasin.

Treaty Indian tributary fisheries that are included in the 2018 Agreement are ongoing fisheries that have undergone ESA consultation in the past (NMFS 2008d), and thus are part of the environmental baseline. Table 2-88 presents historical information on ESA-listed populations affected by these fisheries. The observed averages and range of harvest rate values during the 2008 Agreement for these fisheries were low for the most part, and with significant year-to-year variations for some populations. For the Wind River summer steelhead population, the highest harvest rate value for this time period was 8.4% and the lowest was 0.0% (TAC 2017, Table 3.4.6). For the Klickitat River summer steelhead population the highest observed harvest rate for this period was 21.4% and the lowest 1.3%; averaging 5.4 for 2008-2015 (TAC 2017, 3.4.10). The 2008-2016 average harvest rate for all other populations was below 5%, and most below 2% or close to zero. Incidental mortality of ESA-listed populations related to the treaty Indian tributary fisheries that are included in the 2018 Agreement was taken into account in the latest status review for their respective ESU or DPS.

Table 2-88. Observed Incidental Take for Treaty Indian tributary fisheries (2008-2016) (TAC 2017).

Tributary Fishery Location	Affected ESA-Listed Populations	Treaty Indian Observed Take - Average % HR (range)	TAC 2017 Table Number
Wind River	Wind River summer steelhead	1.5% (0.0 - 8.4%)	Table 3.4.6
Hood River	Hood River spring Chinook salmon	1.9% (0.7 - 3.7%)	Table 3.4.8
Hood River	Hood River winter steelhead	2.0% (1.8 - 2.3%)	Table 3.4.9
Klickitat River	Klickitat summer steelhead	5.4% (1.3 - 21.4%)	Table 3.4.10
Deschutes River	Deschutes River steelhead	0.4 (0 – 1.6%)	Table 3.4.12
John Day River	John Day River steelhead	0.0 - 0.5 % (0.2%)	Table 3.4.13
Umatilla River	Umatilla River steelhead	3.1% (1.1 - 6.2%)	Table 3.4.16
Walla Walla River	Walla Walla River steelhead	0 observed harvest	Table 3.4.18
Yakima River	Yakima River steelhead	0% (0-0.1%)	Table 3.4.19
Icicle Creek Tributary	Natural-origin summer steelhead	0 observed harvest	Table 3.4.120

Summary

In summary, harvest in the action area results in incidental take of ESA-listed species and these take effects are incorporated into our baseline where previous consultations on harvest actions have occurred. These fisheries in the action area have undergone a mix of section 7 consultations, and in some cases Section 10(a)(1)(A) permitting, or 4(d) determinations under the 4(d) Limit, resulting in the escapements reviewed in Section 2.2.1 and were found to meet the ESA standards for avoiding jeopardy.

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 Harvest Effects

Analysis of the proposed action identified that multiple ESA-listed species are likely to be adversely affected and take is reasonably certain to occur as a result of fisheries that may affect salmon and steelhead in several ways. Immediate mortality occurs from the capture, by hook or net, and subsequent retention of individual fish - those direct effects are considered explicitly in the following subsections of this opinion.

In addition, other effects occur when fish that are caught and released alive, to comply with non-retention requirements that may be related to species or size limits, are injured or subsequently die. Non-retention regulations are also sometimes used in mark-selective fisheries that target marked hatchery-origin fish for retention while requiring the release of unmarked fish. These effects are accounted for in the review of fishery management actions, as catch-and-release mortalities primarily result from implementation of management regulations designed to reduce mortalities to listed natural-origin fish through live release.

In reviewing fishery management action effects it is important to highlight the definition of stock used in the 2018 Agreement again. We introduced the stock concept in Section 1.3. Typically stocks of fish are independent breeding populations that are by definition expected to have some genetic basis, and sometimes described using a geographical proxy. The stocks used within the 2018 Agreement are mixtures of many independent breeding populations. There are various conservation and allocation goals that are further complicated by biological and logistical challenges that have led managers to adopt stock units that do not align perfectly with the ESU or DPS delineations, which is the relevant inquiry for ESA purposes. TAC (2017) indicates overlapping timing of river entry and dam passage by ESU and/or DPS precludes making precise separations by ESU or DPS at points where fish are counted and harvested. Therefore, the Parties group salmon and steelhead into stocks using various attributes that define the group, including run timing and general geographic distribution. These stock groups used for fishery management are surrogates of ESU or DPSs. Fisheries are managed accordingly for allocation and conservation needs for a stock, through a combination of management time periods, allowable harvest rates, and geographic areas. Harvest rates on stocks are an index of the actual harvest rate on natural-origin fish in the ESU and DPS that are affected by fisheries. Table 2-89 lists each ESU or DPS and its subsequent corresponding stock surrogate.

Table 2-89. Stock descriptions and corresponding ESA-listed surrogates in the 2018 Agreement (TAC 2017).[1]

***US v Oregon* Stock name**	**General stock description**	**ESA-listed ESU or DPS represented**

Upriver spring/summer Chinook Salmon		Number of Chinook salmon entering the Columbia River destined to cross Bonneville Dam between January 1 and June 15	UCR spring-run Chinook Salmon ESU
			Snake River spring/summer-run Chinook Salmon ESU
Sockeye		Number of sockeye salmon entering the Columbia River	Snake River Sockeye Salmon ESU
Winter Steelhead		Number of steelhead entering the Columbia River and harvested in the LCR (below Bonneville Dam) from November 1 through April 30 of the year following and those caught in the Bonneville Pool (Bonneville Dam to The Dalles Dam) from November 1 through March 31 of the year following	LCR Steelhead DPS (winter component)
			MCR Steelhead DPS (winter component)
			UWR Steelhead DPS
Summer steelhead	Skamania	Number of steelhead caught in the mainstem LCR (below Bonneville Dam) from May 1 through June 30 each year and those caught in the Bonneville Pool (Bonneville Dam to The Dalles Dam) from April 1 through June 30	LCR Steelhead DPS (summer component)
	A-Index	Number of steelhead destined to cross Bonneville Dam between July 1 through October 31 each year measuring less than or 78 cm fork length (<~30 inches)	MCR Steelhead DPS (summer component)
			UCR Steelhead DPS
			Snake River Basin Steelhead DPS
	B-Index	Number of steelhead destined to cross Bonneville Dam between July 1 through October 31 each year measuring greater than or 78 cm fork length (>~30 inches)	Snake River Basin Steelhead DPS (primary component of Index)
			MCR Steelhead DPS (minor component of Index)
			UCR Steelhead DPS (minor component of Index)
Fall Chinook Salmon	Lower River Hatchery (LRH)	Tule fall Chinook salmon returning to hatcheries and spawning areas below Bonneville Dam	LCR Chinook Salmon ESU (tule component)

	Lower River Wild (LRW)	Late fall bright Chinook salmon returning to the North Fork Lewis and Sandy rivers	LCR Chinook Salmon ESU (bright component)
	Upriver Bright (URB)	Chinook salmon destined for the Hanford Reach section of the Columbia River and for the Deschutes, Snake, and Yakima rivers.	Snake River fall-run Chinook Salmon ESU
Coho	Upriver	Coho salmon destined to pass Bonneville Dam	LCR Coho Salmon ESU
	Lower River	Coho salmon entering the Columbia River not destined to pass Bonneville	LCR Coho Salmon ESU
Chum		Chum salmon returning to the Columbia River	Columbia River Chum Salmon ESU

[1] Several stocks are not listed in this table that represent groups of non-ESA-listed fish.

Effects of the proposed action on listed species occur through implementation of the fisheries and associated research as described earlier (see Sections 1.3). Escapements and harvest rates expected to result from these fisheries during January 1, 2018 through December 31, 2027 are summarized in the following sections.

2.5.1.1 Lower River Stocks

LCR Chinook Salmon

NMFS completed a section 7 consultation of the effects of PFMC and Fraser Panel fisheries on LCR Chinook salmon (NMFS 2015b) concluding that fisheries managed subject to a total exploitation rate established each year would not jeopardize the LCR Chinook Salmon ESU. The proposed action considered in this opinion adopts the same management strategy that was analyzed in the 2012 PFMC biological opinion. The PFMC opinion therefore provides the substantive foundation for the review of the management strategy for LCR Chinook salmon.

The spring component of the LCR Chinook Salmon ESU is being managed to achieve hatchery escapement goals in the Sandy, Cowlitz, Kalama, and Lewis hatchery complexes (TAC 2017). There is no lower river spring Chinook salmon stock specified in the 2018 Agreement. Impacts to natural-origin LCR spring Chinook salmon populations that are caught in fisheries below Bonneville Dam and that are subject to the 2018 Agreement are expected to be similar to those allowed for upriver spring Chinook salmon (see Table 2-89 for upriver spring Chinook salmon stock definition). Mark selective fisheries are used below Bonneville Dam during the spring season to limit impacts to natural-origin fish. The expected harvest rate in non-treaty fisheries on the spring component of the LCR ESU in mainstem Columbia River fisheries ranges from 0.2 to 2.0% (TAC 2017, Table 5.1.9). The escapement of spring Chinook salmon to the Lewis River hatchery was below goal in 2015 and 2016, but escapements have otherwise exceeded the goal by a wide margin in every year since 2000. The recent escapement shortfall at the Lewis River hatchery is inconsistent with a pattern of escapements for other hatchery stocks in the lower river region. Given the long history of healthy returns, NMFS does not anticipate the need to take specific management actions to protect the spring component of the LCR Chinook Salmon ESU in 2018 or for the duration of the 2018 Agreement. However, NMFS does expect that the states of Washington and Oregon will continue to take appropriate actions through their usual authorities to ensure that the escapement goals are met by taking into account mainstem harvest of primary populations in this ESU and modifying mainstem fisheries downstream of each population's confluence to account for hatchery escapement goals. NMFS will monitor escapements and trends and take more specific action in the future if necessary.

The bright component of the LCR Chinook Salmon ESU is being managed to achieve the escapement goal for the North Fork Lewis population of 5,700 fish based on estimates of maximum sustainable yield (TAC 2017). The expected incidental take in the 2018 Agreement fisheries on the bright component of the LCR ESU is expected to range from 6.0 to 18.8%, similar to recent years (TAC 2017, Table 5.1.9). Escapement under these harvest rates has exceeded the goal, averaging 12,400 spawners over the past 10 years (Table 2-9) and is expected to do so under the proposed action.

Harvest on the tule component of the LCR ESU is subject to an incidental take limit, expressed as a total exploitation rate limit for all ocean and in-river fisheries below Bonneville Dam (NMFS 2012c) (Table 2-89). That rate is defined annually using the abundance-based harvest rate schedule based on the annual forecast of LRH stock (see Table 2-89 for the LRH stock definition) and is specified annually through NMFS' guidance letter to the PFMC (NMFS 2017r). As a result, the incidental take limit for the tule component of the LCR ESU will vary annually depending on the year specific estimates of run size. Each year, fisheries in the Columbia River will be managed, after accounting for anticipated ocean harvest, so as not to exceed the total exploitation rate limit. After accounting for anticipated harvest in ocean fisheries, the associated exploitation rate for in-river fisheries has ranged in recent years from 7.7 to 14.9% (TAC 2017, Table 5.1.9). The distribution of harvest between ocean and in-river fisheries may vary from year-to-year and inseason so long as the total exploitation rate does not exceed the year specific total. Some additional harvest occurs in fisheries above Bonneville Dam that may affect three of the four Gorge MPG fall populations. The LCR recovery plan (NMFS 2013e) identified the Hood population as problematic, but primarily called for additional research and monitoring before prescribing harvest rates based on the needs of this population. The plan acknowledges the uncertainties related to populations in the Gorge MPG and, as discussed in Section 2.2.2.1, sought to address those uncertainties by putting greater emphasis on recovery of additional populations in the Cascade MPG.

Table 2-90. Variable fishing exploitation rate limits based on abundance tier of LRH stock preseason abundance for LCR fall tule Chinook salmon (TAC 2017, Table 5.1.9).

Lower River Hatchery (LRH) tule Chinook salmon Abundance Forecast	Total Exploitation Rate Limit for fisheries in the ocean and Columbia River up to Bonneville Dam
0 – 30,000	0.30
30,000 – 40,000	0.35
40,000 – 85,000	0.38

>85,000	0.41

Fisheries subject to the 2018 Agreement that are part of the proposed action described in Section 1.3 must be managed subject to the overall exploitation rate limit as proposed annually during the PFMC process and have been since 1999.

Critical Habitat

The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR Chinook salmon.

Lower Columbia River Coho Salmon

NMFS completed a section 7 consultation of the effects of PFMC and Fraser Panel fisheries on LCR coho salmon (NMFS 2015b) concluding that fisheries managed subject to a total exploitation rate established each year would not jeopardize the LCR Coho Salmon ESU. The proposed action considered in this opinion adopts the same management strategy that was analyzed in the 2015 PFMC biological opinion for fisheries downstream of Bonneville Dam. The PFMC opinion therefore provides the substantive foundation for the review of the harvest management strategy for LCR coho salmon.

Fisheries affecting LCR coho salmon will be managed subject to an incidental take limit, expressed as a total exploitation rate, that will be defined annually using the harvest matrix that is based on brood year escapement and marine survival (Table 2-91) and is specified annually through NMFS' guidance letter to the PFMC (NMFS 2017r). The exploitation rate limit will apply to all ocean and in-river fisheries below Bonneville Dam. TAC (2017) describes Columbia River salmon fisheries as being held to the associated total exploitation rate on LCR natural-origin coho equivalent to the remainder of the harvest matrix after ocean fisheries are accounted for. After accounting for anticipated harvest in ocean fisheries, the associated exploitation rate limit for in-river fisheries has ranged in recent years from 13.3 to 24.3% (TAC 2017, Table 5.1.11). The distribution of harvest between ocean and in-river fisheries may vary from year-to-year and inseason so long as the total exploitation rate does not exceed the year specific total.

Table 2-91. Harvest management matrix for LCR coho salmon showing allowable fishery exploitation rates based on parental escapement and marine survival index for fisheries in the ocean and Columbia River up to Bonneville Dam (TAC 2017, Table 5.1.11).

Parental escapement (rate of full seeding)	**Marine Survival Index (based on return of jacks per hatchery smolt)**					
	Very Low (≤ 6%)	**Low (≤ 8%)**	**Medium (≤ 17%)**	**High (≤ 40%)**	**Very High (> 40%)**	

Normal	≥ 0.30	10%	15%	18%	23%	30%	Allowable exploitation rate
Very Low	< 0.30	≤ 10%	≤ 15%	≤ 18%	≤ 23%	≤ 30%	

Three LCR coho salmon populations from the Gorge MPG are subject to some additional harvest in fisheries above Bonneville Dam. Coho salmon generally are not targeted in fall season mainstem fisheries above Bonneville Dam and no change in recent years' mainstem coho salmon fisheries is expected during 2018-2027. The harvest rate on LCR coho salmon in treaty Indian fisheries above Bonneville Dam, expressed as a proportion of the coho that pass Bonneville Dam, ranges from 0.8 to 3.5%. This is not equivalent to the exploitation rate on the LCR coho salmon ESU referenced in Table 2-91 that is expressed as a proportion of the abundance of LCR coho salmon in the ocean prior to harvest. The harvest rate metric cannot be added directly to the exploitation rate, but it does provide a conservative estimate of effect on LCR coho salmon populations above Bonneville Dam.

Critical Habitat

The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR coho salmon.

Willamette River Spring Chinook Salmon and Upper Willamette River Steelhead

Similar to LCR Chinook and coho salmon, the effect of fisheries being considered under the proposed 2018 Agreement on UWR Chinook salmon and steelhead were evaluated under the FMEPs previously submitted by ODFW. The ODFW submitted FMEPs pursuant to limit 4 of the ESA Section 4(d) rule (NMFS 2000a). The UWR Chinook salmon and UWR steelhead FMEPs were dated February 7, 2001 and June 8, 2001, respectively (ODFW 2001a; 2001b). We reviewed the proposed FMEPs and determined that they adequately addressed the requirements of the 4(d) rule (Kruzic 2001a; 2001b). Therefore, these opinions provide the substantive foundation for the review of the harvest management strategy for UWR Chinook salmon and UWR steelhead. The respective FMEPs are subject to regular reporting requirements and periodic review, but have no specified expiration date and are therefore still in effect. The FMEPs considered all fishing in the Willamette and Lower Columbia rivers that may affect either of the listed species or their critical habitat. In considering those FMEPs, NMFS determined that Section 9 take prohibitions under the ESA for UWR Chinook salmon and steelhead do not apply to freshwater fishery activities, including those considered in this proposed action.

Because provisions of the FMEP are fully incorporated into the 2018 Agreement the anticipated harvest rate on UWR spring Chinook salmon in the proposed mainstem Columbia River fisheries in 2018-2027 ranges from 5-11%, and will not exceed an overall combined harvest rate of 15% from all freshwater fisheries combined. The 2018 Agreement proposes to continue adhering to these limits for harvest effect to UWR Chinook salmon.

The 2018 Agreement also proposes to continue adhering to the previously considered limits for harvest effect to UWR steelhead. This would be an aggregate of all non-treaty harvest in mainstem Columbia River freshwater fisheries capped at an annual harvest rate for all winter steelhead DPSs at no more than 2%. Winter management period Tribal fisheries are all located above Bonneville Dam and therefore would not affect UWR steelhead populations given their geographic location.

Additionally, Lamprey harvest at Willamette falls occurs by a method, hand removal, which will not affect UWR Chinook salmon and steelhead nor their critical habitat.

Critical Habitat

The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UWR Spring Chinook salmon or UWR steelhead.

Lower Columbia River Steelhead

Proposed non-treaty fisheries will be managed subject to 2% harvest rate limits on natural- origin steelhead from the LCR winter and summer components. The summer component is represented by the Skamania stock, and the winter component by the winter steelhead stock (see Table 2-89 for stock definitions). However, the expected incidental harvest impacts on the winter steelhead and Skamania stocks, acting as surrogates for the LCR Steelhead DPS, associated with proposed non-treaty fisheries (TAC 2017, Table 5.1.10) are expected to be less than ESA- prescribed limits. The incidental catch of unclipped winter steelhead in non-treaty fisheries has averaged 0.6% since 2008 (TAC 2017, Table 3.3.2). The yearly incidental catch of Skamania steelhead in non-treaty fisheries has averaged 0.5% on the unclipped portion of the stock below Bonneville Dam and 0.04% on the unclipped portion of the stock above Bonneville Dam since 2008 (TAC 2017, Table 3.3.16). Harvest rates associated with non-treaty fisheries are not expected to change over the course of the 2018 Agreement (TAC 2017).

There are no specific incidental harvest rate limits for mainstem treaty fisheries on the LCR steelhead DPS (TAC 2017). The expected incidental harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with proposed treaty tribal fisheries is the same as the range observed in earlier years (TAC 2017, Table 5.1.13) ranging from 1.4% to 6.9% for the winter component and 4.6% to 12.9% for the summer component. However, the observed harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with proposed treaty fisheries were less during the 2008 Agreement’s implementation. For example, the harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville Pool from 2008 to 2017 averaged 0.5% and ranged from 0.1% to 1.4% (TAC 2017, Table 3.3.12). The harvest rate for treaty fisheries on the unclipped Skamania stock in the Bonneville Pool from 2008 to 2017 averaged 2.0% and ranged from 0.2%

to 3.9% (TAC 2017, Table 3.3.13). The ranges expressed as expectations by TAC (2017, Table 5.1.13) incorporate longer-term fluctuations and are therefore conservative as they capture the highest range observed. Incidental harvest rates for winter and Skamania stocks associated with proposed treaty fisheries are not expected to change over the course of the 2018 Agreement (TAC 2017).

Critical Habitat
The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR steelhead.

Columbia River Chum Salmon
The 2008-2016 annual non-treaty commercial landings observed one chum landing in 2009 (TAC 2017). Impacts in the recreational fishery (from non-retention mortalities) are expected to be near zero in 2018-2027 as chum salmon migration typically occurs during the end of October, which has been recently coinciding with declining angler effort (TAC 2017). The incidental harvest rate is limited to no more than 5.0%; however, based on a longer-term data series (since 2001), the expected total impact rate on Columbia River chum salmon between 2018 and 2027 is expected to average 1.6% (TAC 2017, Table 5.1.11). This s a conservative estimate through TAC's (2017) use of a longer-term dataset. There are no impacts expected in treaty Indian fisheries (TAC 2017).

Critical Habitat
The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Columbia River chum salmon.

2.5.1.2 Middle River Stocks

Middle Columbia River Steelhead
MCR summer steelhead populations are part of the A-Index steelhead stock (see Table 2-89 for stock definitions). Two populations of the MCR steelhead DPS are also winter run populations and therefore represented by the winter steelhead stock.

Proposed non-treaty fisheries, pursuant to the 2018 Agreement, will be managed subject to A-Index and winter steelhead stock harvest rate limits. Steelhead harvested in the LCR (downstream of Bonneville Dam) between November 1 and April 30 are counted as winter steelhead. Steelhead caught in the Bonneville Pool between November 1 and March 31 are also counted as winter steelhead (See Table 2-89). TAC has not developed a method to separate the winter season steelhead counts into LCR and MCR DPSs, and these fisheries are subject to a 2% harvest rate limit for all fisheries combined. A-Index summer steelhead are caught in summer fisheries downstream of Bonneville Dam and during fall through the following spring season fisheries upstream. Therefore, non-treaty fisheries are subject to a 2% harvest rate limit for A-Index summer steelhead in summer (from July 1 through July 31) and then from January 1 through the following spring since these are the same run of steelhead which have now migrated upstream in the Columbia River Basin. The total annual harvest rate limit for A-Index summer steelhead therefore is 4%. The expected harvest impacts on non-treaty fisheries are less than those proposed. The incidental catch of winter steelhead in non-treaty across all fisheries has averaged 1.9% since 2008 (TAC 2017, Table 3.3.2). The yearly incidental catch of A-Index summer steelhead in non-treaty fisheries has averaged 1.9% since 2008 compared to the 4% yearly combined limits (TAC 2017, Table 3.3.54). Harvest rates are not expected to change over the course of the 2018 Agreement (TAC 2017).

There are no specific incidental harvest rate limits for treaty fisheries on the MCR steelhead DPS (TAC 2017). The expected incidental harvest impacts on the winter steelhead stock (winter-component) and A-Index (summer-component) surrogate components for the MCR steelhead DPS associated with proposed treaty tribal fisheries is the same as the range observed in earlier years (TAC 2017, Table 5.1.13) between 1.4% and 6.9% for the winter steelhead stock and 4.6% and 12.9% on the A-Index. However, the expected incidental harvest impacts on the winter stock and A-Index components of the MCR Steelhead DPS associated with proposed treaty fisheries are expected to be less. The harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville Pool from 2008 to 2017 averaged 0.5% and ranged from 0.1% to 1.4% (TAC 2017, Table 3.3.12). The harvest rate for treaty fisheries on the unclipped A-Index stock in the Bonneville Pool from 2008 to 2017 averaged 1.6% and ranged from 0.7% to 7.0% during the winter/spring/summer combined seasons (TAC 2017, Table 3.3.35) and averaged 6.5% and ranged from 4.0% to 10.0% during the fall seasons (TAC 2017, Table 3.3.52). Incidental harvest rates for winter and A-Index stocks associated with proposed treaty fisheries are not expected to change over the course of the 2018 Agreement (TAC 2017).

Proposed treaty fall season fisheries will be managed using the abundance-based harvest rate schedule for B-Index steelhead contained in the 2018 Agreement (TAC 2017, Table 5.1.2). TAC (2017) indicates B-Index steelhead occur in most regions, however the Snake Basin has the highest proportion of B-sized fish. While most B-Index steelhead are part of the Snake River DPS, some B-Index fish may be part of any other DPS and are mentioned here as a result.

Under the abundance based harvest rate schedule, harvest may vary up or down, depending on the abundance of B-Index steelhead. The harvest rate allowed under the proposed schedule is also limited by the abundance of upriver fall Chinook salmon. The purpose of this provision is to recognize that impacts to B-Index steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook salmon, is higher and remain consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-Index steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right to harvest 50% of the harvestable surplus of fall Chinook salmon in years when conditions are favorable. Even with these provisions, it is unlikely that the treaty right for Chinook salmon or steelhead can be fully satisfied. The harvest rate for B-Index steelhead in tribal fall season fisheries may range from 13 to 20%. As indicated above, the non-Treaty fall season fishery harvest rate for B-Index steelhead will remain fixed at 2%.

Critical Habitat
The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for MCR steelhead.

2.5.1.3 Upriver Stocks

Snake River fall-run Chinook Salmon
Fisheries affecting Snake River fall-run Chinook salmon will be managed using the agreed abundance-based harvest rate schedule (Table 2-92) for the URB stock (see Table 2-89 for stock definitions). Harvest will depend on the abundance of unlisted upriver fall Chinook and natural-origin Snake River fall-run Chinook salmon. The allowable harvest rate will range from 21.5% to 45.0%.

Table 2-92. Abundance-based harvest rate schedule for URB fall Chinook (with limits on Snake River fall-run Chinook salmon) in fall management period mainstem fisheries (TAC 2017, Table 5.1.5).

State/Tribal proposed upriver bright Chinook salmon harvest rate schedule					
Expected URB River Mouth Run Size	**Expected River Mouth Snake River Wild Run Size [1]**	**Treaty Total Harvest Rate**	**Non-Treaty Harvest Rate**	**Total Harvest Rate**	**Expected Escapement of Snake R. Wild Past Fisheries**
<60,000	<1,000	20%	1.50%	21.50%	784
60,000	1,000	23%	4%	27.00%	730
120,000	2,000	23%	8.25%	31.25%	1,375
>200,000	5,000	25%	8.25%	33.25%	3,338
	6,000	27%	11%	38.00%	3,720
	8,000	30%	15%	45.00%	4,400

[1] If the Snake River natural fall-run Chinook forecast is less than level corresponding to an aggregate URB run size, the allowable mortality rate will be based on the Snake River natural fall-run Chinook run size.

Notes:
Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from August 1-December 31.

Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the confluence of the Snake River and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from August 1-December 31.

The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in the 2018 Agreement.

Fishery impacts in Hanford sport fisheries count in calculations of the percent of harvestable surplus achieved.

When expected river-mouth run sizes of naturally produced Snake River fall-run Chinook salmon equal or exceed 6,000, the states reserve the option to allocate some proportion of the non-treaty harvest rate to supplement fall-run Chinook directed fisheries in the Snake River.

In most years, the actual harvest rates will be less than the maximum allowed maximum allowable harvest rates. The harvest rate on Snake River natural-origin Chinook salmon in non-treaty across all fisheries has averaged 11.4% since 2008 (TAC 2017, Table 3.3.48) and 21.6% in treaty fisheries (TAC 2017, Table 3.3.49). The distribution of harvest mortality between non-treaty and treaty Indian fisheries may vary so long as the total harvest rate does not exceed the year specific maximum. The total harvest rate has ranged from 17.5 to 32.0% since 2008.

The proposed harvest rate schedule provides a management structure that is responsive to the status of the species. Harvest may vary up or down depending on the overall abundance of unlisted upriver fall Chinook and listed natural-origin Snake River fall-run Chinook salmon. The harvest rate schedule is generally calibrated to provide higher harvest rates when abundance is high enough to accommodate the increased harvest and still meet the TRT recovery abundance threshold of 4,200 natural-origin fish. Conversely, when numbers are low, harvest rates are reduced to provide greater protection.

Critical Habitat
The effects of harvest activities on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Snake River fall-run Chinook salmon.

Snake River Spring/Summer-run Chinook & Upper Columbia River spring-run Chinook Salmon
Fisheries affecting Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon will be managed using the agreed to abundance based harvest rate schedule (Table 2-93). The incidental take limit for Snake River spring/summer-run Chinook and UCR spring-run

Chinook salmon will therefore vary annually depending on the year specific estimates of run size and is tracked using the Upriver Spring Chinook salmon stock (see Table 2-89 for stock definitions). The maximum allowable harvest rates in non-treaty and treaty Indian fisheries are 2.7% and 14.3%, respectively. The stock includes all Chinook salmon passing Bonneville Dam during the spring management period from January 1 and June 15. The total combined abundance based harvest rate schedule allows the harvest rate on the stock to vary from 5.5% to 17% (Table 2-93). In most years, the year specific harvest rates will be less than the maximum allowed. The distribution of harvest mortality between non-treaty and treaty Indian fisheries may vary so long as the total harvest rate does not exceed the year specific maximum.

Table 2-93. Abundance-based harvest rate schedule for upriver spring Chinook salmon stock and in spring management period fisheries (TAC 2017).

Harvest Rate Schedule for Chinook in Spring Management Period					
Total Upriver Spring and Snake River Summer Chinook Run Size	**Snake River Natural Spring/Summer-run Chinook Run Size[1]**	**Treaty Zone 6 Total Harvest Rate [2,5]**	**Non-Treaty Natural Harvest Rate [3]**	**Total Natural Harvest Rate4**	**Non-Treaty Natural Limited Harvest Rate[4]**
<27,000	<2,700	5.0%	<0.5%	<5.5%	0.5%
27,000	2,700	5.0%	0.5%	5.5%	0.5%
33,000	3,300	5.0%	1.0%	6.0%	0.5%
44,000	4,400	6.0%	1.0%	7.0%	0.5%
55,000	5,500	7.0%	1.5%	8.5%	1.0%
82,000	8,200	7.4%	1.6%	9.0%	1.5%
109,000	10,900	8.3%	1.7%	10.0%	
141,000	14,100	9.1%	1.9%	11.0%	
217,000	21,700	10.0%	2.0%	12.0%	
271,000	27,100	10.8%	2.2%	13.0%	
326,000	32,600	11.7%	2.3%	14.0%	
380,000	38,000	12.5%	2.5%	15.0%	
434,000	43,400	13.4%	2.6%	16.0%	
488,000	48,800	14.3%	2.7%	17.0%	

[1] If the Snake River natural spring/summer-run forecast is less than 10% of the total upriver run size, the allowable mortality rate will be based on the Snake River natural spring/summer-run Chinook run size. In the event the total forecast is less than 27,000 or the Snake River natural spring/summer-run forecast is less than

2,700, Oregon and Washington would keep their mortality rate below 0.5% and attempt to keep actual mortalities as close to zero as possible while maintaining minimal fisheries targeting other harvestable runs.

[2] Treaty Fisheries include: Zone 6 Ceremonial, subsistence, and commercial fisheries from January 1-June 15. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.

[3] Non-Treaty Fisheries include: Commercial and recreational fisheries in Zones 1-5 and mainstem recreational fisheries from Bonneville Dam upstream to the Hwy 395 Bridge in the Tri-Cities and commercial and recreation SAFE (Selective Areas Fisheries Evaluation) fisheries from January 1-June 15; Wanapum tribal fisheries, and Snake River mainstem recreational fisheries upstream to the Washington-Idaho border from April through June. Harvest impacts in the Bonneville Pool tributary fisheries may be included if TAC analysis shows the impacts have increased from the background levels.

[4] If the Upper Columbia River natural spring-run Chinook forecast is less than 1,000, then the total allowable mortality for treaty and non-treaty fisheries combined would be restricted to 9% or less. Whenever Upper Columbia River natural fish restrict the total allowable mortality rate to 9% or less, then non-treaty fisheries would transfer 0.5% harvest rate to treaty fisheries. In no event would non-treaty fisheries go below 0.5% harvest rate.

[5] The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in the 2018 Agreement.

The harvest rate schedule for Upriver Spring Chinook Salmon under the proposed agreement is the same as was used under the 2008 Agreement. Although the harvest rate schedule allows harvest rates to range from 5.5 to 17%, the year specific harvest rates have ranged from 10.0 to 13.0%.

As indicated by the Upriver Spring Chinook salmon harvest rate table (Table 2-93), treaty fisheries are managed on a total harvest rate on the river mouth run size. However, the effect to natural-origin fish is slightly higher than the total harvest rate. This is because mark selective fishing in the LCR below Bonneville Dam modifies the clipped to unclipped ratio of fish that eventually cross Bonneville Dam by removing a disproportionate number of hatchery-origin fish. Fisheries above Bonneville Dam, prominently the treaty Zone 6 fishery, are therefore operating on a higher proportion of natural-origin fish passing Bonneville Dam as compared to the ratio that entered the river at the mouth of the Columbia River. This results in an average 0.7% higher harvest rate on natural-origin salmon in the spring management period treaty Indian fisheries upstream of Bonneville Dam since the implementation of mark selective fisheries in 2000 (TAC 2017). TAC uses a conservative average 0.8% higher harvest rate to account for this effect on natural-origin in its annual calculations, but the actual average effect has been slightly lower. While the treaty fishery is planned on the total runsize, non-treaty fisheries are planned on a buffered runsize forecast, essentially a decrease of the forecast artificially each year by 30%. This is a conservative way to plan fisheries as the majority of non-treaty fishing occurs downstream of Bonneville Dam and prior to when a inseason runsize estimate generally occurs, so it provides some level of built in conservatism for years when a returning forecast of fish might be higher than the actual return.

The current management framework was developed at a time when there was less information about the diversity of run timing of various components of Chinook salmon. It was apparent that there were three peaks in the counts of Chinook salmon at Bonneville Dam representing the spring, summer, and fall stocks (Figure 2-21). There was a general understanding that there was some diversity in run timing of stocks returning during the spring season based initially on observation of when fish were returning to the terminal areas. For example, it was apparent that fish from the Clearwater and Rapid River in the Snake River Basin returned much earlier than other components of the Snake River return. Additional information from the recovery of CWTs in the fisheries or other locations helped supplement the run timing information. But it was not until PIT tags became widely available that we were able to observe and better quantify the diversity and complexity of population specific run timing information. The PIT tag data also allowed us to assess for the first time how adult survival during upstream migration varied between populations and the factors that affected observed differences.

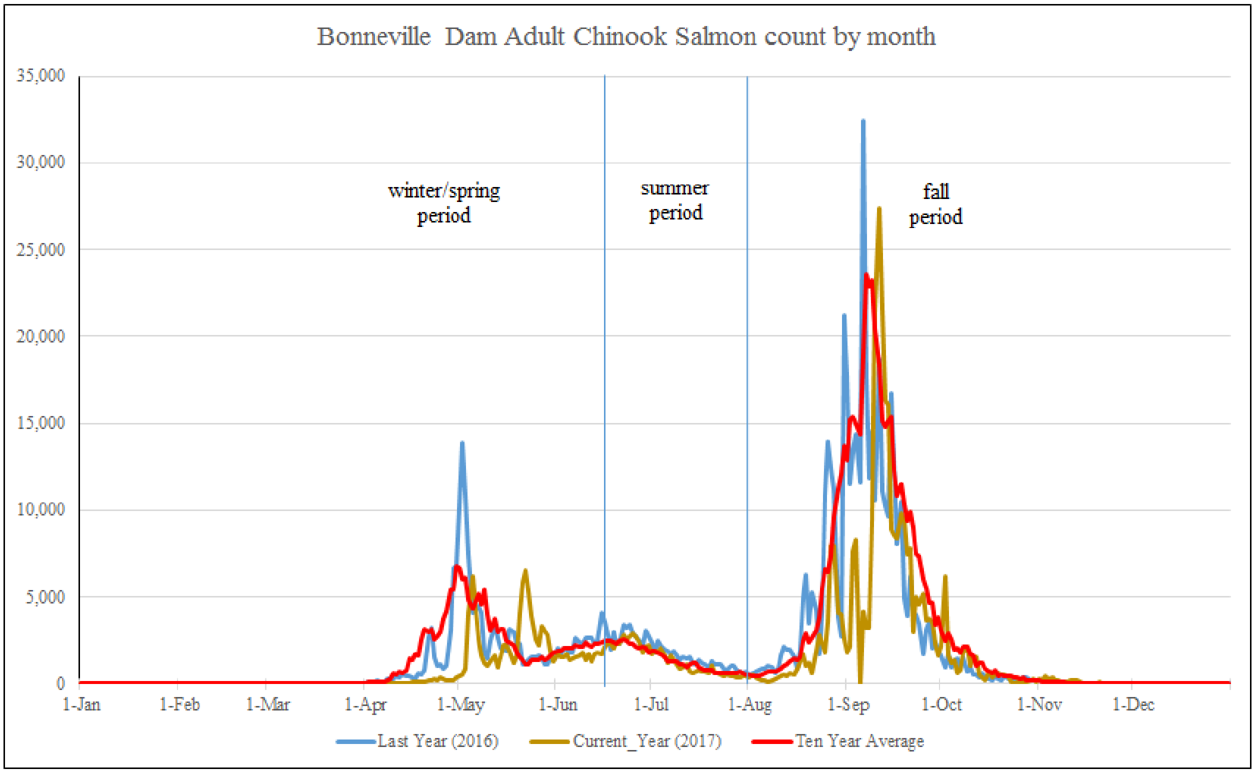

Figure 2-21. Chinook salmon counts at Bonneville Dam (using data from Fish Passage Center, fpc.org).

Adequate numbers of PIT tags were first recovered beginning in 2004 with release numbers and population representation expanding thereafter. By about 2009 PIT tags were being recovered from representative groups for most of the upriver spring and summer Chinook salmon populations. PIT tag detection systems were also being added over time providing increasing resolution to the run timing and survival information. For example, the detection system at The Dalles Dam became operational in 2013. The Dalles Dam is located between Bonneville Dam and McNary Dam and thus provides additional detail about the complex run timing and survival dynamics in Zone 6 at least for recent years.

Although the PIT tag data was used extensively over the years as it became available to explore specific questions, there are two reports that provide the most recent comprehensive analysis of all of the available PIT tag data for UCR spring-run Chinook and Snake River spring/summer-run Chinook salmon. These reports refine our understanding about run timing, adult survival during upstream migration, and the factors that affect them (Crozier et al. 2016; Crozier et al. 2017).

The proposed action is to continue to manage spring season fisheries using the abundance based harvest rate schedule for the Upriver spring Chinook salmon stock. Harvest rates on the stock are thereby limited to a year-specific harvest rate limit. As a practical matter, managing at the stock level remains a practical necessity, at least for the time being, as we do not yet have procedures or tools to manage this complex fishery at a finer level of resolution. However, in assessing the effects of the proposed action, we also have to consider the fact that different components of the Upriver spring Chinook salmon stock may be affected differently by the proposed action. Although the year-specific harvest rate on the stock may be set at 12%, for example, harvest rates on different components of the stock are likely to be both higher and lower depending on the circumstances. Although this diversity of harvest rates is not inconsistent with the proposed action, we do need to look more closely to understand the effects of the proposed action at a population and MPG scale in order to assess the effects of the action on the ESA-listed species.

The first of the Crozier papers (Crozier et al. 2016) synthesizes the available information related to run timing, travel time, fallback, and survival. The report distinguishes between groups of early and later timed fish. The early group includes UCR spring-run Chinook salmon and most of the fish returning to the Snake River. The late group includes fish returning to the Pahsimeroi, Imnaha, and South Fork Salmon Rivers that are all part of the Snake River spring/summer-run Chinook Salmon ESU. The median run timing of the late group is 2 - 4 weeks later than early group. As a consequence, a significant portion of the late group, is often still in Zone 6 after June 15 when the fishery transitions to summer season management[20] and is thus vulnerable to higher harvest rates. The possibility that the late timed fish are consistently subject to higher harvest rates has come up as a point of particular concern that is considered below. Although we can summarize the differences between the early and late groups, it is important to emphasize that there is considerable variation in run timing even within the early and late groupings.

Run timing (when adult fish are migrating through the system) and travel time (how long it takes the fish to get from one place to another) for different populations is important because it means individual populations and larger groups of fish are exposed to different migration conditions and different parts of the fishery. Populations with the earliest timing include the Clearwater, Rapid River, and Lower Snake populations, and Methow, Entiat, and Wenatchee populations from the UCR spring-run Chinook Salmon ESU. The median passage date at Bonneville Dam for the early group is around May 1. The median passage date at Bonneville for populations in the late timed group is around June 1 (Crozier et al. 2016). Even then there are significant differences in timing for stocks within the early and late groups. For example, hatchery fish from the UCR spring-run Chinook Salmon ESU have earlier timing than natural-origin fish. For the Wenatchee population in particular, hatchery-origin fish return about three weeks ahead of their natural-origin counterparts. Even for the late group, fish from the Pahsimeroi are on average a

[20] Summer season management begins on June 16. UCR summer Chinook are the principal stock targeted in the summer fishery. UCR summer Chinook are not listed under the ESA and are sufficiently abundant to allow for harvest rates that are significantly higher than those that occur during the spring management period.

week later than the other late timed populations.

Travel time through Zone 6 varies within a fairly narrow range. Although there are statistical differences in travel time for different groups of fish, the differences are generally on the order of a day or less. Average travel time from Bonneville to McNary for UCR spring-run Chinook salmon is 5.9 days and for early fish from the Snake River 5.7 days. Average travel time for the late group is 6.3 days (Crozier et al. 2016). However, river conditions and year specific circumstances affect travel time for the late group in particular. In 2008 and 2011, late timed fish were delayed and travel time from Bonneville to McNary Dam was extended to 8.0 days again emphasizing that year specific differences matter.

Run timing and travel time combine to affect exposure to fisheries in Zone 6. On average one-quarter of late timed fish pass above McNary Dam after June 15, but the proportion still in Zone 6 after June 15 can exceed half in late-run and slow migration years like 2007 and 2011.

As described above, the Crozier paper first summarized information related to run timing and travel time and documented which populations and groups of fish are in the river when (Crozier et al. 2016). It then summarized estimates of adult migration survival and took a preliminary look at the factors than can affect survival. First, it is generally apparent that natural-origin fish have higher survival rates than hatchery-origin fish. For fish from the Snake River, the mean survival rate for natural-origin fish is 0.84 vs. 0.79 for hatchery fish. For UCR fish, the average survival rates for natural-and hatchery-origin fish are 0.84 and 0.81, respectively. The second general observation is that fish from the Snake River that migrate in river have higher survival rates than fish that are transported as juveniles during downstream migration although the average difference is relatively small (0.81 vs. 0.79). There was no similar effect for UCR fish because fish from this ESU are no longer transported.

Survival rates through Zone 6 for UCR spring-run and Snake River spring/summer-run Chinook salmon are not significantly different averaging 81.9% and 80.5% respectively. If you limit the comparison to natural-origin, inriver migrants, the survival rates for UCR and Snake River fish are the same, 0.84. However, there are differences in survival rates for early and late groups from the Snake River. Survival rates for early and late groups averaged 0.83 and 0.79, respectively. There are two things worth noting. First, the difference in the average survival rate for the early and late groups (0.83 – 0.79) was due primarily to the very low survivals for late fish in three years 2011, 2014, and 2015 (Table 2-94). Second, survival rates for late timed fish are higher than for early timed fish in four out of the twelve years indicating that survival rates for late fish are not uniformly lower (Figure 2-24) (Figure 7 from Crozier et al. 2017).

Table 2-94. Survival rates for UCR spring-run Chinook Salmon ESU and the early and late timed groups from the Snake River spring/summer-run Chinook Salmon ESU and the harvest rate in Zone 6 on the Upriver Spring Chinook stock.

Year	UCR Spring[1]	Snake River early[1]	Snake River late[1]	Harvest Rate (%) for the Upriver Spring Chinook Stock[2]

2004	-	0.86	0.81	8.7
2005	-	0.92	0.91	6.3
2006	0.78	0.78	0.79	6.7
2007	0.81	0.86	0.83	7.1
2008	0.79	0.79	0.87	13.3
2009	0.82	0.85	0.86	7.3
2010	0.83	0.83	0.81	13.2
2011	0.79	0.79	0.65	6.4
2012	0.83	0.82	0.86	8.6
2013	0.85	0.87	0.84	5.4
2014	0.86	0.79	0.67	10.9
2015	0.79	0.78	0.61	11.2
Mean	0.82	0.83	0.79	8.9

[1] From Tables 13 and 15 in Crozier et al. (2016).
[2] From TAC (2017).

Crozier's second paper looked in more detail at the factors that drove the variation in survival during upstream migration (Crozier et al. 2017). The analysis considered the difference between the early and late groups and, where appropriate, compared survival characteristics of UCR spring-run Chinook salmon, and Snake River spring and Snake River summer populations. Temperature, spill, and catch are the factors that have the greatest influence on adult survival. It is not surprising that catch is a significant contributor. On average 79 – 83% of the UCR and Snake River spring and summer fish survive passage from Bonneville to McNary Dam (Table 2-94). The average harvest rate on the upriver spring Chinook salmon stock in this area is 8.9%. So roughly half the mortality that occurs during upstream migration is attributable to the harvest that is associated with implementation of the proposed action. However, it is important that we consider the factors that influence the observed year-to-year variability in survival in more detail.

Temperature has the most consistent influence on the survival of all stocks. High temperatures are associated with low survival. In 2015, summer run Chinook salmon experienced the warmest river conditions of all study years with a mean temperature at Bonneville Dam of 17.9° C. Of the fish that passed Bonneville Dam while temperatures were above 16° C (71% of the run) only 41% survived to Lower Granite Dam. In comparison, of the fish that passed Bonneville Dam at temperatures of 16° C or less, 76% survived (Crozier et al. 2016). Survival from Bonneville to McNary Dam was also affected negatively be high spill. Spill had high importance for all stocks in Zone 6. The second lowest survival for late timed Snake River Chinook salmon occurred in 2011 when flows were 50% above normal.

High temperature and high spill typically occur later in the spring migration. Temperature increases steadily through the season. As noted earlier, the peak of the timing at Bonneville Dam for spring and summer migrants is around the May 1 and June 1, respectively. Peak flows typically occur around the first week in June (Figure 2-22). As a consequence, fish that enter the river at the end of the run nearly always experience more challenging conditions. If temperature and/or spill are more extreme (outside the normal range) survival will likely be reduced as they were in 2011 and 2015, in particular.

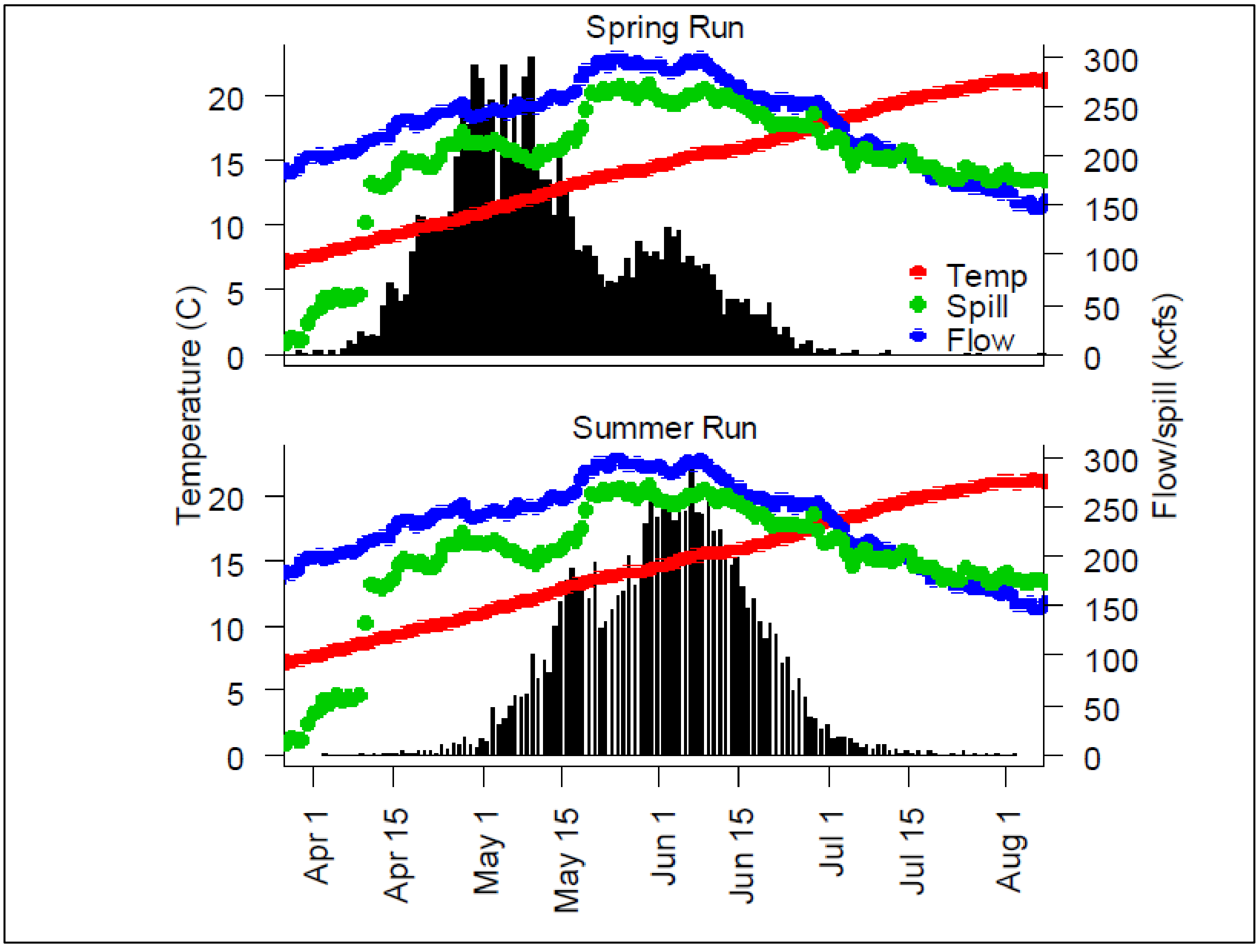

Figure 2-22. Bars show density distribution and run timing of adult Snake River spring/summer-run Chinook salmon based on PIT-tagged fish returning 2004-2015. Lines show mean daily temperature, flow, and spill (doubled for plotting purposes) at Bonneville Dam overlaid on spring (upper panel) and summer run timing (lower panel) (reproduced from Crozier et al. 2017).

Catch also has the potential to have a greater impact on late timed fish. As discussed above, a significant portion of the late time fish are still in Zone 6 when the fishery transitions to summer season management (see Table 9 in Crozier et al. 2017). So for example, if half of a group of fish are subject to a 10% harvest rate in the spring season and the other half are subject to a harvest rate of 20% after the June 15 transition, the overall harvest rate, at least conceptually, would be 15% thus posing the possibility that late timed fish are consistently subject to higher harvest rates. The average proportion of the late timed populations still in Zone 6 after June 15 ranges from 27 – 42%, but in some years can be as high as 50% or 60%.

To examine the stock specific harvest rate patterns more directly, Crozier et al. (2017) developed three alternative catch indices. In the end, all gave similar results. These catch indices basically combined estimates of the number of fish in Zone 6 based on dam counts and passage timing, what stocks were in Zone 6 at a given point in time based on PIT tag data, and estimates of daily catch to calculate a measure of catch exposure. These were then summed over time to provide a stock specific index of catch. The catch index should not be considered a harvest rate and cannot be compared directly to the harvest rate estimates for the upriver spring Chinook salmon stock, but the indices can be compared to each other as relative measures of catch.

Figure 2-23 shows weekly catch along with the distribution of fish passage dates for the spring and summer groups at Bonneville Dam (Crozier et al. 2017). Figure 2-24 shows estimates of the weighted catch for the UCR spring-run and Snake River spring/summer-run Chinook salmon groups. It is apparent that the weighted catch in 2014 and 2015 were quite high (0.21 and 0.25) relative to the indices for UCR and Snake River spring stocks. However, it is also apparent that the weighted catch for the Snake River summer stock is actually lower than that for the spring stocks in eight of twelve years. In 2007, 2008, and 2009 in particular the weighted catch for summer fish is half or less of what it was for the early timed fish.

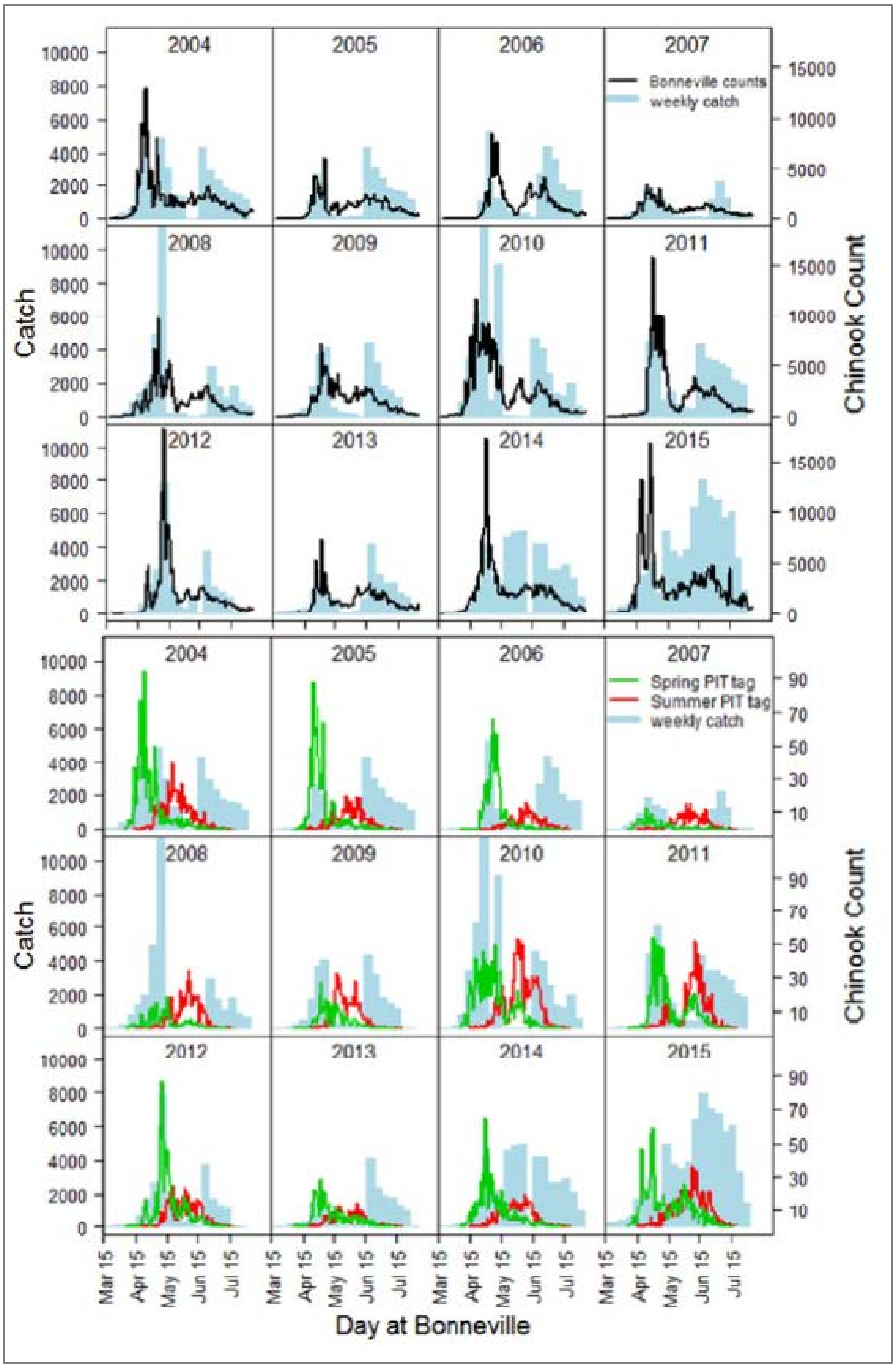

Figure 2-23. Frequency distribution of fish passage dates at Bonneville Dam vs. weekly catch in Zone 6, 2004-2016. Fish passage dates are garnered from Bonneville fish count window (upper panel), and PIT-tag detection data (lower panel). Estimated weekly catch is the same in both panels (Figure 1 from Crozier et al. 2017).

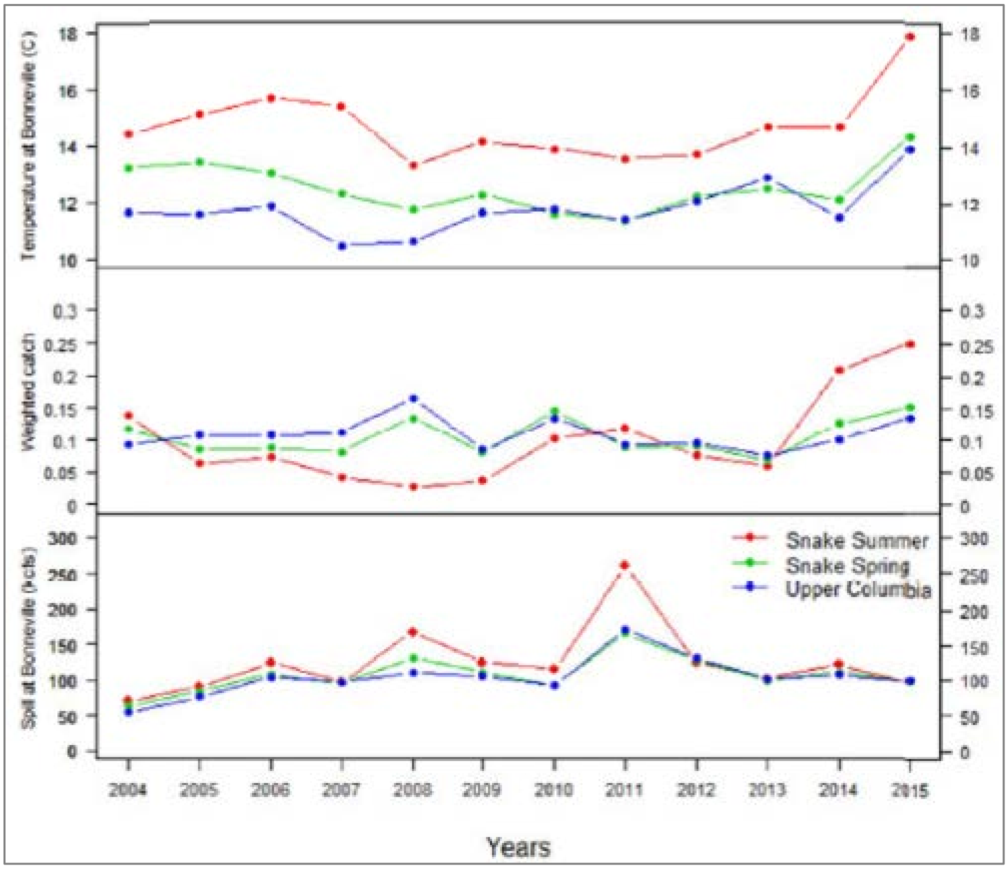

Figure 2-24. Annual mean value for each run (i.e., weighted by fish timing) for temperature at Bonneville Dam on the day of passage (top), weighted catch in Zone 6 (middle), and spill at Bonneville Dam on the day of passage (bottom) (Figure 7 from Crozier et al. 2017).

Late time fish that are still in Zone 6 after June 15 may be subject to higher harvest rates during the summer management period. However, what appears to be more important in determining the overall harvest impact on the late time group is the year specific circumstances and how the fishery progresses throughout the season.

The spring season fishery is managed through the season based on evolving information. The preseason forecast is used to set an initial target harvest rate. But the forecast run size is adjusted continuously inseason based, in particular, on counts of fish at Bonneville Dam. Fisheries are set conservatively initially until there is more confidence in the inseason estimate. As a result, the timing of the catch from week-to-week varies considerably from year-to-year. In many years, there is an initial pulse of fishing early in the season, followed by an extended closure or much reduced harvest until more is known about the run size. In 2007, 2008 and 2009, when the weighted catch for Snake River summer fish was lowest, the fishery was closed during the peak of the run timing of the summer run fish. In 2014 and 2015, there was no midseason break in the fishery (Figure 2-23). So what seems important in evaluating the effects of the proposed action on summer run fish is not so much what happens after June 15, but more how the fishery is structured and the collective effects of the fishery throughout the season.

The analysis indicates that the survival rates of late timed fish are more variable ranging from 60 – 90%, even though the average survival rates for early and late timed fish are, on average, not significantly different. High temperatures and spill are more likely to adversely affect the survival of late timed fish because temperature increases with time and spill tends to peak coincident with the run timing of late timed fish. High catch rates after June 15 may also contribute to lower survival, particularly in years when migration is late or delayed.

It's reasonable to examine if the fishery could be managed to reduce the potential for disproportionate impacts to various components of the run. For example, it may be useful to think about ways to apply an even and consistent pattern of fishing throughout the run so all components are subject to similar impacts. This could be done, for example, by applying a fixed schedule in terms of days fishing per week. However, a fixed schedule fishery would likely compromise the ability to also manage for a variable abundance based harvest rate that is responsive to changes in inseason estimates of run size.

But it is important to emphasize that this is a complex system. Adult survival is influenced by a complex array of factors natural-origin/hatchery-origin interactions, migration patterns, temperature effects of spill operations all interacting with fishing effects.

Recently, the NWFSC has begun life-cycle modeling analysis that is considering the effects of hatcheries, habitat conditions, and recovery actions for the populations in both the UCR spring-run and Snake River spring/summer-run Chinook Salmon ESUs at various harvest rates (2017 pers. comm. E. Buhle, NWFSC). This information was still in draft form and at the time of the completion of this opinion not available to be incorporated into the analysis (Dygert 2018). If the life-cycling modeling analysis subsequently modifies our analysis in a manner that causes an effect on these listed species or critical habitat that was not considered in this opinion we would reinitiate consultation.

One additional way to consider the effect of the proposed action on late timed populations is to consider the status of the populations, relative to others in the ESU, and how that has changed over time. NMFS recently completed its five-year status view of ESA-listed salmonids (NMFS 2016b). The new information indicates that the status of each ESU has improved over the last five years, although the overall viability ratings remain unchanged. The abundance of natural-origin spawners has increased over the last five years for 25 of the 26 populations in the Snake River spring/summer-run Chinook Salmon ESU. The percent change in natural-origin spawners for the three late timed populations increased by 47 - 165%. Recent trends in productivity are also up for two of the three late timed populations. Ratings for spatial structure and diversity remain unchanged as they do for most of the other populations in the Snake River spring/summer-run Chinook Salmon ESU. Under the proposed action, fisheries would continue to be managed using the abundance based harvest rate schedule and fishery management procedures in place since at least 2005. Under this regime, the status of the late timed populations has improved along with others populations in the Snake River spring/summer-run Chinook Salmon ESU, and for each population in the UCR spring-run Chinook Salmon ESU.

Effects on Critical Habitat

The effects of harvest activities in the proposed action on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook- and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UCR spring-run Chinook or Snake River spring/summer-run Chinook salmon.

Snake River Sockeye Salmon

Management provisions for sockeye in the 2018 Agreement have not changed from those in the 2008 agreement. Non-treaty fisheries will be limited to a harvest rate of 1% and treaty Indian fisheries to 5 to 7%, depending on the total run size of sockeye stocks returning to the Columbia River (Table 2-95). Fisheries managed under these same provisions since sockeye were first listed in 1991 have resulted in harvest rates below those allowed. The total harvest rate from 2008-2016 has averaged 6.3% on Snake River sockeye salmon. While the river mouth runsize has averaged 348,000 sockeye between 2008 and 2016 (Table 2-78), the proportion of the run consisting of Snake River sockeye salmon has averaged less than 1% of the overall run, or about 1,500 sockeye annually. This means that less than 100 Snake River sockeye salmon are annually harvested during fisheries targeting abundant sockeye stocks bound for the UCR, which is a low effect.

Table 2-95. Sockeye Harvest Rate Schedule.

River Mouth Sockeye Run Size	Treaty Harvest Rate	Non-Treaty Harvest Rate	Total Harvest Rate
< 50,000	5%	1%	6%
50,000 -75,000	7%	1%	8%
> 75,000	7% *	1%	8 % *

*If the upriver sockeye run size is projected to exceed 75,000 adults over Bonneville Dam, any party may propose harvest rates exceeding those specified in Part II.C.2. or Part II.C.3. of the 2008-2017 Management Agreement. The parties shall then prepare a revised biological assessment of proposed Columbia River fishery impacts on ESA-listed sockeye and shall submit it to NMFS for consultation under section 7 of the ESA.

Effects on Critical Habitat

The effects of harvest activities in the proposed action on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook- and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Snake River sockeye salmon.

Snake River and Upper Columbia River Steelhead

Harvest management for steelhead is unavoidably complex. There are four stocks (winter, Skamania, A-Index, and B-Index) that contribute in varying degrees to five steelhead DPSs. The geographical distribution varies by stock. Some are only present in the lower river while others return to the head waters of the Snake and upper Columbia rivers. Steelhead run timing is complex so that harvest impacts on some stocks occur in different seasons and even different calendar years. All of these details complicate how harvest impacts are monitored and accounted for. The easiest way to summarize the catch accounting system under the proposed action is to say that non-Treaty fisheries are subject to a 2% harvest rate limit on both natural-origin A-Index and B-Index steelhead during the summer season when they enter the Columbia River in July, then including the following winter/spring season for fisheries upstream of The Dalles Dam (see Figure 2-25), and a 2% harvest rate limit on both steelhead Indexes in the fall season. Under the proposed action Treaty Indian fisheries are managed subject to a harvest rate limit on B-Index steelhead during the fall season that varies depending on stock status (Table 2-98). The following explains the details of the catch accounting system under the proposed action in more detail, but the focus in this section on the effects of the proposed action on the Snake River and Upper Columbia River DPSs.

Winter steelhead include populations from the Lower Columbia River, Middle Columbia River, and Upper Willamette River DPSs, which were discussed in earlier section specific to those DPSs. Summer steelhead are divided into three stocks: Skamania River, A-Index, and B-Index. The Skamania River stock includes the summer component of the Lower Columbia River DPS, which was also discussed above (Section 2.5.1.1). Recall, that the A-Index stock includes the summer component of fish from the Middle Columbia River DPS, and fish returning to the Upper Columbia River and Snake River DPSs. The B-Index stock returns primarily the Snake River DPS, but some B-Index fish also return to the Middle and Upper Columbia River DPSs (Table 2-96) (See Table 2-89 for all stock definitions, Table 2-96 is a repeat of this information here for reference purposes). The Snake River and Upper Columbia steelhead DPSs only include A- and B-Index stocks; therefore, only the A- and B-Index harvest rate limits are discussed in this section (shaded boxes in Table 2-96).

Table 2-96. Steelhead stock descriptions and corresponding ESA-listed surrogates in 2018 Agreement (TAC 2017).

***US v Oregon* Stock Name**		**General Stock Description**	**ESA-listed ESU or DPS represented**
Winter Steelhead		Number of steelhead entering the Columbia River and harvested in the LCR (below Bonneville Dam) from November 1 through April 30 of the year following and those caught in the Bonneville Pool (Bonneville Dam to The Dalles Dam) from November 1 through March 31 of the year following	LCR steelhead (winter component)
			MCR steelhead (winter component)
			UWR steelhead
Summer steelhead	Skamania	Number of steelhead caught in the mainstem LCR (below Bonneville Dam) from May 1 through June 30 each year and those caught in the Bonneville Pool	LCR steelhead (summer component)

		(Bonneville Dam to The Dalles Dam) from April 1 through June 30	
	A-Index	Number of steelhead destined to cross Bonneville Dam between July 1 through October 31 each year measuring less than or 78 cm fork length (<~30 inches)	MCR steelhead (summer component)
			UCR steelhead
			Snake River steelhead
	B-Index	Number of steelhead destined to cross Bonneville Dam between July 1 through October 31 each year measuring greater than or 78 cm fork length (>~30 inches)	Snake River steelhead
			MCR/UCR steelhead

Non-Treaty Fisheries

For management purposes, the steelhead run year starts on July 1 at Bonneville Dam. From July 1 to July 31, a separate 2% harvest rate limit begins on natural-origin A- and B-Index steelhead in fisheries upstream from the mouth of the Columbia River. A portion of the annual steelhead run is unclipped hatchery-origin fish, and this component is annually calculated to correct for the actual natural-origin steelhead return (TAC 2017). Beginning August 1 there is a new 2% harvest rate limit on the natural-origin component of each Index that applies to fisheries that affect the same set of returning fish that occur through October 31. This fall harvest rate limit extends from November 1 through December 31 for fisheries upstream of The Dalles Dam. In the following year, for fisheries upstream of The Dalles Dam to the Washington/Idaho border, from January through June 30 (the winter/spring management period) fisheries are limited as part of the same 2% harvest rate limit that occurred in the previous July, since these are the same run of steelhead which have now migrated upstream in the Columbia River Basin. In total, each Index is subject to a maximum 4% harvest rate limit on natural-origin steelhead each run year. Figure 2-25 visually represents the harvest rate limits in for non-treaty fisheries for all steelhead stocks throughout the steelhead run year. The summer accounting period extends through July 31, the fall accounting period is from August 1 to October 31, and then upstream of The Dalles Dam from November 1 to December 31, and the spring accounting period, added to the winter period, is January 1 to June 30 for areas upstream of The Dalles Dam. These harvest rate limits and accounting periods are for A- and B-Index steelhead runs annually crossing Bonneville Dam from July 1 through October 31.

Limits on B-Index steelhead include fish that may seek thermal refuge and dip into tributary mouths in Drano Lake at the mouth of the Little White Salmon River, the lower Wind River, the lower Deschutes River (upstream to Sherars Falls), and the John Day River Arm of John Day Reservoir.

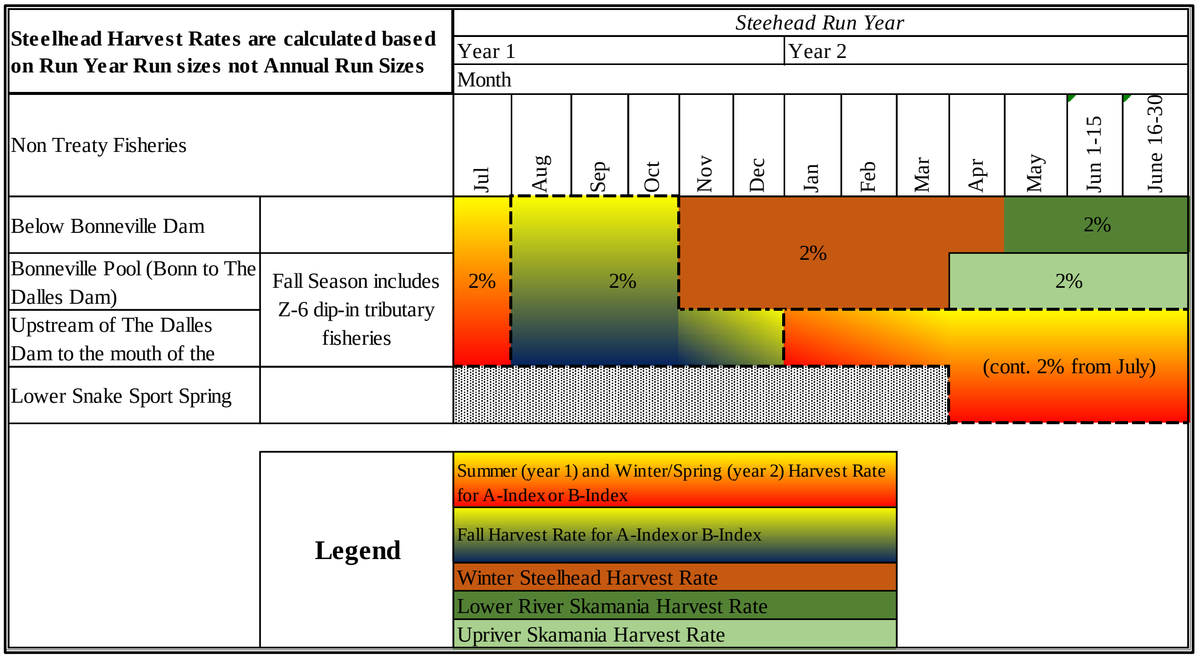

Figure 2-25. Non-treaty harvest rate limit distribution by location and month (as described from (as described from TAC 2017).

Generally, the expected harvest rates from non-treaty fisheries are less than those proposed. Non-treaty winter/spring season fisheries have an average harvest rate of 0.1% on the unclipped portion of both the A-and B-Index stocks (TAC 2017). Non-treaty summer fisheries averaged a harvest rate of 0.7% on unclipped A-Index steelhead and 0.04% on unclipped B-Index steelhead from 2008-2016 (TAC 2017). Non-treaty fall fisheries averaged a harvest rate of 1.9% on unclipped B-Index steelhead in the same frame (Table 2-97).The yearly non-treaty harvest rate of unclipped A-Index steelhead in fisheries has averaged 1.9% and 2.0% for unclipped B-Index steelhead since 2008 (TAC 2017, Table 3.3.56).

Table 2-97. Non-treaty harvest rates averages by management period for natural-origin steelhead A- and B-Index (from TAC (2017)).

Non-treaty Harvest Rates 2008-2016 (unclipped steelhead)				
	Summer	Fall (August 1-December 31)	Winter/Spring	Annual
A-Index (Total 2% limit in summer and following winter/spring and 2% limit in fall)	0.7%	1.1%	0.1%	1.90%
B-Index (Total 2% limit in summer and following winter/spring and 2% limit in fall)	0.04%	1.9%	0.1%	2.0%

Treaty Fisheries
The treaty winter/spring harvest rate on unclipped A-Index steelhead during winter/spring fisheries averages 0.01% and 0% on unclipped B-Index steelhead (TAC 2017). Summer fisheries have averaged 1.5% on unclipped A-Index steelhead and 2.4% on unclipped B-Index steelhead (Table 2-99). The yearly treaty fall harvest rate of unclipped A-Index steelhead in fisheries has averaged 6.5% since 2008 and 17.9% on unclipped B-Index steelhead (TAC 2017, Table 3.3.52). From 2008-2016 the average treaty harvest rate on the unclipped portion of the B-Index steelhead stock was 20.2% (Table 2-99).

Treaty Indian fisheries affecting B-Index steelhead will be managed using the agreed abundance-based harvest rate schedule (Table 2-98) in the fall management period only. In the remaining seasons, there is no directed treaty steelhead fishery downstream of the Dalles Dam.

Table 2-98. Fall management period steelhead harvest rate schedule (TAC 2017, Table 3.3.51).

Forecast Bonneville Total B Steelhead Run Size	River Mouth URB Run Size	Treaty Total B Harvest Rate	Non-Treaty Natural-origin B Harvest Rate	Total Harvest Rate
<20,000	Any	13%	2.0%	15.0%
20,000	Any	15%	2.0%	17.0%
35,000	>200,000	20%	2.0%	22.0%
B-Index Steelhead are defined as steelhead measuring ≥78 cm				

This harvest rate schedule applies to fall season fisheries only. These fisheries include all mainstem fisheries below the mouth of Snake River from August 1 through October 31 and for mainstem fisheries from The Dalles Dam to the mouth of the Snake River from November 1 through December 31. Also included are fall season treaty fisheries in Drano Lake and tributary mouth sport fisheries in Zone 6 that impact Snake River steelhead.

B-Index steelhead are defined as any steelhead caught in mainstem fisheries downstream of the mouth of the Snake River measuring greater than or equal to 78 cm fork length (~30 inches) that are destined to pass Bonneville Dam between July 1 and October 31. B-Index steelhead are subject to higher harvest rates than A-Index because they are larger and thus more susceptible to catch in gillnets. Harvest impacts on B-Index steelhead generally are also higher because their timing coincides with the return of fall Chinook salmon, the primary target of fall fisheries. A-Index steelhead typically return a few weeks earlier, are smaller in body size, and thus are less susceptible to catch in treaty fisheries than B-Index steelhead. Consequently, there are no specific management constraints in treaty fisheries for A-Index steelhead during any period. Limits to target Chinook salmon species during each season, coupled with the B-Index steelhead limit, as indicated by the following table, has been a management framework that kept A-Index harvest rates below those observed for B-Index steelhead by a large margin, which for both stocks are low during Summer and Winter/Spring management periods, and highest during the Fall management period.

Table 2-99. Treaty harvest rates averages by management period for natural-origin steelhead A- and B-Index (TAC 2017).

Treaty Incidental Catch 2008-2016 (unclipped steelhead)				
	Summer	Fall (August 1- December 31)	Winter/Spring	Annual
A-Index (None)	1.5%	6.5%	0.1%	8.10%
B-Index (See management period harvest rate schedule (Table 2-98.))	2.4%	17.9%	0%	20.2%

Effects on Critical Habitat

The effects of harvest activities in the proposed action on PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River, but also in the Snake River up to the Washington/Idaho border during spring. The gear that are used include hook- and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UCR or Snake River steelhead.

2.5.1.4 Tributary treaty fishery effects

Some additional harvest occurs in fisheries above Bonneville Dam in treaty tributary fisheries. These fisheries are operated at population specific levels and are not related to the stock aggregate rate limits used for mainstem fishery management. Table 2-100, presents the proposed level of harvest expected during the 2018 Agreement for specific populations expressed as an annual harvest rate or a number of fish.

Table 2-100. Proposed Incidental Take for Treaty Indian tributary fisheries (TAC 2017).

Tributary Fishery Location	Affected ESA-Listed Populations	Proposed Incidental Take limit
Wind River	Wind River Summer steelhead	3.25%, 3-year average
Hood River	Hood River Spring Chinook salmon	3.0%, 3-year average
Hood River	Hood River Winter steelhead	2.0%, 3-year average
Klickitat River	Klickitat Summer steelhead	9.6%, 3-year average
Deschutes River	Deschutes River Steelhead	1.6%, 3-year average
John Day River	John Day River steelhead	0.5%, 3-year average
Umatilla River	Umatilla River steelhead	6.2%, 3-year average

Walla Walla River	Walla Walla River steelhead	2.0%, 3-year average
Yakima River	Yakima River steelhead	0.5%, 3-year average
Icicle Creek Tributary	Natural-origin summer steelhead	0.5% per year

LCR Chinook Salmon

Treaty tributary fisheries will affect one Gorge MPG spring population. The 2008-2016 incidental harvest rate average for the Hood River spring Chinook salmon population is 1.9% (TAC 2017; Table 3.4.8). The proposed harvest limit is a rolling three-year average of 3.0% from release mortalities. This is a low population specific incidental rate of harvest.

LCR Steelhead

Some additional harvest occurs in tributary fisheries above Bonneville Dam that may affect the three additional LCR steelhead populations. The 2008-2016 average indirect effect of the Wind River treaty spring Chinook salmon tributary fishery is 1.5%, ranging from 0% to 8.4% (TAC 2017; Table 3.4.6). The proposed incidental take limit of Wind River steelhead in the treaty spring Chinook salmon fishery is a rolling three-year average of 3.25% (TAC 2017). This is a low population specific incidental rate of harvest.

Harvest that may affect the Little White Salmon River population occurs in the estuary portion of the river known as Drano Lake, and no Skamania stock harvest has been known to occur (TAC 2017). TAC (2017) expects the indirect effect of the treaty tributary hatchery steelhead fishery in the Hood River on the Hood River winter steelhead population as an additional 2.0% harvest rate on this population based on the 2008-2016 average (TAC 2017; Table 3.4.8). This is a low population specific incidental rate of harvest. The proposed harvest limit of Hood River spring Chinook salmon is a rolling three-year average of 3.0% (TAC 2017). This is a low population specific incidental rate of harvest. The proposed harvest limit of Hood River winter steelhead population is a rolling three-year average of 2.0%, from release mortalities (TAC 2017). This is a low population specific incidental rate of harvest.

Middle Columbia River Steelhead

Some additional harvest occurs in tributary fisheries above Bonneville Dam that may affect additional MCR steelhead populations. Since the removal of Condit Dam there has not been a treaty fishery in the White Salmon River, but if there were TAC (2017) expects the indirect effect to be up to 50 steelhead per year of a combination of natural and hatchery-origin fish, which could be from the White Salmon River population or could include stray fish from other basins. Information is not available on the current makeup of this population. TAC (2017) expects the indirect effects of the treaty tributary fisheries to affect the respective winter and/or summer steelhead populations specified at additional harvest rates based on average rates observed during 2008 to 2016 (TAC 2017). The proposed harvest limit of Klickitat River summer steelhead is a rolling three-year average of 9.6% (TAC 2017). This is a moderate population specific incidental rate of harvest. The proposed harvest limit of Deschutes River steelhead population is a rolling three-year average of 1.6% (TAC 2017). This is a low population specific incidental rate of harvest. The proposed harvest limit of John Day River steelhead is a rolling three-year average of 0.5% (TAC 2017). This is a very low population specific incidental rate of harvest. The proposed harvest limit of Walla Walla River steelhead population is a rolling three-year average of 2.0% (TAC 2017). This is a low population specific incidental rate of harvest. The proposed harvest limit of Yakima River steelhead population is a rolling three-year average of 0.5% (TAC 2017). This is a very low population specific incidental rate of harvest.

Upper Columbia River spring-run Chinook Salmon

Some additional harvest occurs in tributary fisheries above McNary Dam that may affect the Wenatchee population if fish were to stray into Icicle creek. TAC (2017) expects harvest to occur in the treaty spring-run Chinook salmon tributary fishery in Icicle Creek to adhere to a 0.5% harvest rate limit on the unclipped spring-run Chinook salmon per year (TAC 2017). This is a very low population specific incidental rate of harvest.

Effects on Critical Habitat

The effects of harvest activities in the proposed action on PCEs occur from boats or along the river banks of each tributary. The gear that are used include hook- and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for any of the populations affected here.

2.5.1.5 Green Sturgeon

Green sturgeon are caught in non-Treaty commercial and recreational fisheries below Bonneville Dam. Retention of green sturgeon is not allowed in either fishery. Take therefore occurs in the form of catch, handling, and subsequent release. The mortality of released fish is low.
When recreational retention fisheries are open for white sturgeon some minor level of green sturgeon may be misidentified by anglers and retained. Between 2007 and 2013, the number of misidentified and retained green sturgeon averaged four (range 0 - 7) per year (TAC 2017). This number is expected to be similar through 2027 if sturgeon retention fisheries were to return to past levels. However, as anglers become more proficient at identifying green sturgeon, mistaken retention numbers should decrease. If retention seasons are small as in 2017, then mistaken retention of green sturgeon is expected to be very low or zero. Between 2007 and 2013 an average of 144 green sturgeon (range: 61 to 255) were incidentally caught and released; incidental catch rates were lower from 2014 to 2016 when white sturgeon retention was prohibited (TAC 2017). Less than 10 green sturgeon incidentally caught in the recreational fisheries are estimated to be misidentified by anglers and kept, and less than seven fish killed from release mortalities, based on up to 255 fish released and an estimated post-release mortality rate of 2.6% for hook-and-line gear (Robichaud et al. 2006). Overall, the recreational fisheries may catch up to 255 green sturgeon per year and kill up to 17 green sturgeon per year. Of these, we expect 72% (184 fish caught and 12 fish killed) to belong to the Southern DPS, based on the proportion of Southern DPS versus Northern DPS fish in the Columbia River estuary (Israel et al. 2009; Schreier et al. 2016). In most years, however, we expect incidental catch of green sturgeon to be lower. Although incidental catch can be as high as 255 green sturgeon in any one year, we expect the five-year average to be less than or equal to 144 green sturgeon caught and

14 green sturgeon killed per year, based on the average incidental catch for 2007 through 2013 (TAC 2017). Of these, we expect 72% (104 fish caught and 10 fish killed) to belong to the Southern DPS.

No green sturgeon are expected to be encountered in Zones 4 and 5 during fall season commercial fisheries. However, summer season fisheries occurring in Zones 1 through 5 and fall season fisheries in Zones 1 through 3 or the SAFE Areas may encounter green sturgeon. The expected incidental catch of green sturgeon during these fisheries is not expected to exceed, and would likely be lower than, estimates for the period prior to July 2006 when retention was allowed. Between 2003 and 2005 these commercial fisheries incidentally caught an average of about 350 green sturgeon per year, which would result in an estimated 18 mortalities per year (5.2%; TAC 2017). Of these, we expect 72% (252 fish caught and 13 fish killed) to belong to the Southern DPS. Commercial fishers do not generally misidentify green sturgeon. In most years, we expect incidental catch of green sturgeon to be lower. Landings in 2001 through 2005 ranged from 41 to 340 green sturgeon per year (TAC 2017), with an average of 137 green sturgeon per year. Although incidental catch can be as high as 350 green sturgeon in any one year, we expect the five-year average to be less than or equal to 137 green sturgeon caught and 7 green sturgeon killed per year (5.2% post-release mortality). Of these, we expect 72% (99 fish caught and 5 fish killed) to belong to the Southern DPS.

Overall, the total annual take of Southern DPS green sturgeon associated with fisheries implemented as part of the proposed action is estimated to be up to 436 fish caught per year (up to 184 incidentally caught in the recreational fishery and up to 252 fish caught in the commercial fishery per year) and up to 25 fish killed per year (up to 12 fish killed in the recreational fishery and up to 13 fish killed in the commercial fishery per year). These estimates are based on historical catch numbers and are likely overestimates. The actual incidental take of Southern DPS green sturgeon in the proposed fisheries is likely to be less than 436 fish per year. We expect the five year average to be less than or equal to 203 Southern DPS fish caught and 15 Southern DPS fish killed per year. Additional catch data, particularly for the commercial fisheries, are needed to refine our estimates.

Green sturgeon are not known to occur upstream of Bonneville Dam and no expected take of Southern DPS green sturgeon is expected in the prospective treaty Indian fisheries.

The proposed action also includes sturgeon research, monitoring, and evaluation activities involving mark-recapture of white sturgeon in the lower Columbia River and will result in incidental catch of Southern DPS green sturgeon. These mark-recapture studies use gillnets to capture sturgeon for tagging, primarily in May through July. From 2008 through 2016, the number of green sturgeon handled in the white sturgeon gillnet tagging activities ranged from 2 to 48 per year (TAC 2017). Of these, we expect 72% (up to 35 fish) to belong to the Southern DPS. We also expect up to 5.2% (up to two Southern DPS fish) to die per year due to post-release mortality (TAC 2017). WDFW may also continue tagging operations in the lower Columbia River, in which green sturgeon would be incidentally captured in gillnets, tagged, and released. Based on past white sturgeon test fishery catch rates, up to 79 green sturgeon are expected to be caught annually, of which 72% (57 fish) are estimated to belong to the Southern DPS (TAC 2017). No direct mortality is expected, but post-release mortality (estimated at 5.2%) may result in mortality of up to three Southern DPS fish per year (TAC 2017).

The proposed action occurs within designated critical habitat for Southern DPS green sturgeon; however, the effects of the proposed action were determined to not likely adversely affect critical habitat for the species (see Section 2.12).

2.5.2 Hatchery Effects

All of the hatchery programs included in the 2018 Agreement have completed section 7 consultations, so their effects are captured in the environmental baseline section of this biological opinion, with one exception: the 2018 Agreement includes a change to the Snake River fall-run Chinook salmon hatchery program that was not anticipated in the 2012 site-specific biological opinion. The 2018 Agreement includes a footnote that says starting in with broodyear 2018 that 1,000,000 hatchery-origin fall Chinook salmon subyearlings will be released in Salmon River instead of the mainstem of the Snake River just below Hells Canyon Dam. Therefore, NMFS will evaluate the effects of that change here. Otherwise, the proposed action has the same effects as those described generally in the environmental baseline section and in detail within the site-specific biological opinions referenced in Table 2-81. For efficiency, the discussion of these effects is not repeated in its entirety, but rather is summarized below and organized into the following categories: competition and predation effects, disease effects, genetic effects, and broodstock collection and facility effects. These effects are further described in Appendix B and Appendix C. The effects of the change to the Snake River fall-run Chinook salmon hatchery program are analyzed separately in Section 2.5.2.5.

2.5.2.1 Competition and Predation

Predation, for the purposes of considering effects of hatchery programs, occurs when a fish from a program included in the proposed action preys upon and consumes a natural-origin fish. More broadly, predation may occur in reverse, with natural-origin fish preying on hatchery fish. However, since the purpose of this opinion is to gauge the effects of the proposed action on listed species, only the former and its impacts to abundance and productivity of listed species is of concern.

As for competition, generally speaking, competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions between hatchery-origin and natural-origin fish. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for natural-origin fish (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmonid behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both intraspecific and interspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intraspecific or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors. However, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature outmigration by natural-origin juvenile salmonids. Pearsons et al. (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas in the vicinity of hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The hatchery programs in the 2018 Agreement minimize risk associated with competitive interactions between hatchery- and natural-origin fish by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012).
- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population.
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by naturally produced juveniles.
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely.

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish are released at a later stage, so they are more likely to emigrate quickly to the ocean, and can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (as residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

(Rensel et al. 1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas at the time. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook salmon and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook salmon fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (Rensel et al. 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (Pearsons and Fritts 1999; HSRG 2004), but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

The hatchery programs in the 2018 Agreement minimize risk associated with predation of hatchery-origin fish on natural-origin fish by:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

In an effort to better understand the aggregate competition and predation effects, NMFS used the PCD (Predation, competition, disease) Risk model (Pearsons and Busack 2012) to simulate predation and competition on natural-origin salmon and steelhead juveniles from all of the hatchery-origin juveniles included in the 2018 Agreement, from their release sites to the mouth of the Columbia River (Appendix B). As discussed in more detail in Appendix B, outputs from the PCD Risk model should not be considered estimates of the actual predation and competition impact on natural-origin salmon and steelhead from hatchery-origin juveniles because the PCD Risk model is not a total simulation of ecological interactions between hatchery and wild fish. Nonetheless, the simulations are useful in that they give an example of the magnitude of interactions that could occur under a certain set of assumptions. Based on the assumptions used in NMFS' simulations, it appears that ecological impacts from the release of hatchery-origin fish included in the 2018 Agreement may be greatest on the Snake River spring/summer-run Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, and Snake River Steelhead DPS. Most of the ecological effects on natural-origin ESA-listed salmon and steelhead were predicted to occur via competition. Our simulations did not suggest any predation effects on natural-origin juveniles in the Snake River Steelhead DPS, UCR Steelhead DPS, MCR Steelhead DPS, LCR Steelhead DPS, or Snake River Sockeye Salmon ESU.

Competition and Predation in the Estuary and Plume

Once fish reach the estuary, residence time differs by species and life history. Longer residence times allow for potentially longer periods of interactions with natural-origin fish. Weitkamp et al. (2012) noted periods of time when each species and life history of salmon (91-100% of these fish were of hatchery-origin) were caught in the estuary, an indication of residence time. Chum and sockeye salmon were typically caught during a two to four week period, yearling Chinook salmon, steelhead, and coho salmon were caught for a six to eight week period, and subyearling Chinook salmon were present for at least two months (but possibly longer due to the end of sampling in July, when subyearling Chinook salmon were still being caught) (Weitkamp et al. 2012). Another study by Bottom et al. (2008) found that Chinook salmon estuary residence time (time of first contact with salt water) ranged from 10-219 days and averaged 73 days. However, almost half of the Chinook salmon sampled were less than 60 mm, much smaller than Chinook salmon released from hatchery programs. Estimates from marked hatchery groups indicated that Chinook salmon had residency periods of about one week (Dawley et al. 1986; Bottom et al. 2008), but may have underestimated residency due to sampling of larger stream-type Chinook salmon and not smaller ocean-type Chinook salmon.

Data suggest that subyearling Chinook salmon overlap with hatchery-origin yearling Chinook salmon, coho salmon, and steelhead is minimal, and the subyearling Chinook salmon are likely protected from ecological effects through both habitat partitioning and temporal differences. Subyearling Chinook salmon tend to occupy shallower habitats than yearlings (Weitkamp et al. 2014), with this life stage accounting for 97.4% of the Chinook salmon in the estuary (Roegner et al. 2012). Chinook salmon less than 90 mm (i.e., subyearlings), are the primary users of Columbia River wetlands (Bottom et al. 2008). In addition, subyearlings can be found throughout the year, although abundance is low from October through January. Their peak abundance differed depending on estuary zone; from April to June in the tidal freshwater zone, two peaks in May and July in the middle estuary zone, and July in the lower estuary zone. Weitkamp et al. (2012) also found peak subyearling abundance in June/early July. During the winter and early spring, fry comprised 25% of the samples, with the highest percentage of fry in the tidal freshwater zone. Most of the Chinook salmon fry (85%) were from either the Cascade MPG or were Spring Creek fall Chinook salmon.

In addition to subyearling Chinook salmon, Roegner et al. (2012) found that the predominant species and life history types using the shallow tidal freshwater and estuary sites were chum salmon fry from March to May. Weitkamp et al. (2012), found that sampling in mid-April yielded low catches of juvenile salmon, but that chum salmon abundance peaked in mid-May, which overlaps with the timing identified by Roegner et al. (2012). In addition, the peak in sockeye salmon abundance occurred in late June/early July, whereas the maximum abundances of yearling Chinook salmon, coho salmon, and steelhead in the estuary occurred in mid-May (Weitkamp et al. 2012). Thus, both chum and sockeye salmon are not likely to interact to a large degree with yearling hatchery fish in the estuary due to temporal and spatial differences in habitat use; chum salmon mostly use the shallow areas and sockeye salmon abundance peaks after yearling Chinook salmon have likely moved offshore. However, both species are exposed to hatchery-origin subyearling Chinook salmon, which use the shallow habitats and are present for most of the year.

This overlap with hatchery-origin subyearling Chinook salmon can be further refined based on work by the Lower Columbia River Estuary Partnership (LCREP) (Sagar et al. 2015). The LCREP found higher proportions of marked (hatchery) salmonids higher in the tidal freshwater area than in areas closer to the Columbia River mouth. Also, marked Chinook salmon were present primarily from May through July. In contrast, unmarked (presumably natural-origin) Chinook salmon were found throughout the spring and summer until August. Unmarked and marked juvenile spring Chinook salmon had similar spatial distributions in the marine environment, but peak abundance occurred earlier for hatchery fish (May) than for natural fish (June). One caveat is that small-scale spatial overlap is unknown due to sampling of fish using trawls that sample a large volume of water (Daly et al. 2012), which is not informative for vertical or dispersed/aggregated patterns. Also, decreases in the proportions of hatchery-origin fish from the estuary to the ocean suggest that hatchery-origin fish may have reduced survival early in their marine residence (Claiborne et al. 2014). Interestingly, there was no evidence for selective mortality of smaller salmonids, which the authors believe was because of favorable ocean conditions for salmonids (e.g., cooler temperatures, plenty of food).

The ISAB (2015) concluded there is little direct evidence of density dependent interactions between hatchery- and natural-origin juvenile salmonids in the Columbia River estuary and ocean because of the lack of carefully designed experimental studies. The lack of scientific knowledge about density dependence of Columbia River salmonids during their time in the estuary and ocean is an important information gap, as understanding density dependence might help explain abundance patterns of natural salmonid resources in the Columbia River Basin. Density dependence is not included as a limiting factor in the Columbia River estuary ESA recovery plan module for salmon and steelhead because of uncertainty about the mechanisms and effects of density dependence in the estuary (NMFS 2011b).

Other researchers have expressed similar sentiments about the lack of information needed to appropriately assess density dependence. Daly et al. (2012) stated that competition for food resources could not be determined due to the lack of an estimate of prey availability and whether or not it is limiting. However, other researchers found that the amount of food in juvenile salmon stomachs was < 1% of body weight (Dawley et al. 1986; Weitkamp et al. 2014), which is generally lower than that found in studies of other estuary systems. This could be an indicator of competition with hatchery fish or an exceedance of system carrying capacity. However, hatchery-origin fish had less full stomachs than natural-origin fish. In addition, for both juvenile steelhead and juvenile spring Chinook salmon, unmarked fish had smaller lengths, but better body condition, fuller stomachs and higher Insulin Growth Factor (IGF-1) levels than hatchery counterparts (Daly et al. 2012; Daly et al. 2014). This suggests that natural-origin fish are faring better in the marine environment than natural-origin fish, and thus may be better competitors in the marine environment.

2.5.2.2 Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou* virus (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

- Introduction of exotic pathogens,
- Introduction of endemic pathogens to a new watershed,
- Intentional release of infected fish or fish carcasses,
- Continual pathogen reservoir,
- Pathogen amplification.

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990; Naish et al. 2008). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., Renibacterium salmoninarum, the cause of Bacterial Kidney Disease).

The hatchery programs in the 2018 Agreement minimize disease risk by adhering to a number of state, Federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; NWIFC and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., Vibrio anguillarum). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as infectious hematopoietic necrosis virus (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, Federal and tribal fish health policies, disease risks is further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent also minimizes amplification, but does not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply.

2.5.2.3 Genetic Effects

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risks.

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). Another is when N_e is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of N_e reduction is the

Ryman-Laikre effect (Ryman and Laikre 1991; Ryman et al. 1995), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Fiumera et al. 2004; Busack and Knudsen 2007).

Inbreeding depression, another N_e -related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects, the second major area of genetic effects of hatchery programs, are caused by gene flow from one distinct population to another, and when used in reviews of hatchery programs, we are specifically referring to flow from hatchery fish to natural-origin fish. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Grant 1997; Quinn 1997; Jonsson et al. 2003; Goodman 2005), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from hatchery populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery operators to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g.(Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The pHOS[21] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These “dip-in” fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Saisa et al. 2003; Blankenship et al. 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-influenced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). For an individual, the amount of time a fish spend in the hatchery mostly equates to fish culture. For a population, exposure is determined by the proportion of natural-origin fish in the hatchery broodstock, the proportion of natural spawners consisting of hatchery-origin fish (Lynch and O'Hely 2001; Ford 2002), and the number of years the exposure takes place. In assessing risk or determining impact, all three factors must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential

[21] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.

outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., Berntson et al. 2011; Theriault et al. 2011; Ford et al. 2012; Hess et al. 2012). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[22]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 2-26).

More recently, the HSRG developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by (Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on PNI, which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[23]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5% for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically

[22] Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish. In other words, all will contribute to the natural-origin gene pool.

[23] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence, but operationally the distinction is unimportant.

as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

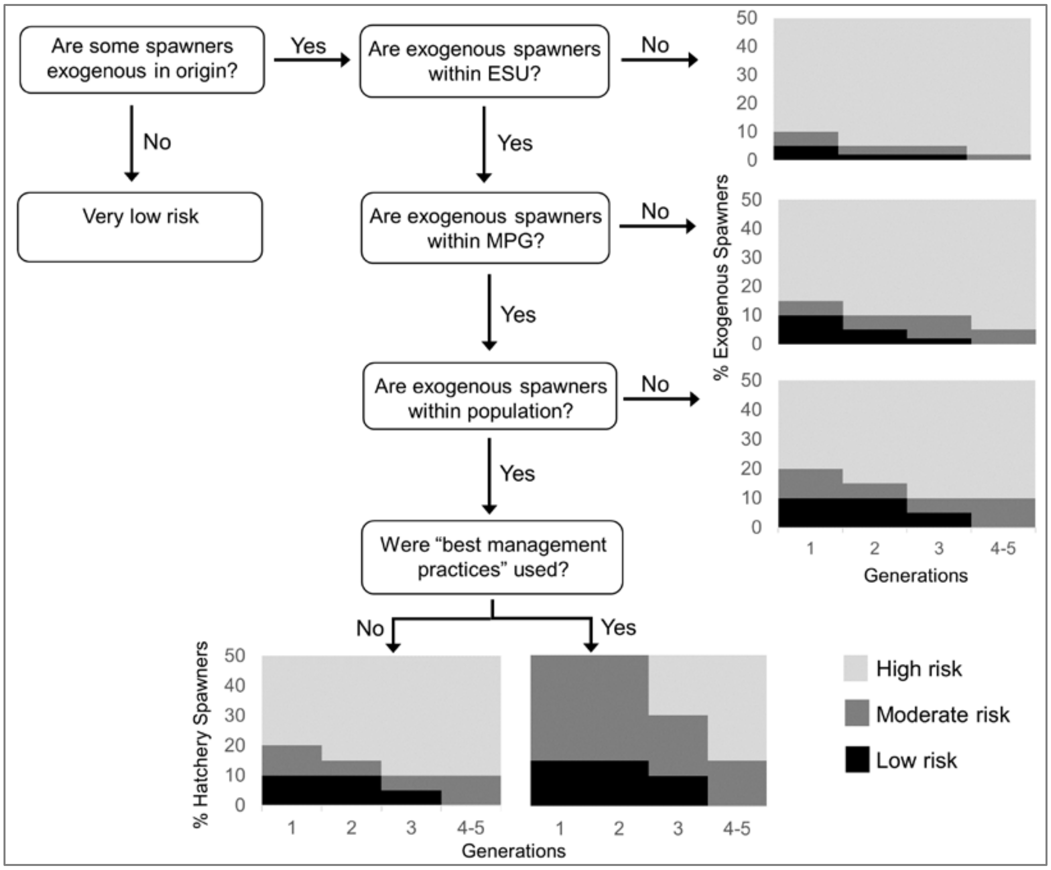

Figure 2-26. ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish hatchery-origin, and non-normative strays of natural-origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5%. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity." They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose demographic risk to the natural population.

While these risks are present as discussed in the baseline section and the site-specific biological opinions associated with the programs in the proposed action, the hatchery programs in the 2018 Agreement minimize genetic risk by:

- Managing returning hatchery-origin adults to remove excess hatchery-origin fish at dams or weirs when they are unneeded for supplementation,
- Developing sliding scale approaches in some hatchery programs to reduce pHOS and increase pNOB as the abundance of natural-origin returns increases (see, for example, NMFS (2017k)),
- Developing "stepping stone" programs to better link genetically some of their segregated hatchery-origin programs to natural-origin salmon and steelhead populations. Initial analysis by NMFS of programs connected this way shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs (Busack 2015),
- Making changes to release locations to support establishment of Natural Production Emphasis Areas (see Section 2.5.2.5),
- Transitioning away from the use of non-endemic stocks,
- Equalizing sex ratio in broodstock,
- Taking broodstock throughout the run,
- Using older spawners to prevent age structure changes,
- Marking nearly 100% of hatchery fish.

2.5.2.4 Broodstock Collection and Facility Effects

In addition to intentionally removing fish for broodstock purposes, the construction/installation, operation, and maintenance of hatchery facilities can unintentionally affect those fish not targeted for collection by altering fish behavior and injuring or killing eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Many of the hatchery programs use instream structures, such as weirs or fish ladders, to collect broodstock or remove hatchery-origin fish from the river to prevent them from spawning naturally.

The hatchery programs in the 2018 Agreement minimize risk associated with broodstock collection and facility effects by:

- Constructing and operating water diversions and fish passage facilities consistent with NMFS criteria,

- Ensuring no hatchery structures, including weirs, adversely affect spatial structure, productivity, or abundance of a natural population. Pursuant to that goal, all fish collection structures are monitored to ensure minimal fish migration delay,
- Limiting the proportion of the natural-origin run that can be taken as hatchery broodstock to avoid "mining" the natural-origin component of the population,
- Ensuring that water withdrawals are operated in a manner that maintains adequate stream flow for rearing and migrating ESA-listed salmon and steelhead.

2.5.2.5 Proposed Change to Snake River Fall Chinook Hatchery Production

The 2018 Agreement includes the movement of subyearlings previously released at Hells Canyon Dam into the Salmon River (Appendix A). The Snake River fall-run Chinook salmon hatchery program was previously analyzed in a site-specific biological opinion (Table 2-81) and are included in the environmental baseline. However, because the movement of subyearlings from Hells Canyon Dam to the Salmon River is a new proposal, it was not considered in the 2012 site-specific biological opinion. Therefore, the effects of this change are analyzed here.

The recently completed Snake River fall-run Chinook salmon recovery plan (NMFS 2017m) includes one recovery scenario that deals with genetic risk in an innovative way with the creation of natural production emphasis areas (NPEA). An NPEA is essentially a region of greatly reduced hatchery influence relative to other spawning areas, which benefits the species by having a portion of the population with very low genetic risk. Such a scenario would be made possible by reconfiguration of hatchery releases without reducing program size. Modeling based on homing fidelity studies available at that time indicated this approach was feasible. Updated homing fidelity information (USFWS 2017) supported the preliminary feasibility of the NPEA, implemented by moving at least the Hells Canyon and Pittsburgh Landing releases to the Salmon River. Considerations of the uncertainties regarding survival rates, homing to the Salmon River, and response of natural production to a large scale change from the present configuration of releases led to the operators making changes to reduce hatchery effects through an NPEA approach in a phased manner. Therefore the 2018 Agreement (Appendix A) includes only one change in release locations: moving the release of 1,000,000 subyearling fall Chinook salmon from Hells Canyon to a site (of equivalent distance to Lower Granite Dam) on the lower Salmon River.

Although this change from the current program is not expected by itself to reduce pHOS in the upper Snake River to the levels desired for a NPEA-based recovery, it should result in a substantial pHOS reduction there. This is because the movement of the Hells Canyon releases reduces the number of fish released in that region by two thirds. In addition, pHOS may be further reduced if natural production increases in the Hells Canyon area in the Snake River due to reduced density of spawners in the reach. Although pHOS may change in the reach below Hells Canyon Dam, total pHOS for the Snake River fall-run Chinook population is not expected to change as a result of the proposed change in release location. Therefore, the effects of this change, including any take involved, is not beyond that included in the baseline as a result of the 2012 Opinion for this program.

The movement of subyearlings previously released at Hells Canyon Dam into the Salmon River is expected to have similar ecological effects to what has already been analyzed in the 2012 site-specific biological opinion because the distance between where the fish were previously released at Hells Canyon Dam and the mouth of the Columbia River is almost the same distance as from the proposed future release site in the Salmon River and the mouth of the Columbia River.

Critical Habitat

There are no additional effects on critical habitat from the release of hatchery-origin fish included in the production tables of the 2018 Agreement that was not already analyzed in the site-specific hatchery biological opinions. These effects are part of the environmental baseline.

2.5.3 Effects from Research, Monitoring and Evaluation

There are several research, monitoring and test fishing activities that occur on an annual basis, and are used to monitor and evaluate fisheries and monitor stock status (TAC 2017). The various monitoring and evaluation activities for anadromous fish would cause many types of take (as defined by ESA §3(19)). Research, monitoring and evaluation (RM&E) (including test fishing) activities may occur from the mouth of the Columbia River up to the Canadian Border or the Snake River from the mouth to Hells Canyon Dam. The proposed ESA mortality impact limits assigned specifically for these RM&E activities are summarized in Table 2-101, expressed as harvest rates. These are derived by estimating a rate of mortality from fish released during encounters through RM&E activities.

Each type of RM&E activity may accrue ESA impacts differently. And, depending on circumstances and information needs, RM&E priorities may change during the course of the 2018 Agreement. Therefore, instead of establishing ESA limits for each activity or type of activity, the proposal is for a total combined harvest rate limit by ESU or DPS. All impacts from proposed RM&E activities (TAC 2017) will be tallied together and reported as annual total harvest rate by ESU or DPS not to exceed the percentages in Table 2-101.

Table 2-101. Proposed incidental take limits for ESA-listed ESUs, DPSs, and stocks associated with RM&E activities in the 2018 Management Agreement.

ESU/DPS/Stock	% Mortality Rate
Snake River spring/summer-run Chinook Salmon	0.1% - 0.5%
Upper Columbia River spring-run Chinook Salmon	0.1% - 0.5%
Upper Willamette River spring Chinook Salmon	0.1% - 0.5%
Snake River Fall Chinook Salmon	0.1% - 0.5%
LCR Chinook Salmon – Spring	0.1% - 0.5%
LCR Chinook Salmon – Fall Tule	0.1% - 0.5%
LCR Chinook Salmon – Fall Bright	0.1% - 0.5%

Snake River Steelhead – A-Index	0.1% - 0.3%
Snake River Steelhead – B-Index	0.1% - 0.3%
Upper Columbia River Steelhead	0.1% - 0.3%
MCR Steelhead - Winter	0.1% - 0.3%
MCR Steelhead - Summer	0.1% - 0.3%
LCR Steelhead - Winter	0.1% - 0.3%
LCR Steelhead - Summer	0.1% - 0.3%
Upper Willamette River Steelhead	0.1% - 0.3%
LCR Coho Salmon	0.1% - 0.3%
Snake River Sockeye Salmon	0.1% - 0.3%
Green Sturgeon	0.1% - 0.5%

2.5.4 Climate Change Effects

A decrease in winter snow pack would be expected to reduce spring and summer flows and increase water temperatures throughout the Columbia River Basin. Warmer temperatures may also increase the probability of higher sediment loads in tributaries due to more rain-on-snow events on the upper slopes of various mountain ranges throughout the basin releasing sediment that is no longer protected by winter snow pack. Reduced summer flows and higher water temperatures would be expected to reduce the habitat quality and habitat quantity needed for juvenile rearing and for adult holding, making those areas in the upper basin more essential for the persistence and recovery of the ESA-listed populations. Habitat quantity and quality may be degraded as annual flows are reduced and water temperatures increase as a result of climate change. These climate change effects on the quantity and quality of habitat in the action area would be expected over the next 50 years to reduce the spatial distribution of the populations because some sections of individual tributaries may become too warm for rearing, as well as reducing their productivity unless the natural-origin populations can adapt to these changes. These effects are assumed in the status of the ESA-listed species affected by the proposed action because these type of effects are already occurring, and are reflected in the trends exhibited in the most recent updates to the status of each ESU. This interaction is expected to continue at similar levels, with similar biological variation, into the near future, allowing us to project climate change having similar adverse effects.

In most cases the proposed action addresses this by aligning future decisions for harvest management tiers with the abundance returning to the river mouth or Bonneville Dam. This abundance based approach provides restriction to fisheries during low levels years of returns. In rarer circumstances, such as non-treaty steelhead and chum harvest rates, the proposed action caps the annual harvest rate for fisheries at a fixed rate. Harvest management in both approaches is responsive to environmental changes, resulting from climatic change or otherwise, as the number of fish harvested is lower in years of low abundance, although overall, the limit is very low every year as it's capped at just 2% or 5%, for steelhead and chum in non-treaty fisheries respectively. Additionally, hatchery operations are currently now aligned with recovery plans where they exist, primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments. As explained in Section 2.2.7, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations.

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.

In NMFS' 2014 opinion (NMFS 2014g) on the FCRPS we described information provided by the states of Idaho, Oregon, and Washington for ongoing, future, or expected projects that were reasonably certain to occur and that were expected to benefit recovery efforts in the Interior Columbia Basin. Here we briefly update that in the relevant sections below.

State of Idaho – ESA Section 6 Cooperative Agreement
The state of Idaho's Department of Lands is pursuing an ESA Section 6 Cooperative Agreement. This forestry program, if approved, would apply to forestry management and timber harvest on state and private lands (voluntary) in the Salmon and Clearwater Basins in Idaho. The intent of the cooperative agreement is to develop forest management practices that would better protect aquatic habitat for ESA-listed fish.

State of Oregon – Oregon Plan for Salmon and Watersheds
The Oregon Plan for Salmon and Watersheds includes voluntary restoration actions by private landowners, monitoring, and scientific oversight that is coordinated with state and Federal agencies and tribes. The Oregon Legislature allocates monies drawn from the Oregon Lottery and salmon license plate funds, which have provided $100 million and $5 million, respectively, to projects benefiting water, salmon, and other fish throughout Oregon. Projects include reducing road-related impacts on salmon and trout streams by improving water quality, fish habitat, and fish passage, providing monitoring and education support, helping local coastal watershed councils, and providing staff technical support.

State of Washington – Governor's Salmon Recovery Office
The Governor's Salmon Recovery Office arose from Washington's Salmon Recovery Act, and it

includes the Salmon Recovery Funding Board (SRFB). SRFB has helped finance more than 900 salmon recovery projects focused on habitat protection and restoration. SRFB administers two grant programs (general salmon recovery grants and Puget Sound Acquisition and Restoration grants). Municipalities, tribal governments, state agency non-profit organizations, regional fisheries enhancement groups, and private landowners may apply for these grants. Lower Columbia Conservation and Sustainable Fisheries Plan (CSF Plan) (WDFW and LCFRB 2015) provides the framework for implementing recovery plan hatchery and harvest actions in the LCR. The goal of the CSF Plan is to: 1) support efforts to recover salmon and steelhead populations to healthy, harvestable levels; and, 2) sustain important fisheries. The CSF Plan encompasses the tenets of the recovery plan, and acknowledges that an “all H” (Habitat, Hatcheries, Harvest, Hydro) approach to recovery is necessary.

All those actions are either completed or ongoing and were thus part of the environmental baseline, or, are reasonably certain to occur and therefore qualified here as cumulative effects. Both beneficial and adverse cumulative effects related to habitat and hydropower, development, and harvest are addressed. The description of the cumulative effects from our 2014 opinion (NMFS 2014g) on the FCRPS is incorporated by reference here, and reviewed below.

Non-Federal habitat and hydropower actions are supported by state, and local agencies; tribes; environmental organizations; and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. In areas upstream of where the 2018 Agreement governs fisheries, (e.g., the UCR and Snake River upstream into Idaho) within the action area, state, tribal, and local government actions are likely to be in the form of fishing permits. These continuing commercial and sport fisheries, which have some incidental catch of listed species will have adverse impacts through removal of fish that would contribute to spawning populations.

It is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the action area will change over time. Although adverse effects will continue, these changes are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery and harvest programs funded and operated by non-Federal agencies and tribes in the Columbia Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that “take” under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Although adverse effects on natural-origin salmon and steelhead will likely not be completely eliminated, effects would be expected to decrease from current levels over time to the extent that hatchery programs are reviewed and approved by NMFS under the ESA. Currently this is only the case in certain tributary sections of the action area in the LCR, specifically in the Cowlitz and Lewis Rivers, and Abernathy Creek. While past effects from these programs are in our environmental baseline, future effects are included here. We expect reductions in effects on listed salmon and steelhead are likely to occur through changes in:

- Hatchery monitoring information and best available science,
- Times and locations of fish releases to reduce risks of competition and predation,
- Management of overlap in hatchery- and natural-origin spawners to meet gene flow objectives,
- Decreased use of isolated hatchery programs,
- Increased use of integrated hatchery programs for conservation purposes,
- Incorporation of new research results and improved best management practices for hatchery operations,
- Creation of wild fish only areas,
- Changes in the species propagated and released into streams and rivers and in hatchery production levels,
- Termination of programs,
- Increased use of marking of hatchery-origin fish,
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches.

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 2.4.1; also see Section 2.2.7).

Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. These actions may include changes in ocean policy and increases or decreases in the types of activities that currently occur, including changes in fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. These actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area; however, we anticipate these activities will be mindful of ESA-listed species and will perhaps be less harmful than would have otherwise occurred in the absence of the current body of scientific work that has been established for anadromous fish. In general, we think the level of adverse effects will be lower than those in the recent past, and much lower than those in the more distant past. NMFS anticipates that available scientific information will continue to grow and tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms that are likely to result in improvements in fish survival.

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 biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Lower River ESUs/DPSs

2.7.1.1 Lower Columbia River Chinook Salmon

NMFS' recent review affirmed the status of this ESU as threatened (NWFSC 2015). The recent status review (NWFSC 2015) concluded that there has been little change since the last status review (Ford 2011) in the biological status of Chinook salmon natural populations in the LCR Chinook Salmon ESU, though there are some positive trends. For example, increases in abundance were observed in about 70% of the fall-run populations, and decreases in the hatchery contribution were noted for several populations. The improved fall-run VSP scores reflect both changes in biological status and improved monitoring. However, the majority of the populations in this ESU remain at high risk, with low natural-origin abundance levels, especially the spring-run Chinook salmon population in this ESU (NWFSC 2015). Hatchery contributions remain high for a number of populations, especially in the Coast Fall MPG, and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, which contributes to the high risk. Moreover, hatchery produced fish still represent a majority of fish returning to the ESU even though hatchery production has been reduced (NWFSC 2015). Because spring-run Chinook salmon populations generally have low abundance levels due to hydroelectric dams cutting off access to essential spawning habitat, it is unlikely that there will be significant improvements in the status of the ESU until efforts to improve juvenile passage systems are in place and proven successful (NWFSC 2015).

The status of LCR Chinook salmon is also likely to be affected by climate changes. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Chinook Salmon ESU. Because of the location of the ESU in the LCR Basin, the ESU is likely to be more affected by climate related effects in the estuary. Because of their life history, the spring Chinook salmon populations in the ESU may be subject to additional affects from climate change to the stream ecosystems.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected LCR Chinook salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), fisheries, and hatcheries on LCR Chinook salmon. Regarding changes in hatchery effects to the LCR Chinook Salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a

genetic and ecological risk. The production level changes will reduce the pHOS, as described in Table 2-82, and reduce genetic and ecological risk.

- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Although all of the factors considered in the environmental baseline have contributed to the listing of the ESU, all have improved in the way they are managed and operated. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for loss in Bonneville Reservoir and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Fisheries affecting LCR Chinook salmon have been managed since 2012 using an abundance based exploitation rate matrix for the tule component of the ESU that applies to all ocean and inriver fisheries below Bonneville Dam. NMFS concluded in its 2012 biological opinion that fisheries managed as proposed were not likely to jeopardize the continued existence of the LCR Chinook Salmon ESU (NMFS 2012c). The proposed action considered in this opinion adopts the same management strategy that was analyzed in the 2012 PFMC biological opinion. The PFMC opinion therefore provides the substantive foundation for the review of the management strategy for LCR Chinook salmon.

The effect of fisheries managed under the 2018 Agreement are discussed in detail in Section 2.5.1.1. As discussed above, ocean and inriver fisheries will continue to be managed subject to provisions of the abundance based exploitation rate matrix for tule Chinook salmon and provisions and limits for the spring and bright populations considered in the 2012 biological opinion (NMFS 2012c). For consistency with Section 2.2.2.1, we will continue our review in this section by discussing harvest effects for the spring Chinook salmon MPGs, followed by the tule Chinook salmon MPGs, and finish with the bright Chinook salmon MPG.

Spring Chinook salmon MPGs

Harvest impacts to natural-origin LCR spring Chinook salmon populations, subject to the 2018 Agreement, are expected to be similar to those allowed for upriver spring Chinook salmon (see Table 2-89 for salmon stock definitions). Mark selective fisheries are used below Bonneville Dam during the spring season to limit impacts to natural-origin spring Chinook salmon. Impacts to the spring populations in the ESU in the winter, spring and summer seasons are low with an expected harvest rate ranging from 0.2-2.0%.

Three of the spring Chinook salmon populations in the Cascade MPG are supported by associated hatchery programs since dams currently block passage to most, if not all, of their historic spawning and rearing habitat. Therefore, the genetic legacies of the Upper Cowlitz, Tilton, and Lewis populations in the Cascade Spring MPG are still housed in hatchery programs. NMFS concluded in an earlier consultation (NMFS 2012c) that it is appropriate that harvest be managed to ensure that hatchery escapement goals are met, thus protecting what remains of the genetic legacy of the ESU until such time that future planning efforts can lay out a more comprehensive solution leading to recovery (NMFS 2012c). The proposed fisheries will not preclude meeting hatchery escapement goals for these programs. Because hatchery escapement goals have generally been met, NMFS does not anticipate a need for specific fishery management actions to protect the spring component of the LCR Chinook Salmon ESU in 2018 or for the duration of the 2018 Agreement. The recent escapement shortfall at the Lewis River hatchery is inconsistent with a pattern of escapements for other hatchery stocks in the LCR. However, NMFS does expect that the states of Washington and Oregon will continue to take appropriate actions through their usual authorities to ensure that the annual escapement goals are individually met by taking into account mainstem harvest and modifying mainstem fisheries downstream of each population's confluence with the mainstem Columbia River to account for hatchery escapement goals. NMFS will monitor escapements and trends and address more specific fishery management action in the future if necessary.

The proposed action will result in mortality of fish from all populations in the Cascade Spring MPG primarily as a result of catch-and-release or inadvertent retention during fisheries targeting hatchery surplus Chinook salmon returning to the Columbia River during the spring management period. Estimates for the expected harvest impacts are anticipated to be similar to recent years. The remaining populations in the Cascade MPG have seen increases in status during the last decade. The Sandy River population has met recovery-related abundance objectives and is expected to continue to do so under the proposed action. The Kalama population is designated as a contributing population and targeted for low persistence probability under the recovery scenario. The hatchery program in the Kalama River is managed to augment harvest in the lower river, but natural-origin spring Chinook salmon are being passed above the falls to utilize inaccessible, but otherwise suitable habitat in the upper basin. This is expected to improve the status of the population to meet the level targeted for the population. Less is known about the remaining spring Chinook salmon population, the Toutle population. The impact to the Toutle spring Chinook salmon population is likely low, at least in part, because empirically measurable reductions in harvest have occurred throughout the Cascade Spring MPG.

There are two additional spring populations in the Gorge MPG. Since there are currently no established spring Chinook salmon in the White Salmon River, none will be caught as a consequence of the proposed action. If spring Chinook salmon successfully recolonize the White Salmon and begin to produce natural-origin fish, a very low level of take may occur. Most of the habitat that was historically available to spring Chinook salmon in the Hood River is still accessible, but the basin was likely not highly productive for spring Chinook salmon due to the character of the basin. Because the Hood River population was considered extirpated or nearly so, recovery now relies on the success of a reintroduction program. The reintroduction program for Hood River spring Chinook salmon is using spring Chinook salmon from the Deschutes River which is the nearest source for brood stock, but is from the MCR ESU. Details related to the reintroduction program are described in the recovery plan (NMFS 2013e).

The proposed harvest rate of 2.0% for a tributary fishery directed at hatchery spring Chinook salmon in the Hood River, affecting only the Hood River population, is unchanged from recent historical levels. The recovery plan (NMFS 2013e) indicates that harvest does not appear to be a significant factor limiting the success of the reintroduction program and that current harvest levels are not an impediment to recovery of Hood River spring Chinook salmon. The proposed tributary harvest rates may not be consistent with achieving recovery goals once populations are reintroduced, habitat improvements are made, and the populations are no longer reliant on hatcheries for their continued survival. However, given the current reliance on the hatchery supplementation program for Hood River spring Chinook salmon and the lack of harvest on the currently-extirpated White Salmon population, NMFS concludes that the proposed fisheries are adequately protective of the Gorge Spring MPG populations.

The proposed harvest rates in mainstem fisheries are consistent with the recovery plan. However, it may become necessary necessary to revisit harvest management once spring Chinook salmon populations are reintroduced, habitat improvements are made, and the populations are no longer reliant on hatcheries for their continued survival. The recovery plan details that managing for harvest rates based on natural-origin spring Chinook salmon originating from the LCR Chinook salmon ESU requires first achieving higher levels of smolt survival in both the Lewis and Cowlitz Rivers that are currently dealing with tributary hydrosystem passage issues. Until that time, the recovery strategy is to maintain these populations in the hatchery system.

Tule Chinook salmon MPGs

LCR tule Chinook salmon are managed subject to an abundance rate schedule for a total ER that ranges from 30 to 41%. NMFS previously determined that the rate schedule for the tule populations and other provisions for the spring and bright life history components of the ESU were not likely to jeopardize the continued existence of the LCR Chinook Salmon ESU (NMFS 2012c). The harvest schedule applies to all ocean and inriver fisheries below Bonneville Dam. The 2018 Agreement proposes to continue adhering to the harvest schedule for fisheries downstream of Bonneville Dam that affect tule populations. This is a conscientious approach because while the inriver fisheries must annually work out sharing agreements with ocean fishery managers, continuing to limit fisheries to an ER that was previously found to not likely to jeopardize the continued existence of LCR Chinook Salmon ESU when the status of the ESU were lower than current is a careful approach, which ensures the recent gains that have been made in VSP scores in the past few years continue to accrue.

There are three additional populations in the Gorge MPG that are located above Bonneville Dam. These populations are subject to some additional harvest that occurs during fall season fisheries in the lower half of Bonneville pool. These circumstances were considered in both the recovery plan and 2012 biological opinion on the management strategy proposed (NMFS 2012c).
The recovery plan acknowledges the uncertainties related to populations in the Gorge MPG and, discussed in more detail in section 2.2.2.1, sought to address those uncertainties by putting greater emphasis on recovery of additional populations in the Cascade MPG. Therefore, in the context of the recovery strategy, mainstem fisheries upstream of Bonneville Dam are not likely to appreciably reduce the likelihood of survival and recovery of the LCR Chinook Salmon ESU. Even though these fisheries are not subject to the total ER limit management strategy, populations upstream of Bonneville Dam are not required in order to achieve delisting due to additional populations targeted for high viability below Bonneville Dam (NMFS 2012c).

Bright Chinook salmon MPGs

The North Fork Lewis and Sandy River populations are the only bright populations in the ESU. The current status for the North Fork Lewis population is listed as very high. The North Fork Lewis population is the principal indicator stock for management for this component of the ESU. It is a natural-origin population with little or no hatchery influence. The population is targeted for very high persistence probability in the recovery plan (Table 2-2). The escapement goal for management purposes is 5,700 and is based on estimates of the escapement needed to achieve maximum sustained yield (MSY). NMFS (2013e) also identified an abundance target for delisting of 7,300 (Table 2-2). The harvest rate on the bright component of the LCR ESU resulting from the proposed action is expected to range from 6.0 to 18.8%, similar to recent years (TAC 2017, Table 5.1.9). Escapements over the last 10 years averaged 12,400 (Table 2-9), thus exceeding both the MSY escapement goal and the delisting abundance goal for the North Fork Lewis population. The Sandy River population has averaged escapements of 600 over the same time frame (Table 2-9). Under the proposed action, it is reasonable to expect that escapement would continue to be above goals consistent with observations in recent years and the overall management objective.

Considering hatchery effects and related impacts across the entire ESU, for all components (spring, tule, and bright) these are likely to be reduced in the coming decade as stronger performance goals associated with requirements for Mitchell Act funded hatchery programs in the action area are required to reduce the risks of hatchery programs to natural-origin salmon and steelhead populations, including the LCR Chinook Salmon ESU, and primarily to the tule Chinook salmon MPGs (NMFS 2017j). NMFS (2017j) required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated. While the information presented above, at the beginning of Section 2.7.1.1, is a review of updated status information available, NMFS expects the prevalence of hatchery-origin Chinook salmon spawning contribution to decrease over the course of the 2018 Agreement due to the ITS limits and terms and conditions required by the Mitchell Act opinion (NMFS 2017j).

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS

2013e), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR Chinook salmon.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on LCR Chinook salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-4 through Table 2-9 take into account the anticipated effects of this harvest. NMFS also anticipates that human development activities that are included as part of cumulative effects will continue to have adverse effects on LCR Chinook salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the LCR Chinook Salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, tributary hydrosystem passage improvement completions, and site specific hatchery program ESA-reviews will contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in increased VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in abundance were observed in about 70% of the fall-run populations.

Decreases in the hatchery contribution were noted for several populations and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The improved fall-run VSP scores reflect changes in both biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the improved status of the LCR Chinook Salmon ESU. Abundance based management in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management, which is consistent with the strategy in the recovery plan (NMFS 2013e). Current harvest, while still an adverse effect, therefore will not appreciably reduce the likelihood of either ESU's survival, either short or long term, as evidenced by the increases in abundance. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. Given the current circumstances, the spring Chinook salmon component of this ESU are managed to achieve the hatchery escapement goals and thereby preserve the genetic heritage of the populations. This preservation of genetic heritage reduces the extinction risk of the populations, and acts as a safety valve for the eventual recovery of two primary populations until tributary passage is addressed. The tule Chinook salmon component of the ESU aligns future decisions about the rate of harvest with indicators of the abundance returning to the river mouth. This abundance based approach reduces harvest during years of low abundance and provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. The management of the bright component of the ESU is already achieving current levels of abundance that are exceeding their expected recovery scenario VSP criteria and we expect that to continue. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the ESU is difficult to determine with current data sources. What is clear for the large majority of populations in the LCR Chinook Salmon ESU is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. We also expect individual population productivity to improve in this ESU as a result of the ITS limits and terms and conditions required by the Mitchell Act opinion (NMFS 2017j). Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the LCR Chinook Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR Chinook salmon or appreciably reduce the value of designated critical habitat.

2.7.1.2 Lower Columbia River Coho Salmon ESU

NMFS' recent review affirmed the status of this ESU as threatened (NWFSC 2015). The lack of data, as well as poor data quality, has made it difficult to assess spatial structure and diversity VSP attributes for LCR coho salmon. Low abundance, past hatchery stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations (LCFRB 2010; ODFW 2010a). The low persistence probability and risk category for the majority of LCR coho salmon populations reported above is related to the loss of spatial structure and reduced diversity. Spatial structure of some coho salmon populations is constrained by migration barriers (i.e., tributary dams) and development of lowland areas (NMFS 2013g). Inadequate spawning survey coverage, along with the presence of unmarked hatchery-origin coho salmon mixing with natural-origin spawners, has also made it difficult to ascertain the spatial structure of natural-origin populations. The mass-marking of hatchery-origin fish and more extensive spawning surveys have provided better information regarding species status recently (NWFSC 2015).

There is less information available for the Gorge MPG populations. Table 2-14 and Table 2-15 provide estimates of escapement for Oregon and Washington tributaries that make up the Lower Gorge population. It is not clear how comprehensive the surveys are or if the estimates are intended to represent all escapement. In Washington at least the numbers are characterized as estimates for index areas which suggest that they are incomplete. The information, although limited, indicates there are a several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are relatively low. The sum of natural-origin escapement to the Lower Gorge tributaries (Table 2-14 and Table 2-15) has averaged 944 since 2010, which is half of the recovery abundance target (Table 2-13) and well above the critical abundance threshold of 300 set for primary populations.

Table 2-14 provides estimates of escapement for the Upper Gorge Oregon-side population but is limited to Hood River and does not include returns to other Oregon-side tributaries. Table 2-15 provides a limited set of information for the Upper Gorge Washington-side population but these estimates are limited to the Wind River. The Big White Salmon River is the largest tributary on the Washington side of the Upper Gorge MPG. Coho in the Big White Salmon were extirpated by Condit Dam that was built in 1913. Condit Dam was removed in 2012 freeing up 21 miles of new habitat above the dam location. The recovery plan for the Big White Salmon calls for a period of passive reintroduction following dam removal, a process that is currently underway. Unfortunately funding for spawning surveys has been limited and prioritized to look for Chinook salmon. As a consequence, there is no recent information on coho abundance in the Big White Salmon.

The 2015 status review (NWFSC 2015) concluded that the LCR Coho Salmon ESU is still at very high risk. A total of 6 of the 23 populations in the ESU are at or near their recovery viability goals (Figure 69 in NWFSC 2015), although under the recovery plan scenario these populations had less ambitious goals designated as moderate risk. The remaining populations require a higher level of viability (NWFSC 2015) and therefore still require substantial improvements. Best available information indicates that the LCR Coho Salmon ESU is at high risk and remains at threatened status.

The status of LCR coho salmon is also likely to be affected by climate changes. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Coho Salmon ESU. Because of the location of the ESU in the LCR Basin, the ESU is likely to be more affected by climate related effects in the estuary. Because of their life-history, coho salmon smolts spend a year in the freshwater rearing environment, the ESU may be subject to additional affects from climate change to the stream ecosystems.

The environmental baseline provides for a broad range of past and present actions and activities that have affected LCR coho salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on LCR coho salmon. Regarding changes in hatchery effects to the LCR Coho Salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production level changes will reduce the pHOS, as described in Table 2-83, and reduce genetic and ecological risk.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Fisheries affecting LCR coho salmon have been managed since 2015 using an abundance based exploitation rate matrix that applies to all ocean and inriver fisheries below Bonneville Dam. NMFS concluded in its 2015 biological opinion that fisheries adhering to the management strategy represented in the harvest matrix were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (NMFS 2015b). The proposed action considered in this opinion adopts the same management strategy that was analyzed in the 2015 PFMC biological opinion. The PFMC opinion therefore provides the substantive foundation for the review of the harvest management strategy for LCR coho salmon.

Although all of the factors considered in the environmental baseline have contributed to the listing of the ESU, all have improved in the way they are managed and operated since 2015. Reductions in overall harvest rates for all marine area fisheries and freshwater fisheries up to Bonneville Dam, averaging from exploitation rates of 80% from 1970-1983, down to 49% from 1984-1993, 10% from 1994-2007, and 7% from 2008-2014, in combination with reductions in basin-wide hatchery releases, habitat improvement and other all-H benefits, has contributed to the survival and recovery of Gorge MPG populations as evidenced by the apparent improvement in status since the last status review (NMFS 2015b). In particular, moving to an abundance based harvest management strategy that has been in place since 2008 (with an average exploitation rate of 16%) appears to be consistent with maintaining and even increasing recovery trajectories for Gorge MPG populations. The improvement is most evident for the Lower Gorge population. Escapement information for the Upper Gorge populations is limited and our sense that the status of the populations is improving must be inferred largely from the evidence available for other populations in the ESU. WDFW and ODFW will continue to collect status information for all LCR coho salmon populations. This information will be periodically reviewed in the future to confirm our assessment that the implementation of the harvest matrix is not reversing the positive recovery trends recently observed for these populations. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for losses in Bonneville Reservoir and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

The effect of fisheries managed under the 2018 Agreement on LCR coho salmon populations are discussed in detail in Section 2.5.1.1. Ocean and inriver fisheries, including those subject to the proposed 2018 Agreement, will be managed subject to provisions of the abundance based exploitation rate matrix for LCR coho salmon that were considered in the 2015 biological opinion (NMFS 2015b). Additional provisions in the 2018 Agreement apply to unlisted upriver coho stocks. Impacts to natural-origin LCR coho salmon populations for inriver fisheries are expected to be similar to those observed in recent years ranging from 13.3 to 24.3% (TAC 2017, Table 5.1.11).

The 2018 Agreement proposes to continue adhering to the harvest schedule for fisheries downstream of Bonneville Dam that affect populations downstream of Bonneville Dam for a total ER that ranges from 10 to 30%. The harvest schedule would apply to all ocean and inriver fisheries below Bonneville Dam, and annually managers responsible for in-river fisheries propose to take NMFS' guidance, along with the yearly biological opinion on the PFMC fisheries, into account when planning the 2018-2027 in-river fishery seasons. This is a conscientious approach because while the inriver fisheries must annually work out sharing agreements with ocean fishery managers, continuing to limit fisheries to an ER that was previously found to not likely to jeopardize the continued existence of LCR Coho Salmon ESU (NMFS 2015b) when the status of the ESU was lower than current is a careful approach, which ensures the recent gains that have been made in VSP scores in the past few years continue to accrue.

Some additional harvest occurs in fisheries above Bonneville Dam, in the Bonneville Pool, that may affect the three Gorge MPG coho salmon populations. The LCR recovery plan (NMFS 2013e) identified the Hood population as problematic in terms of ability to recover, but called for additional research and monitoring before prescribing harvest rates based on the needs of this population. The Lower Gorge population includes several small tributaries located on the Washington and Oregon side below Bonneville Dam. There are two populations in the Upper Gorge. On the Washington side the Upper Gorge population includes fish returning to the Big White Salmon, Little White Salmon and Wind Rivers, and Spring Creek. On the Oregon side the

Upper Gorge population includes Hood River and several small tributaries (McElhany et al. 2006).

The two Upper Gorge populations are subject to some additional harvest in Zone 6 fisheries above Bonneville Dam. Coho salmon are not specifically targeted in fall season mainstem fisheries. No change in recent years' mainstem coho salmon fisheries is expected during 2018-2027. The take of LCR coho salmon in treaty Indian fisheries above Bonneville Dam as measured against the number of coho that pass Bonneville Dam ranges from 0.8 to 3.5%. This is not equivalent to a harvest rate on the LCR Coho Salmon ESU, as many of the upriver coho (see Table 2-89 for a definition of the upriver coho) passing Bonneville Dam are non-ESA-listed coho that are part of reintroduction efforts located upstream of LCR Coho Salmon ESU geographical boundary. Moreover, the Upper Gorge/Hood River population is early timed so the fish begin entering the tributaries by early September. As a consequence, the Oregon side population has likely largely cleared the Bonneville Pool prior to the peak of the fall season tribal coho fisheries and so are likely subject to relatively little harvest in Bonneville Pool. Upper Gorge/White Salmon population is late timed and is presumably present during the peak of the tribal fisheries. However, these harvest apply to all of Bonneville Pool. The Big White Salmon and Hood River mark the upstream boundary of the ESU and are located about midway in the pool. For these reasons harvest rates likely overestimate the actual impact to the Upper Gorge populations, and are therefore a conservative estimate for possible LCR coho salmon populations subject to harvest upstream of Bonneville Dam.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS 2013e), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR coho salmon.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on LCR coho salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-14 and Table 2-15 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on LCR coho salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the LCR Coho Salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in increased VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in abundance, to where a population had greater than 500 natural-origin spawners for more than four years, were observed in over 48% of the populations since 2008. Prior to 2008 this only occurred in 10% of the populations. This indicates the framework of the proposed action appears to be consistent with maintaining and even increasing recovery trajectories for LCR coho salmon populations at the ESU level. Decreases in the hatchery contribution were noted for several populations and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The improved VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the improved status of the LCR Coho Salmon ESU. Abundance based management in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management, which is consistent with the strategy in the recovery plan (NMFS 2013e). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this ESU in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. Given the current circumstances, future decisions about the rate of harvest affecting the MPGs of this ESU below Bonneville Dam align with indicators of their abundance when returning to the river mouth. This abundance based approach reduces harvest during years of low abundance and provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. The management of the MPG upstream of Bonneville Dam will be fixed at a low rate relative to the number of coho that pass Bonneville Dam, which will also decrease in years of lower returns. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the ESU is difficult to determine with current data sources. What is clear for all populations in the LCR Coho Salmon ESU is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. We also expect individual population productivity to improve in this ESU as a result of the ITS limits and terms and conditions required by the Mitchell Act opinion (NMFS 2017j). Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the LCR Coho Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR coho salmon or appreciably reduce the value of designated critical habitat.

2.7.1.3 Upper Willamette River Chinook Salmon ESU

NMFS' recent review affirmed the status of this ESU as threatened (NWFSC 2015). According to the most recent status review (NWFSC 2015), abundance levels for five of the seven natural populations in this ESU remain well below their recovery goals. Of these, the Calapooia River population may be functionally extinct, and the Molalla River population remains critically low (although perhaps only marginally better than the 0 VSP score estimated in the Recovery Plan). Abundances, in terms of adult returns, in the North and South Santiam Rivers have risen since the last review (Ford 2011), but still range only in the high hundreds of fish. Improvements in the status of the MF Willamette River population relates solely to the return of natural-origin adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the MF Willamette River individual population. The status review incorporates valuable information from the Fall Creek program that is relevant to the use of reservoir drawdowns as a method of juvenile downstream passage. The proportion of natural-origin spawners has improved in the North and South Santiam Basins, but is still below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production there. Additionally, the Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but both individual populations have experienced declines in abundance[24] (NWFSC 2015). Furthermore, limited data are available for natural-origin spawner abundance for UWR Chinook salmon populations.

Table 2-21 includes the most up-to-date available data for natural-origin Chinook salmon spawner estimates from UWR subbasins. The McKenzie subbasin has the largest amounts of

[24] Spring-run Chinook salmon counts on the Clackamas River are taken at North Fork Dam, where only unmarked fish are passed above the Dam presently. A small percentage of these unmarked fish are of hatchery-origin. While there is some spawning below the Dam, it is not clear whether any progeny from the downstream redds contribute to escapement.

natural-origin Chinook salmon spawners compared to the other surveyed subbasins. Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. The overview above for UWR Chinook salmon populations suggests that there has been relatively little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk (Table 2-22) (NWFSC 2015).

The status of UWR Chinook salmon is also likely to be affected by climate changes. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UWR Chinook Salmon ESU. Because of the location of the ESU in the LCR Basin, the ESU is likely to be more affected by climate related effects in the estuary. Because of their life history, spring Chinook salmon smolts spend a year in the freshwater rearing environment, the ESU may be subject to additional affects from climate change to the stream ecosystems.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected UWR Chinook salmon and contributed to their current status. The environmental baseline analysis considers the effects of changes in habitat (both beneficial and adverse), fisheries, and hatcheries on UWR Chinook salmon. Regarding changes in hatchery effects to the UWR Chinook Salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a

genetic and ecological risk. The production level changes will reduce the pHOS, as described in Table 2-82, and reduce genetic and ecological risk.

- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Although all of the factors considered in the environmental baseline have contributed to the listing of the ESU, all have improved in the way they are managed and operated.

Operation of the Willamette Project has been determined to jeopardize UWR Chinook salmon and steelhead (NMFS 2008c). Where these projects are located, the flood control structures block or delay adult fish passage to the most important holding and spawning habitat for UWR Chinook salmon. The effects to UWR Chinook salmon resulting from the continued existence and operation of this project are embedded in the limiting factors that face these species, and is only recently being addressed through implementation of the RPA. Improvements to passage, habitat and hatchery operations is expected to generate important benefits for listed species, and we expect implementation will continue to move forward. To date, those benefits have not led to significant improvements to UWR Chinook salmon though NMFS remains confident that continued implementation and the time necessary for the species to respond to improvements will lead to positive results. The Willamette Project will continue to interact with habitat, including passage, in ways that fundamentally impact the species' survival, as described above in the baseline and in the Opinion for the Willamette Project. These effects are not meaningfully exacerbated by the harvest that results from the proposed action.

As discussed in Section 2.5.1.1 of this opinion, the effect of freshwater fisheries on UWR Chinook salmon, including those being proposed under the 2018 Agreement, were considered previously through an ESA evaluation, pursuant Section 4(d), of an FMEP from the state of Oregon (NMFS 2001c). Because provisions of the FMEP are fully incorporated into the 2018 Agreement the anticipated harvest rate on UWR spring Chinook salmon in the proposed mainstem Columbia River fisheries in 2018-2027 ranges from 5-11%, and will not exceed an overall combined harvest rate of 15% from all freshwater fisheries combined. NMFS has previously determined that Section 9 take prohibitions do not apply to the proposed fisheries, so long as the limits imposed in the previously submitted FMEP remain in place (NMFS 2001c). NMFS concluded previously that managing UWR spring Chinook salmon according to the provisions of the FMEP is not likely to jeopardize the continued existence of the ESU (NMFS 2001c). That opinion provides the substantive foundation for the review of the management strategy for UWR Chinook salmon pertaining to fisheries managed subject to the proposed 2018 Agreement. The 2018 Agreement proposes to continue adhering to these limits for harvest effect to UWR Chinook salmon. This is a conscientious approach because limiting fisheries to a rate that was previously found to not likely to jeopardize the continued existence when the status of the ESU was lower than current is a careful approach, which ensures the recent gains that have been made in VSP scores in the past years continue to accrue.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS and ODFW 2011), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UWR Chinook salmon.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on UWR Chinook salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2015 average escapement levels reported in Table 2-21 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on UWR Chinook salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the UWR Chinook Salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, partial implementation of the Willamette Project RPA, and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in increased VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in both the North and South Santiam populations have doubled in average abundance since 2008. While the McKenzie River population has not seen a comparable increase in abundance it still has an average spawning population of over 1,400 and exhibits a strong overall VSP score of three compared to a delisting scenario score requirement of four. This information indicates the framework of the proposed action appears to be consistent with maintaining and even increasing recovery trajectories for UWR Chinook salmon populations at the ESU level. Decreases in the hatchery contribution were noted for several populations and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The improved VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline in habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the improved status of the UWR Chinook Salmon ESU. The proposed action proposes to continue harvest management consistent with recovery plan expectations (NMFS and ODFW 2011). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this ESU in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. Given the current circumstances, the management of this ESU will be fixed at a low rate relative to the number of fish that are annually forecast to the return to the Columbia River, which will decrease the number harvested in years of lower returns. This approach constrains harvest management relative to the annual return of fish and is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is relatively low each year. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the ESU is difficult to determine with current data sources. What is clear for the majority of populations in the UWR Chinook Salmon ESU is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the UWR Chinook Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UWR Chinook salmon or appreciably reduce the value of designated critical habitat.

2.7.1.4 Upper Willamette River Steelhead DPS

NMFS' recent review affirmed the status of this DPS as threatened (NWFSC 2015). Since the 2005 status review, UWR steelhead initially increased in abundance but subsequently declined and current abundance is at the levels observed in the mid-1990s when the DPS was first listed. The DPS appears to be at lower risk than the UWR Chinook Salmon ESU, but continues to demonstrate the overall low abundance pattern that was of concern during the 2005 status review (Table 2-25). The elimination of winter steelhead hatchery releases in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity. In 2011 and 2015, a five-year review for the UWR steelhead concluded that the species should maintain its threatened listing classification (Ford 2011; NWFSC 2015).

The status of UWR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UWR Steelhead DPS. Because of the location of the DPS in the LCR Basin, the DPS is likely to be more affected by climate related effects in the estuary. Because of their life history, steelhead smolts spend a year in the freshwater rearing environment, the DPS may be subject to additional affects from climate change to the stream ecosystems.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected UWR steelhead and contributed to their current status. The environmental baseline analysis considers the effects of changes in habitat (both beneficial and adverse), fisheries, and hatcheries on UWR steelhead. Regarding changes in hatchery effects to the UWR Steelhead DPS, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Elimination of the release of Chambers Creek steelhead, a hatchery stock that does not originate from within the Columbia River Basin.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Harvest management for steelhead in the Columbia River Basin is more complex than that for other listed ESUs. For most listed species an outcome of NMFS' section 7 consultation process is a harvest rate limit that is specific to the ESU (e.g., Snake River fall-run Chinook salmon or Snake River sockeye salmon) or even a component of the ESU (e.g., LRH rate limit as a surrogate for LCR Chinook tule salmon stocks). Because of the complexity of steelhead biology and limitations on our ability to assess DPS-specific impacts, harvest limitations on steelhead are expressed in terms of other identifiable stock groups during particular seasons of the year.

Given these circumstances, fisheries have evolved and our ESA consultation standards have developed to focus management on identifiable stock groups during particular seasons that are considered "limiting" in the sense that they are weak stocks in need of protection. Winter, spring, and summer season fisheries (January 1- July 31) are managed as a block that is distinct from fall season fisheries (August 1 – December 31). For species other than steelhead, separation by season works in the sense that impacts occur either in one season or the other. For steelhead, run timing overlaps the seasons and there are no convenient breakpoints. The primary management constraint in non-treaty winter and spring fisheries are winter run steelhead, represented by the winter steelhead stock (see Table 2-89 for stock definitions) that return primarily to the area below Bonneville Dam.

Through the course of past consultations NMFS has considered previous efforts to reduce the level of harvest in both non-treaty and treaty Indian fisheries. The most significant management actions in non-treaty fisheries related to steelhead occurred 40 years ago. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Prior to efforts during the last few years to promote commercial selective fisheries, time, area, and gear restrictions limit handling and mortality of winter steelhead by the non-treaty fishery to less than 2% of the run. In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries. Although all of the factors considered in the environmental baseline have contributed to the listing of the DPS, all have improved in the way they are managed and operated.

Operation of the Willamette Project has been determined to jeopardize UWR Chinook salmon and steelhead (NMFS 2008c). Where these projects are located, the flood control structures block or delay adult fish passage to the most important holding and spawning habitat for UWR steelhead. The effects to UWR steelhead resulting from the continued existence and operation of this project are embedded in the limiting factors that face these species, and is only recently being addressed through implementation of the RPA. Improvements to passage, habitat and hatchery operations is expected to generate important benefits for listed species, and we expect implementation will continue to move forward. To date, those benefits have not led to significant improvements to UWR steelhead though NMFS remains confident that continued implementation and the time necessary for the species to respond to improvements will lead to positive results. The Willamette Project will continue to interact with habitat, including passage, in ways that fundamentally impact the species' survival, as described above in the baseline and in the Opinion for the Willamette Project. These effects are not meaningfully exacerbated by the harvest that results from the proposed action.

As discussed in Section 2.5.1.1 of this opinion, the effect of freshwater fisheries on UWR steelhead, including those being proposed under the 2018 Agreement, were considered previously through an ESA evaluation, pursuant Section 4(d), of an FMEP from the state of Oregon (NMFS 2003b). Because provisions of the FMEP are fully incorporated into the 2018 Agreement, the anticipated harvest rate on UWR steelhead in the proposed mainstem Columbia River fisheries in 2018-2027 ranges from 0.2-1.0%. NMFS has previously determined that Section 9 take prohibitions do not apply to the proposed fisheries, so long as the limits imposed in the previously submitted FMEP remain in place (NMFS 2003b).

NMFS concluded previously that managing UWR steelhead according to the provisions of the FMEP is not likely to jeopardize the continued existence of the ESU (NMFS 2003b). That opinion therefore provides the substantive foundation for the review of the harvest management strategy for fisheries managed subject to the proposed 2018 Agreement. The 2018 Agreement proposes to continue adhering to these limits for harvest effect to UWR steelhead. This would be an aggregate of all non-treaty harvest in mainstem Columbia River freshwater fisheries capped at an annual harvest rate for all winter steelhead DPSs at no more than 2%. Winter management period Tribal fisheries are all located above Bonneville Dam and therefore would not affect UWR steelhead populations given their geographic location.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS and ODFW 2011), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UWR steelhead.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on UWR steelhead. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution.

While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2015 average escapement levels reviewed in Section 2.2.2.4 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on UWR steelhead in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the UWR Steelhead DPS will continue to accrue. The benefits from completed habitat restoration projects, and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this DPS. These changes in factors that were prior limitations on VSP criteria for this DPS are now resulting in reversing a downward trend in abundance from 2005 through 2009 and stabilized VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. At the time of NMFS recent status review (NWFSC 2015), this DPS appeared to be at lower risk than the UWR Chinook Salmon ESU. This information indicates the framework of the proposed action appears to be consistent with maintaining recovery trajectories for UWR steelhead populations at the DPS level. Decreases in the hatchery contribution were noted for several populations and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. Improvement to the environmental baseline in habitat restoration coupled with significant harvest reductions from historic levels, are positive actions for progress in rebuilding the UWR Steelhead DPS. Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this DPS in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action’s response to climate change is precautionary. Given the current circumstances, the management of this DPS will be fixed at a low rate relative to the number of fish that are annually forecast to the return to the Columbia River, which will decrease the number harvested in years of lower returns. The harvest in mainstem Columbia River freshwater fisheries is capped at an annual harvest rate for all winter steelhead DPSs at no more than 2%.

Although fisheries are managed subject to a consistently low fixed harvest rate, the allowable catch varies with run size and is therefore responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance, although overall, the limit is very low every year as it's capped at just 2%.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the DPS's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the DPS is difficult to determine with current data sources. It is clear that population abundance in the UWR Steelhead DPS rose in 2010 reversing the decline occurring from 2005-2009. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the UWR Steelhead DPS given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the DPS, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this DPS for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UWR steelhead or appreciably reduce the value of designated critical habitat.

2.7.1.5 Lower Columbia River Steelhead DPS

NMFS' recent review affirmed the status of this DPS as threatened (NWFSC 2015). The most recent status review (NWFSC 2015) concluded that the majority of winter and summer steelhead populations continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to the prior review in

2011. The decline in the Wind River summer population is a concern, given that this population has been considered one of the healthiest of the summer populations; however, the most recent abundance estimates suggest that the decline was a single year aberration. Efforts to provide passage above dams in the North Fork Lewis River offer the opportunity for substantial improvements in the winter steelhead population and the only opportunity to re-establish the summer steelhead population. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015).

The status of LCR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Steelhead DPS. Because of the location of the DPS in the LCR Basin, the DPS is likely to be more affected by climate related effects in the estuary. Because of their life history, steelhead smolts spend a year in the freshwater rearing environment, the DPS may be subject to additional affects from climate change to the stream ecosystems.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected LCR steelhead and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on LCR steelhead. Regarding changes in hatchery effects to the LCR Steelhead DPS, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including the following:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there

have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production level changes will reduce the pHOS, as described in Table 2-84, and reduce genetic and ecological risk.

- Elimination of the release of Chambers Creek steelhead, a hatchery stock that does not originate from within the Columbia River Basin. This change will reduce genetic risk to the ESA-listed LCR steelhead DPS.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Although all the factors considered in the environmental baseline have contributed to the listing of the DPS, all have improved in the way they are managed and operated. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for losses in Bonneville Reservoir and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Harvest management for steelhead in the Columbia River Basin is more complex than that for other listed ESUs. For most listed species an outcome of NMFS' section 7 consultation process is a harvest rate limit that is specific to the ESU (e.g., Snake River fall-run Chinook salmon or Snake River sockeye salmon) or even a component of the ESU (e.g., LRH rate limit as a surrogate for LCR Chinook tule salmon stocks). Because of the complexity of steelhead biology and limitations on our ability to assess DPS-specific impacts, harvest limitations on steelhead are expressed in terms of other identifiable stock groups during particular seasons of the year.

There are five listed steelhead DPSs in the Columbia River Basin, which range from the lower river to the upper reaches of the Snake and Columbia rivers. Steelhead have either winter or summer run timing. Among the summer run steelhead, there are A-Index and B-Index populations that have different age, size, and run timing characteristics. One DPS has only winter run populations, two have both winter and summer run populations, and two more have only summer run populations. Management is further complicated by the fact that steelhead have protracted and overlapping run timing characteristics, which greatly limits our ability to assign fish caught in mixed stock fisheries to a particular DPS.

Through the course of past consultations NMFS has considered previous efforts to reduce the level of harvest in both non-treaty and treaty Indian fisheries. The most significant management actions in non-treaty fisheries related to steelhead occurred 40 years ago. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Prior to efforts during the last few years to promote commercial selective fisheries, time, area, and gear restrictions limit handling and mortality of steelhead by the non-treaty fishery to less than 2% of the run. In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries.

Given these circumstances, fisheries have evolved and our ESA consultation standards have developed to focus management on identifiable stock groups during particular seasons that are considered “limiting” in the sense that they are weak stocks in need of protection. Winter, spring, and summer season fisheries (January 1- July 31) are managed as a block that is distinct from fall season fisheries (August 1 – December 31). For species other than steelhead, separation by season works in the sense that impacts occur either in one season or the other. For steelhead, run timing overlaps the seasons and there are no convenient breakpoints. The primary management constraint in non-treaty winter and spring fisheries are winter run steelhead, represented by the winter steelhead stock (see Table 2-89 for stock definitions) that return primarily to the area below Bonneville Dam. Non-treaty fisheries during the late spring and summer are relatively limited, but do have some impacts on summer run steelhead, as LCR steelhead are represented by the Skamania stock. As a consequence, non-treaty winter, spring, and summer season fisheries are also subject to a 2% harvest rate limit on natural-origin summer run Skamania steelhead, both above and below Bonneville Dam. Actual harvest rates have generally been substantially less than these summer run harvest rate limits, as evidenced by the yearly incidental catch of Skamania steelhead in non-treaty fisheries has averaging 0.5% on the unclipped portion of the stock below Bonneville Dam and 0.04% on the unclipped portion of the stock above Bonneville Dam since 2008 (TAC 2017, Table 3.3.16). By the fall season, winter steelhead have cleared. The incidental catch of unclipped winter steelhead in non-treaty fisheries has averaged 0.6% since 2008 (TAC 2017, Table 3.3.2).

Tribal fisheries are all located above Bonneville Dam. There are only a few winter run steelhead populations located above Bonneville Dam and few tribal mainstem fisheries until later in the spring after winter steelhead populations have cleared. As a consequence, there are no specific mainstem constraints on winter run steelhead in tribal fisheries and the focus is on limiting impacts on summer run steelhead during the fall season, when most mainstem fishing occurs. As discussed in more detail further down in this document, the primary ESA-related limit to mainstem treaty tribal fisheries is the harvest rate limits on B-Index steelhead.

There are no specific incidental harvest rate limits for treaty fisheries on the LCR Steelhead DPS (TAC 2017). The expected incidental harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with proposed treaty tribal fisheries is the same as the range observed in earlier years (TAC 2017, Table 5.1.13) ranging from 1.4% to 6.9% for the winter component and 4.6% to 12.9% on the summer component. However, the expected incidental harvest impacts on the winter-run and summer-run components of the LCR Steelhead DPS associated with proposed treaty fisheries are expected to be less. The harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville Pool from 2008 to 2017 averaged 0.5% and ranged from 0.1% to 1.4% (TAC 2017, Table 3.3.12). The harvest rate for treaty fisheries on the unclipped Skamania stock in the Bonneville Pool from 2008 to 2017 averaged 1.98% and ranged from 0.2% to 3.9% (TAC 2017.3.13). Incidental harvest rates for winter and Skamania stocks associated with proposed treaty fisheries are not expected to change over the course of the 2018 Agreement (TAC 2017).

The harvest rate limits proposed for treaty tributary fisheries affecting LCR steelhead are: Wind River - a 3-year rolling average of 3.25% and Hood River - 3-year rolling average of 3.0%. The limit is a conservative approach to management because it is responsive to restricting tributary fisheries to lower numbers of fish harvested during years of low returns. Rather than fixing the limit to a static number of fish each year, fisheries will instead limit their impact relative to the size of each specific year's return, including prior performance from the previous two years. The prior two years' harvest rates would be added to the current year's expected harvest rate to calculate the 3-year rolling average. If fisheries achieved harvest rates slightly above the 3.0% in the first or second year of the calculation, then the third year they are expected to be planned more conservatively to meet the limit. Because steelhead life history exhibits a 3-year age structure this strategy is mindful for protecting an entire broodyear of fish (meaning that in any given year, the steelhead that return are different ages of fish from the previous three years of spawning events). Proposed harvest rates on the populations are expected to be unchanged from recent historical levels as seen in Section 2.4.5.3. Escapement information for these populations is limited but our judgment is that the status of the populations is improving, and has improved from 2008, and given the proposed fisheries and associated limits are not going to deviate from historical levels that allowed the status of these populations to increase, along with the limit being adjusted to be more responsive in years of low returns, indicates this approach is contributing to the survival and recovery of these LCR steelhead populations.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS 2013e), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for LCR steelhead.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on LCR steelhead. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2015 average escapement levels reviewed in Table 2-31 through Table 2-35 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on LCR steelhead in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the LCR Steelhead DPS will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this DPS. These changes in factors that were prior limitations on VSP criteria for this DPS are now resulting in stable VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in abundance were observed in three of the four summer steelhead populations from 2008-2016 (an average of a 38% increase from the previous 10-year period), and increases or stable spawning abundances over the same time period occurred in 70% of the winter-run populations. Decreases in the hatchery contribution for several populations are already occurring, and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the current status of the LCR Steelhead DPS. The proposed action proposes to continue harvest management consistent with recovery plan expectations (NMFS 2013e). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this DPS in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. In most cases, the proposed action addresses considerations related to the cumulative effect of climate change by aligning future decisions about the rate of harvest with indicators of the abundance returning to the river mouth or Bonneville Dam. LCR steelhead are managed based on the annual forecast of fish at the river mouth and the number expected to cross Bonneville Dam. As reviewed above, harvest in mainstem Columbia River freshwater fisheries is capped at an annual harvest rate for all winter steelhead DPSs at no more than 2%. Additionally, a 2% harvest rate cap is placed on the lower river and upriver Skamania stocks. These three stocks represent the winter component, and the summer component, both below and above Bonneville Dam, of the LCR Steelhead DPS. Where the proposed action deals with treaty Indian tributary harvest management, reviewed above, the approach is mindful of climate change by implementing harvest strategies, in this case a 3-year rolling average, which are reactive to fluctuating size of returns, whatever their cause may be, that are also respectful to the age structure of the population. Harvest management is thereby responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the DPS is difficult to determine with current data sources. What is clear for the majority of populations in the LCR Steelhead DPS is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. We also expect individual population productivity to improve in this DPS as a result of the ITS limits and terms and conditions required by the Mitchell Act opinion (NMFS 2017j) which terminated out-of-DPS releases of hatchery steelhead inside this DPS's geographic range. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the LCR Steelhead DPS given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the DPS, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this DPS for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR steelhead or appreciably reduce the value of designated critical habitat.

2.7.1.6 Columbia River Chum Salmon ESU

NMFS' recent review affirmed the status of this ESU as threatened (NWFSC 2015). The most recent status review (NWFSC 2015) concluded that only 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these three populations are those that have very low recovery goals of 0 (Table 2-42). The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of natural populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (NWFSC 2015).

The status of Columbia River chum salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations). As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the Columbia River Chum Salmon ESU. Because of the location and life history of the ESU in the LCR Basin, the ESU is likely to be more affected by climate related effects in the estuary.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected Columbia River chum salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on Columbia River chum salmon. Regarding changes in hatchery effects to Columbia River chum salmon, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017j). As a result, several additional reform measures have been implemented including changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs and upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Although all of the factors considered in the environmental baseline have contributed to the listing of the ESU, all have improved in the way they are managed and operated. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations).

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Chum salmon are not caught in winter, spring, and summer fisheries, or during tribal fall fisheries above Bonneville Dam. Chum are caught occasionally in non-treaty fall season fisheries below Bonneville Dam. There are no fisheries targeted at hatchery or natural-origin chum as they are required to be released in all fisheries. There are also no chum hatchery production programs in the Columbia Basin except for those designed to supplement natural production. The later fall return timing of chum is such that they are vulnerable to relatively little potential harvest in fisheries that target primarily Chinook and coho salmon. Chum salmon are rarely attracted by the kinds of recreational gear that is used to target other species in the Columbia River.

Harvest rates are difficult to estimate since we do not have good estimates of total run size and retention in fisheries are through inadvertent retention due to misidentification. Spawning surveys focus on index areas and so provide estimates for only a portion of the run. However, the incidental catch of chum amounts to a few 10's of fish per year. The harvest rate for proposed state fisheries in the lower river is estimated to be 1.6% (TAC 2017, Table 5.1.11) per year and is almost certainly less than 5%.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS 2013e), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Columbia River chum salmon.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on Columbia River chum salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2015 average escapement levels reviewed in Table 2-40 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on Columbia River chum salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the Columbia River Chum Salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage and mainstem spawning improvements and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in increased VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in abundance were generally over 20% in multiple populations since 2008 and the remaining populations were stable in maintaining their spawning population. This indicates the framework of the proposed action is consistent with maintaining and even increasing recovery trajectories for Columbia River chum salmon populations at the ESU level. Hatchery contribution for several populations is currently high, but this is planned as part of the recovery strategy to reintroduce chum salmon into areas current devoid and are the result of recently completed site specific hatchery program ESA-reviews. Overall, the improved VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the improved status of the Columbia River Chum Salmon ESU. The proposed action proposes to continue harvest management consistent with recovery plan expectations (NMFS 2013e). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this ESU in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action’s response to climate change is precautionary. The incidental harvest in mainstem Columbia River freshwater fisheries is capped at an annual harvest rate for all chum at no more than 5%, but no fisheries are opened that target chum salmon even though their abundance has steadily been increasing. Fixing harvest management to a percent of the return rather than a fixed number of fish is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance, although overall, the limit is very low every year as it's capped at just 5%. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the ESU is difficult to determine with current data sources. What is clear for the populations we currently have data for in the Columbia River Chum Salmon ESU is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. We expect productivity and spatial expansion of chum salmon to occur as their general abundance increases result in colonization of areas currently devoid or lacking chum salmon. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the Columbia River Chum Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of Columbia River chum salmon or appreciably reduce the value of designated critical habitat.

2.7.2 Middle River ESUs/DPSs

2.7.2.1 Middle Columbia River Steelhead DPS

NMFS' recent review affirmed the status of this DPS as threatened (NWFSC 2015). Table 2-45 shows the most recent abundance, productivity, spatial structure, and diversity metrics for the 17 populations in the DPS. Overall viability ratings for the populations in the MCR Steelhead DPS remained generally unchanged from the prior five year review (NWFSC 2015). One population, Fifteen Mile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its ICTRT minimum abundance threshold. The Toppenish River population (in the Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the 5% viability curve, and, therefore, its overall rating remained as viable (NWFSC 2015). The majority of the populations showed increases in estimates of productivity (NWFSC 2015). Productivity of the DPS saw overall improvement with 10 populations improving, and while productivity in two populations decreased or remain unchanged (the North Fork John Day and Umatilla populations respectively), these same populations experienced increased abundances (Table 2-47). Only two populations experienced decreases in both VSP criteria during the last status review (the Toppenish and Lower John Day populations (Table 2-47)). The spatial structure ratings for all five natural populations in the John Day River MPG remains at low or very low risk based on updated spawner distribution data in the current status review. Habitat conditions, believed to limit life history and phenotypic diversity, remain relatively unchanged. Hatchery straying and occurrence on the spawning grounds for populations within the John Day River MPG has declined considerably in recent years (NWFSC 2015).

Three of the four natural populations in the Yakima River MPG remain at low risk for structure based on results from the recent radio tag and pit tag studies described above. Distribution across spawning areas for the fourth population, the Upper Yakima River population, continues to be substantially reduced from inferred historical levels and is rated at moderate. As with the populations in the Walla Walla and Umatilla MPG, risks due to the loss of life history and phenotypic diversity inferred from habitat degradation (including passage impacts within the Yakima River Basin) remain at prior levels. There are no within-basin hatchery steelhead releases in the Yakima River Basin and outside source strays remain at low levels (NWFSC 2015).

Overall, there have been improvements in the viability ratings for some of the component populations, but the MCR Steelhead DPS, as a whole, is not currently meeting the viability criteria (adopted from the ICTRT) in the Mid-Columbia Steelhead Recovery Plan. In addition, several factors cited by the 2005 BRT remain as concerns or key uncertainties. Natural-origin returns to the majority of the population in two of the four MPGs in this DPS increased modestly relative to the levels reported in the previous five year review. Abundance estimates for two of three populations with sufficient data in the remaining two MPGs (Eastside Cascades and Walla Walla and Umatilla Rivers) were marginally lower. Natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. In general, the majority of the population level viability ratings remained unchanged from prior reviews for each MPG within the DPS.

The status of MCR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the MCR Steelhead DPS. Because of the location of the DPS in the Columbia River Basin, the DPS is likely to be more affected by climate related effects in the mainstem affecting migration. Because of their life history, steelhead smolts spend a year in the freshwater rearing environment, the DPS may be subject to additional affects from climate change to the stream ecosystems.

MCR summer steelhead populations are designated part of the A-Index steelhead stock (see Table 2-89 for stock definitions). Two populations of the MCR steelhead DPS are also winter run populations and therefore represented by the winter steelhead stock. Effects to these stocks of fish are representative of effects to MCR steelhead populations in general.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected MCR steelhead and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on MCR steelhead. Regarding changes in hatchery effects to the MCR Steelhead DPS the hatchery programs funded by the public utility districts were reduced in size starting in 2014 because of a revised calculation of their mitigation responsibility bases on increased survivals through the Upper Columbia dams. Reducing hatchery production has reduced pHOS and associated genetic risk from steelhead that might stray into MCR steelhead populations. It has also reduced the number of natural-origin fish removed for the hatchery broodstocks. Also, as a result of site specific consultations now completed (see Table 2-81), several additional reform measures have been implemented including the following:

- The Walla Walla summer steelhead hatchery program (Wallowa stock) has been modified over time to reduce the genetic effects of releasing a non-endemic stock. In addition, the operators are evaluating the feasibility of using an endemic summer steelhead broodstock (Touchet stock), which would further reduce genetic risk of the hatchery program on the MCR Steelhead DPS.

Although all of the factors considered in the environmental baseline have contributed to the listing of the DPS, all have improved in the way they are managed and operated. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for interdam loss on DPSs that pass through mainstem Columbia River hydrosystem dams and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Harvest mortality in fisheries has been reduced substantially in response to evolving conservation concerns. Steelhead impacts associated with fall season fisheries were managed from 1986 to 1998 pursuant to the guidelines contained in the now expired CRFMP. That plan allowed for a tribal harvest rate on B-Index steelhead during the fall season of 32%. The 32% cap was itself a reduced fishing level designed at the time to provide necessary protection to B-Index steelhead. The average B-Index harvest rate from 1985 to 1997 was 26.0%. Since 1998, when ESA constraints specific to B-Index steelhead were first applied, as it was the surrogate adopted by the Parties to represent the most constraining steelhead stock, the harvest rate in the tribal fall season fishery averaged 11.5%. The 15% harvest rate cap represented a 42% reduction from the long-term average harvest rate for the tribal fishery, and a 53% reduction from the CRFMP allowed harvest rate of 32%.

Through the course of past consultations NMFS has considered previous efforts to reduce the level of harvest in both non-treaty and treaty Indian fisheries. Significant management actions in non-treaty fisheries related to steelhead occurred 40 years ago. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Prior to efforts during the last few years to promote commercial selective fisheries, time, area, and gear restrictions limit handling and mortality of steelhead by the non-treaty fishery to less than 2% of the run. In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that a percentage, depending on water temperature and time of year (generally about 10%) will die from resulting injuries.

The harvest rate on A-Index steelhead averaged 13.4% from 1985-1997. The average harvest rate for treaty fisheries on the unclipped A-Index stock in the Bonneville Pool from 2008 to 2017 was 1.6% and ranged from 0.7% to 7.0% during the summer and subsequent winter/spring combined seasons (TAC 2017, Table 3.3.35) and averaged 6.5% and ranged from 4.0 to 10.0% during the fall seasons (TAC 2017, Table 3.3.52). It is therefore apparent that the harvest rate in tribal fisheries has also been reduced over the last 20 years or more. Although the discussion and analysis in this opinion has focused to some degree on B-Index steelhead, it is pertinent to recall that the expected harvest rates on other steelhead stocks in general, relative to their limit, are lower (see Table 2-88).

NMFS, as a matter of policy has sought not to eliminate harvest particularly to the tribes in recognition of their treaty rights and the Federal government's trust responsibility. A review of the baseline unrestrained Native American fish harvest and consumption illustrating the expectation of the reservation of the treaty fishing right during treaty negotiations in the mid-1850's was presented in Section 2.4.5.2, Columbia River Mainstem Harvest. Non-treaty fisheries are second in priority to treaty fisheries when it comes to conservation restriction, and are therefore the fisheries that are first limited by conservation constraints. But here too NMFS will seek, as a matter of similar considerations, to provide some opportunity to access harvestable fish if the states and tribes can resolve critical questions related to allocation and with the provision that the impacts are very limited and all possible measures are taken to minimize the incidental impacts to listed species. The implementation of steelhead mass-marking and selective, non-retention fisheries by the states serves as an example. Even so, the associated impacts must be accounted for and held to acceptable levels.

Ultimately fisheries will be managed, and catch will continue to be limited, based on the needs of the ESA-listed fish. NMFS also believes that fisheries should be managed based on the status of the fish they affect.

The effect of fisheries managed under the 2018 Agreement on natural-origin populations returning to the MCR DPS are discussed in detail in Section 2.5.1.2. Proposed non-treaty fisheries, pursuant to the 2018 Agreement, will be managed subject to A-Index and winter steelhead stock harvest rate limits. Summer and subsequent winter/spring fisheries are subject to a 2% harvest rate limit on unclipped A-index steelhead. Non-treaty fall season fisheries are likewise subject to a 2% harvest rate limit for A-Index steelhead. The total annual harvest rate limit for A-Index steelhead therefore is 4%, but remains 2% for the winter steelhead stock. The expected harvest impacts on non-treaty fisheries are less than those proposed. The incidental catch of winter steelhead in non-treaty across all fisheries has averaged 1.9% since 2008 (TAC 2017, Table 3.3.2). The yearly incidental catch of A-Index steelhead in non-treaty fisheries has averaged 1.9% since 2008 compared to the 4% yearly combined limits (TAC 2017, Table 3.3.54). While non-treaty fisheries are also subject to a 2% harvest rate limit on unclipped B-Index steelhead, in regards to MCR steelhead the A-Index harvest rates are more representative of effects given MCR Steelhead DPS populations generally do not achieve B-Index criteria. Harvest rates are not expected to change over the course of the 2018 Agreement (TAC 2017).

There are no specific incidental harvest rate limits for treaty fisheries on the MCR Steelhead DPS (TAC 2017). The expected incidental harvest impacts on the winter steelhead stock and A-Index surrogate components for the MCR steelhead DPS associated with proposed treaty tribal fisheries is the same as the range observed in earlier years (TAC 2017, Table 5.1.13), between 1.4% and 6.9% for the winter steelhead stock and 4.6% and 12.9% on the A-Index. However, the expected incidental harvest impacts on the winter stock and A-Index components of the MCR Steelhead DPS in proposed treaty fisheries are expected to be less. The harvest rate for treaty fisheries on the winter steelhead stock in the Bonneville Pool from 2008 to 2017 averaged 0.5% and ranged from 0.1% to 1.4% (TAC 2017, Table 3.3.12). The harvest rate for treaty fisheries on the unclipped A-Index stock in the Bonneville Pool from 2008 to 2017 averaged 1.6% and ranged from 0.7% to 7.0% during the summer and subsequent winter/spring combined seasons (TAC 2017, Table 3.3.35) and averaged 6.5% and ranged from 4.0-10.0% during the fall seasons (TAC 2017, Table 3.3.52). Harvest rates for winter and A-Index stocks associated with Proposed treaty fisheries are not expected to change over the course of the 2018 Agreement (TAC 2017).

Treaty fall season fisheries will be managed using the abundance-based harvest rate schedule for B-Index steelhead contained in the 2018 Agreement (TAC 2017, Table 5.1.2). TAC (2017) indicates B-Index steelhead occur in most regions, however the Snake Basin has the highest proportion of B-sized fish. While most B-Index steelhead are part of the Snake River DPS, some

B-Index fish may be part of any other DPS and are mentioned here as a result.

Under the abundance based harvest rate schedule, the harvest rate may vary up or down, depending on the abundance of B-Index steelhead for treaty fisheries. Fall fisheries are also limited by the abundance of upriver fall Chinook salmon. Therefore, impacts to B-Index steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook salmon, is increased. However, the highest harvest rates of steelhead are allowed only if the abundance of B-Index steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right to harvest 50% of the harvestable surplus of fall Chinook salmon in years when conditions are favorable. Even with these provisions, it is unlikely that the treaty right for Chinook salmon or steelhead can be fully satisfied as the harvest rate limits are generally met for B-Index steelhead before the harvestable surplus of fall Chinook salmon is caught. The harvest rate limits for B-Index steelhead in treaty fall season fisheries may range from 13-20% based on the preseason forecast of abundance predicted to cross Bonneville Dam. However, based on the past ten years of actual performance, the expected harvest rate on B-Index steelhead in treaty fisheries is 3.4-15%. As indicated above, the non-treaty fall season fishery harvest rate limit for B-Index steelhead will remain fixed at 2%.

B-Index steelhead are also the component of the returning steelhead upriver run that is most vulnerable to the treaty Indian fall fisheries due to their later timing, larger size, and upstream location which requires them to pass through the full range of fall season fisheries. A-Index steelhead, whether from the MCR or other DPSs, benefit from the protections provided to B-Index steelhead because they are subject to relatively lower harvest rates, again because of their smaller size, earlier timing, and, for the MCR DPS, their downstream location. The winter run component of the MCR Steelhead DPS are also not subject to harvest in the fall season fisheries. B-Index steelhead are therefore considered the most constraining of the steelhead stocks.

There are limits proposed for treaty tributary fisheries affecting MCR steelhead in the following rivers: (1) Klickitat River, a 3-year rolling average of 9.6% (2) Deschutes River, a 3-year rolling average of 1.6% (3) John Day River, a 3-year rolling average of 0.5% (4) Umatilla River, a 3-year rolling average of 6.2% (5) Walla Walla River, a 3-year rolling average of 2.0% (6) Yakima River, a 3-year rolling average of 0.5%. These limits are a conservative approach to management because they are restrict tributary fisheries to harvesting lower numbers of fish during years of low returns. Rather than fixing the limit to a static number of fish each year, fisheries will instead limit their impact relative to the size of each specific year’s return, including prior performance from the previous two years. The prior two years’ harvest rates would be added to the current year’s expected harvest rate to calculate the 3-year rolling average. If fisheries achieved harvest rates slightly above the 3.0% in the first or second year of the calculation, then the third year they are expected to be planned more conservatively to meet the limit. Because steelhead life history exhibits a 3-year age structure this strategy is mindful for protecting an entire broodyear of fish (meaning that in any given year, the steelhead that return are different ages of fish from the previous three years of spawning events).

Proposed harvest rates on the populations are expected to be unchanged from recent historical levels as seen in Section 2.4.5.3. Escapement information for these populations is shown in Table 2-46 and indicates that the status of the populations are improving, and have improved from

2008. Given that the proposed fisheries and associated limits are not going to deviate from historical levels that allowed the status of these populations to increase along with the limits being adjusted to be more responsive during years of low returns, indicates this approach is contributing to the survival and recovery of MCR steelhead populations.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS 2009), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for MCR steelhead.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on MCR steelhead. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the tributary areas not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-46 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on MCR steelhead in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the MCR Steelhead DPS will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this DPS. These changes in factors that were prior limitations on VSP criteria for this DPS are now resulting in stable VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, increases in abundance were observed in 65% of the populations. Of these, some like the John Day or Yakima River populations have seen increases that have more than doubled the spawning abundance since 2008 (Table 2-46). Decreases in the hatchery contribution for several populations are already occurring, and are expected for all populations as a result of recently completed site specific hatchery program ESA-reviews. The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the current status of the MCR Steelhead DPS. The proposed action proposes to continue harvest management consistent with recovery plan expectations (NMFS 2009). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this DPS in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. In most cases, the proposed action addresses considerations related to the cumulative effect of climate change by aligning future decisions about the rate of harvest with indicators of the abundance returning to the river mouth or Bonneville Dam. MCR steelhead are managed based on the annual forecast of fish expected to cross Bonneville Dam. Treaty fisheries use an abundance based approach restricting fisheries during years of lower returns of B-Index steelhead. This abundance based approach reduces harvest during years of low abundance and provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. However, non-treaty fisheries used fixed rates to limit fisheries on both Indexes of steelhead that return to Bonneville Dam. Fixing harvest management to a percent of the return rather than a fixed number of fish is responsive to environmental changes, although overall, the limit is very low every year in non-treaty mainstem fisheries as it's capped at just 2% of the unclipped portion of either Index. Finally, tributary treaty fisheries are based on 3-year rolling average harvest rate frameworks. Where the proposed action deals with treaty Indian tributary harvest management, reviewed above, the approach is mindful of climate change by implementing harvest strategies, in this case a 3-year rolling average, which are reactive to fluctuating size of returns, whatever their cause may be, that are also respectful to the age structure of the population. Overall, harvest management is thereby responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. Given the increase in status this approach is contributing to the survival and recovery of these MCR steelhead populations within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Productivity of the DPS has improved. In our review of status above, that productivity in 10 populations improved, and that while productivity in two of the remaining populations decreased, the same populations experienced increased abundances. Only two populations experienced decreases in both abundance and productivity VSP criteria during the last status review. This indicates that in general, overall DPS productivity is still positive and improving. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the MCR Steelhead DPS given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the DPS, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this DPS for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of MCR steelhead or appreciably reduce the value of designated critical habitat.

2.7.3 Upriver ESUs/DPSs

2.7.3.1 Snake River Fall-Run Chinook Salmon ESU

NMFS' recent review affirmed the status of this ESU as threatened (NWFSC 2015). Overall, the status of Snake River fall-run Chinook salmon has clearly improved compared to the time of listing and since the time of prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of viable developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NWFSC 2015).

The status of Snake River Chinook salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the Snake River fall-run Chinook salmon ESU. Because of the location of the ESU in the Columbia River Basin, the ESU is likely to be more affected by climate related effects in the mainstem affecting migration.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected Snake River fall-run Chinook salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on Snake River fall-run Chinook salmon. Although all of the factors considered in the environmental baseline have contributed to the listing of the ESU, all have improved in the way they are managed and operated. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for interdam loss on ESUs that pass through mainstem Columbia and Snake rivers hydrosystem dams and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

The Snake River fall-run Chinook salmon ESU is affected only by fall season fisheries. Snake River fall-run Chinook are typically one of four limiting stocks (which include LRH Chinook salmon, lower river coho salmon, and B-Index steelhead) in the fall season fisheries represented by the URB stock (See Table 2-89 for stock definitions). In the years leading to, and through the 2008 Agreement's biological opinion (NMFS 2008d), fall season fisheries were subject to ESA take limitations and required to reduce the harvest rate on Snake River fall-run Chinook salmon by 30% relative to the 1988-93 base period. This translated into an overall inriver harvest rate of 31.29%. NMFS first implemented the 30% base period reduction criterion as a standard for evaluating fall season fisheries in 1996, associated with its review of the 1996-1998 Fall Season Agreement (NMFS 1996c). The 1999 fall season biological opinion (NMFS 1999c) again reviewed the history and considerations used in developing the 30% base period reduction standard.

The 30% reduction, in combination with an analogous reduction in ocean fisheries described in Section 2.4.5.1, Ocean Harvest, was considered a significant reduction to address, at least initially, the need for survival improvements in harvest given the current status of the ESU and other anticipated actions. Incorporated into that consideration was the need to balance the risk to the species associated with higher harvest rates and fishery needs that were primarily related to the tribes' treaty fishing rights. The judgment made at the time was that the 30% base period reduction standard provided the appropriate balance without putting the species at undue risk. The 1999 opinion reaffirmed the 30% reduction standard which was applied consistently through 2007. In 2008-2017, incidental harvest of Snake River fall-run Chinook salmon varied from year-to-year based on an abundance-based harvest rate schedule that allowed for increased harvest rates than allowed before under certain conditions, but also lower harvest under certain conditions. Allowed harvest rates depended on the abundance of the aggregate of unlisted upriver fall Chinook and natural-origin ESA-listed Snake River fall-run Chinook salmon. The allowable harvest rate ranged from 21.5% to 45.0%. As indicated above, considerations related to trust obligations and treaty rights were central to the development of the 30% harvest reduction standard implemented up to 2008 and the development of a new variable harvest rate schedule in place since 2008. Since the initial listings of Pacific salmon in 1991, NMFS has sought to develop and articulate its policy on tribal treaty obligations and trust responsibilities as they related to implementation of the ESA.

Policy commitments have provided guidance for consultations on fisheries, particularly as NMFS sought an appropriate balance between trust obligations and the imperative of meeting the conservation needs of the listed species. The guidance was initially incorporated in the 1996 biological opinions (NMFS 1996c) on fall season inriver fisheries (the 1996 opinion covered proposed fisheries from 1996 - 1998) that provided the basis for the current harvest standard, and has been retained since. The policy commitment and guidance related to treaty rights was reiterated in other documents and correspondence, including the All-H paper (Caucus 2000) and subsequent consultations on harvest. Federal court decisions have clarified that the tribes have a treaty right to harvest up to 50% of the harvestable surplus of fish passing through a tribes' usual and accustomed fishing areas.

Harvestable surplus is defined conceptually as runsize minus the escapement goal. During fall season fisheries the tribes' primary target is fall Chinook from the Upper Columbia River summer/fall Chinook ESU which spawn in the Hanford Reach. This ESU is not listed and is in fact healthy. The fall component of the ESU that is targeted in the fishery has exceeded its escapement goal by a wide margin in every year since 1982, with harvest of URB fall Chinook salmon stock going from an average of 30,209 salmon from 2008-2012 in non-treaty fisheries to 86,511 salmon from 2013-2016, and 59,462 salmon from 2008-2012 in treaty fisheries to 140,496 salmon from 2013-2016. During these same time frames the annual average URB aggregate fall Chinook salmon runsize rose from 270,789 salmon from 2008-2012 to 667,765 salmon from 2013-2016 (TAC 2017, Tables 3.3.48 and 3.3.49). The Snake River fall-run Chinook salmon runsize has also increased from an average of 14,821 salmon returning to the mouth of the Columbia River from 2008-2012 to 23,684 salmon from 2013-2016 (TAC 2017, Table 3.3.49).

In the 2018 Agreement, as in past years, the treaty tribes have proposed to voluntarily forego some harvest in order to reduce harvest on listed Snake River fall-run Chinook salmon and other species of concern. The effect of fisheries managed under the 2018 Agreement on LCR coho salmon populations are discussed in detail in Section 2.5.1.1. Harvest will depend on the abundance of unlisted upriver fall Chinook and natural-origin Snake River fall-run Chinook salmon. The allowable harvest rate will range from 21.5% to 45.0%. Under the proposed fishery plan, the tribes would limit their harvest because of conservation concerns for Snake River fall-run Chinook salmon and, as a result, expect to harvest only 30% of the harvestable surplus of URB fall Chinook salmon in 2018, as example of one year under the 2018-27 Management Agreement. Harvest opportunity on other species, particularly steelhead, would also be substantially limited.

In considering the proposed 2018 Agreement fisheries, it is also appropriate to review the magnitude of harvest reductions and the change in spawner escapements in recent years. The average harvest rate of Snake River fall-run Chinook salmon in the Columbia River since 2000 is 28.8%, and 32.9% since 2008. Taken from a broader perspective we can look at the combined impact of ocean and inriver fisheries and how that has changed over the last 20 years. The exploitation rate on Snake River fall-run Chinook salmon in the ocean and inriver fisheries combined has declined from an average of 67%, from 1986-1995, to 45%, since 1995, representing a 33% reduction in the overall exploitation rate. The abundance of Snake River fall-run Chinook salmon has increased dramatically in recent years (TAC 2017, Tables 3.3.48 and 3.3.49). Other available abundance indicators reflect a similar pattern of substantial increase in recent years. The number of redds, smolt out-migrants at Lower Granite Dam, and jacks all increased over the course of implementing the 2008 Agreement (see Section 2.2.4.1).

The adult returns observed in recent years can be compared to the previously identified lower abundance threshold of 300 and recovery escapement goal of 3,000 natural-origin spawners which are the kinds of benchmarks suggested in the VSP paper (McElhany et al. 2000) for evaluating populations status. NMFS drafted a recovery plan it solicited public comment on, which contained the use of a 4,200 natural-origin spawning abundance target for Snake River fall-run Chinook salmon (NMFS 2017m). The escapements of unique natural-origin fall-run Chinook salmon crossing Lower Granite since 2008 has annually averaged 11,084 fish (TAC 2017, Table 2.3.15). This level of return of natural-origin fish in since 2008 exceeded the recovery escapement goal of 4,200 by triple under previous implementation of the proposed harvest framework for a decade.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Snake River fall-run Chinook salmon.

The proposed movement of subyearlings previously released in the Hells Canyon Dam into the Salmon River, as noted in the new 2018 Agreement, will have potentially beneficial genetic implications to the Snake River fall-run Chinook Salmon ESU and minimal to negligible ecological effects from competition and predation on all ESA-listed salmonids in the action area. It should result in a substantial pHOS reduction there. This is because the movement of the Hells Canyon releases reduces the number of fish released in that region by two thirds. In addition, pHOS may be further reduced if natural production increases in the Hells Canyon area in the Snake River due to reduced density of spawners in the reach. Therefore, the movement of subyearlings as described in the 2018 Agreement will likely result in improved genetic conditions of the Snake River fall-run Chinook Salmon ESU. Moreover, the effects of competition and predation under this scenario will only result in a total of eight additional adult Snake River steelhead DPS equivalents lost. This loss would equate to less than a 1% impact on all DPSs down to the estuary, and is thus a minimal to negligible effect. Overall, the proposed movement of subyearlings as described in the 2018 Agreement will be a potential improvement to abundance, productivity, and diversity or the Snake River fall-run Chinook Salmon ESU and will have minimal to negligible effects to other ESA-listed salmonids.

A further consideration in evaluating the status of Snake River fall-run Chinook salmon has been the existence of four artificial propagation programs producing Snake River fall-run Chinook salmon. These rely on the Lyons Ferry Hatchery stock and include a substantial reservoir of fall Chinook that are part of the ESU. Hatchery fish provide a further safeguard against catastrophes or continuing failures of the natural system, which reduces the risk of species extinction. In this case, the Lyons Ferry Hatchery is used to maintain a brood stock, and is also used as a source for a very substantial supplementation program. The supplementation program has been scaled up over the last several years to provide both fingerling and yearling outplants that are acclimated and released in areas above LGD. The immediate objective of the supplementation program is to increase the number of natural-origin spawners. The return of adults to LGD from the supplementation program has increased from 479 in 1998 to over 8,500 in 2003. This is in addition to the adults returning from natural production (see Table 2-49). The total return of Snake River fall-run Chinook salmon to Lower Granite Dam in 2016 was 37,401. The return broken down into hatchery and natural-origin components, continues the trend of increased escapement, and has averaged 27% natural-origin fish to Lower Granite Dam since 2008.

Supplementation can be used to mitigate the risk of extinction by boosting the initial abundance of spawners while other actions are taken to increase the productivity of the system to the point where the population is self-sustaining and supplementation is no longer required. Collectively, artificial propagation programs in the ESU provide slight benefits to ESU abundance, spatial structure, and diversity, but have neutral or uncertain effects on ESU productivity (69 FR 33102, June 14, 2004) consistent with expectations of rebuilding to meet survival and recovery goals.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on Snake River fall-run Chinook salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the areas upstream, like the upper Snake River, not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-49 and redds counted in the Snake River Basin (Table 2-50) take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on Snake River fall-run Chinook salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the Snake River fall-run Chinook salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in much higher VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, the fall Chinook salmon redd counts went from 3,055 in 2008 to 6,182 in

2016 (Table 2-50) with the number of natural-origin fish crossing Lower Granite Dam going from 3,930 to 9,772 over the same time frame (Table 2-49). The overall current risk rating for the Snake River fall-run Chinook salmon population is viable, as indicated by the bold outlined cell in Table 2-51. The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for large progress in rebuilding this particular ESU as indicated by the current status of the Snake River fall-run Chinook salmon ESU. Abundance based management in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management, which is consistent with the strategy in the recovery plan (NMFS 2017m). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this ESU in terms of survival, either short or long term. Here, we have a clear example of the benefit of abundance based management, where with increasing abundance the harvest rate average has increased since 2008 compared to what it was in the prior decade, but a slight increase tailored to abundance still contributed to a rebuilding effort within the context of other improvements. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. Given the current circumstances, future decisions about the rate of harvest on this ESU are made based on indicators of the abundance returning to the river mouth. This abundance based approach, using the URB fall Chinook salmon stock for both treaty and non-treaty fisheries, provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. In the case of Snake River fall-run Chinook salmon, the increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Productivity of the ESU has significantly improved since 2008. In our review of status above, that productivity has contributed to currently lifting the ESU into viable status. This indicates that in general, overall ESU productivity is still positive and improving. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the Snake River fall-run Chinook Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of Snake River fall-run Chinook salmon or appreciably reduce the value of designated critical habitat.

2.7.3.2 Snake River spring/summer-run Chinook Salmon and Upper Columbia River spring-run Chinook Salmon ESUs

NMFS' recent review affirmed the status of these ESUs, respectively, due to their individual risks of extinction (NWFSC 2015). They are combined here as they are managed as aggregate stocks in the 2018 Agreement, allowing us to evaluate them collectively, but taking account of their status and environmental baseline and cumulative effects independently.

Snake River spring/summer-run Chinook Salmon ESU status
The majority of natural populations in the Snake River spring/summer-run Chinook Salmon ESU remain at high risk overall, with one population (Chamberlain Creek in the MF MPG) improving to an overall rating of maintained due to an increase in abundance (Table 2-53). Natural-origin abundance has increased over the levels reported in the prior review (Ford 2011) for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. Ten natural populations increased in both abundance and productivity, seven increased in abundance while their updated productivity estimates decreased, and two populations decreased in abundance and increased in productivity. One population, Loon Creek in the MF MPG, decreased in both abundance and productivity. Overall, all but one population in this ESU remains at high risk for abundance and productivity and there is a considerable range in the relative improvements to life cycle survivals or limiting life stage capacities required to attain viable status. In general, populations within the South Fork grouping had the lowest gaps among MPGs. The other multiple population MPGs each have a range of relative gaps (NWFSC 2015).

Spatial structure ratings remain unchanged or stable with low or moderate risk levels for the majority of the populations in the ESU (Table 2-53 and Table 2-55). Four populations from three MPGs (Catherine Creek and Upper Grande Ronde of the Grande Ronde/Imnaha MPG, Lemhi River of the Upper Salmon River MPG, and Lower MF Mainstem of the MF MPG) remain at high risk for spatial structure loss. Three of the four extant MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn – the more natural-origin fish that return the fewer hatchery fish that are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels. Efforts to evaluate key assumptions and impacts are underway for several programs (NWFSC 2015).

While there have been improvements in the abundance/productivity in several populations relative to prior reviews (Ford 2011), those changes have not been sufficient to warrant a change in ESU status (NWFSC 2015).

UCR spring-run Chinook Salmon ESU status

In the 2015 status review, updated data series on spawner abundance, age structure, and hatchery/natural proportions were used to generate current assessments of abundance and productivity at the population level. Annual spawning escapements for all three of the extant UCR spring-run Chinook salmon populations showed steep declines beginning in the late 1980s, leading to extremely low abundance levels in the mid-1990s. The steep downward trend reflects the extremely low return rates for the natural population from the 1990-94 brood years. Steeply declining trends across indices of total spawner abundance were a major consideration in the 1998 BRT risk assessment prior to listing of the ESU. Updating the series to include the 2009-2014 data, the short-term (e.g., 15 year) trend in wild spawners has been stable for the Wenatchee population and positive for the Entiat and Methow populations. In general, both total and natural-origin escapements for all three populations increased sharply from 1999 through 2002 and have shown substantial year-to-year variations in the years following, with peaks around 2001 and 2010. Average natural-origin returns remain well below ICTRT minimum threshold levels.

The most recent total natural spawner abundance information for UCR spring-run Chinook salmon is provided in Table 2-61. The proportions of natural-origin contributions to spawning in the Wenatchee and Methow populations have trended downward since 1990, reflecting the large increase in hatchery production and releases and subsequent returns from the directed supplementation program in those two drainages. Table 2-61 indicates two of the three populations have increased their productivity since the prior status review, with the third population maintaining its previous level of productivity. There is no direct hatchery supplementation program in the Entiat River. The Entiat NFH spring-run Chinook salmon release program was discontinued in 2007, and the upward trend in proportional natural-origin spawners since then can be attributed to that closure. Hatchery supplementation returns from the adjacent Wenatchee River program stray into the Entiat (Ford et al. 2015). The nearby Eastbank Hatchery facility is used for rearing the Wenatchee River supplementation stock prior to transfer to the Chiwawa acclimation pond. It is possible that some of the returns from that program are homing on the Eastbank facility and then straying into the Entiat River, the nearest spawning area (NWFSC 2015).

Although the status of the UCR spring-run Chinook Salmon ESU is improved relative to measures available at the time of listing, and remains at high risk and listed as endangered under the ESA.

The status of both ESUs is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in these two Chinook salmon ESUs. Because of their locations in the Columbia River Basin and relatively similar life histories, each ESU is likely to be more affected by climate related effects in the mainstem affecting migration. Because of their life history, yearling smolts spend a year in the freshwater rearing environment, and each ESU may be subject to additional affects from climate change at the stream ecosystem level.

The current management framework was developed at a time when there was less information about the diversity of run timing of various components of Chinook salmon. Not until PIT tags became widely available were we able to observe and better quantify the diversity and complexity of population-specific run timing information. The PIT tag data also allowed us to assess, for the first time, how adult survival during upstream migration varied between populations and the factors that affected observed differences.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on UCR spring-run Chinook and Snake River spring/summer-run Chinook salmon. Regarding changes in hatchery effects to each ESU, first for the UCR spring-run Chinook salmon, the hatchery programs funded by the public utility districts were reduced in size starting in 2014 because of a revised calculation of their mitigation responsibility bases on increased survivals through the Upper Columbia dams. Reducing hatchery production has reduced pHOS and associated genetic risk from spring Chinook salmon that might stray into UCR spring-run Chinook salmon populations. It has also reduced the number of natural-origin fish removed for the hatchery broodstocks. Also, as a result of site specific consultations now completed (see Table 2-81), several additional reform measures have been implemented including the following:

- The Winthrop National Fish hatchery spring Chinook salmon program made changes in their broodstock (i.e., developed a "stepping stone" program) to better link their hatchery fish genetically to natural-origin Chinook salmon.
- There has been continued improvement of spring and summer/fall Chinook salmon hatchery rearing practices to minimize early maturation, which could contribute to residualization.
- There has been a change in the use of water at Leavenworth National Fish Hatchery, which has provided more stream flow in Icicle Creek in summer months, which has reduced the potential for dewatering; therefore, reducing risks to the UCR Spring Chinook Salmon ESU.

Second, for changes in hatchery effects to Snake River spring/summer-run Chinook salmon, the South Fork Salmon River summer Chinook salmon hatchery program out of McCall Fish Hatchery created an integrated component and now has two components (segregated and integrated) with a recently implemented genetic relationship between them. In other words, a percentage of returning fish from the integrated component will be used as broodstock in the segregated component. This type of genetic linkage is sometimes referred to as a "stepping stone" system (HSRG 2014). Initial analysis by NMFS of programs connected this way shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs (Busack 2015). According to NMFS' site-specific biological opinions (see Table 2-81), multiple genetic analyses indicate that hatchery programs updated management practices offer a considerable improvement to the genetic risks for the populations they interact with, compared to before the consultations were completed. The hatchery programs in the Upper Salmon River have also committed to strategies to limit hatchery straying and ecological interactions with ESA-listed natural-origin fish. There have also been some improvements in recent years to hatchery programs located in northeast Oregon. The Catherine Creek, Imnaha, and Lostine hatchery programs use sliding scales sensitive to population abundance (NMFS 2016c). Under the sliding scales, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels, but reduce proportions as natural-origin abundance increases. Outplanting of adults is in addition to the pHOS determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

The Clearwater hatchery programs operate where ESA-listed Snake River spring/summer-run Chinook salmon are not present. Furthermore, according to NMFS site-specific biological opinion (NMFS 2017p) these hatchery programs have implemented new strategies to limit straying of program fish into areas where ESA-listed fish are present.

Although all of the factors considered in the environmental baseline have contributed to the listing of these ESUs, all have improved in the way they are managed operated. Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for interdam loss on ESUs that pass through mainstem Columbia and Snake rivers hydrosystem dams and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Harvest mortality has been reduced substantially in response to evolving conservation concerns. The effects of fisheries have been considered through a series of consultations since Snake River spring/summer-run Chinook salmon were listed in 1992. Other listings followed, including UCR spring-run Chinook salmon, and the effects of fisheries on these species were incorporated into subsequent opinions. Prior to 1992, the now expired CRFMP, used for management from 1986 to 1998, allowed for harvest rates up to 4.1% on upriver spring stocks in non-treaty fisheries and either 5% (for aggregate runs less than 50,000) or 7% (for runs between 50,000 and 128,800) in treaty C&S fisheries. For runs greater than 128,800, half the surplus greater than 128,800 was considered harvestable in mainstem fisheries. The CRFMP also provided that all fish in excess of 143,750 were harvestable. The CRFMP set an interim management goal of 25,000 natural-origin spring Chinook salmon as measured at Lower Granite Dam.

In 1992, when the Snake River spring/summer-run Chinook Salmon ESU was listed, new constraints were implemented. These were refined through a series of annual consultations that led to the development in 1996 of a three year Management Agreement that modified the CRFMP's original harvest management framework. The Plan's provisions were modified by reducing allowable impacts in the non-treaty fisheries. The alternative target harvest rates in the treaty fisheries (5-7%) were not changed as a result of the Agreement, but the Agreement did, for the first time, require that fisheries be managed in response to the status of listed natural-origin fish rather than an aggregate runsize that was now composed primarily of hatchery-origin fish. The 1996 Agreement provided that harvest rates would match those of the original CRFMP only if the anticipated return of natural-origin spring Chinook salmon from the Snake River exceeded 10,000 fish.

The CRFMP limited harvest rates on upriver summer Chinook salmon stocks in the non-treaty and treaty fisheries to 5% each. The three-year Agreement reduced the harvest rate limit for upriver summer Chinook salmon in the non-treaty fishery from 5% to 1% and clarified that all treaty fisheries were subject to the 5% harvest rate limit. At the time, the purpose of these further constraints was to limit the potential take of the summer component of the Snake River spring/summer-run Chinook Salmon ESU. These limits on summer Chinook salmon harvest were not particularly confining since both the states and tribes had been managing their fisheries well below these limits because of low returns and conservation concerns.

The 1996-1998 Management Agreement was extended through July 31, 1999 and therefore applied to the 1999 spring fisheries as well. By the time the 2000 season approached, additional listings had occurred, including the UCR spring-run Chinook Salmon ESU. In 2000, there was a preseason forecast for upriver spring-run Chinook salmon of 134,000 that was higher than it had been for some time. Based on the higher aggregate run size, the tribes proposed a harvest rate for spring-run Chinook salmon of 9% while the states proposed a harvest rate ranging from 1-2%. At the time, NMFS concluded that an increase in the harvest rate beyond 9%, no matter how small, was inappropriate given the status of the stock. NMFS issued a jeopardy opinion and limited the overall harvest rate to 9%. The 9% cap was then carried forward in subsequent analyses related to the 2000 FCRPS biological opinion and thus became one of the underlying assumptions related to its conclusions. This then provided the benchmark against which subsequent harvest proposals were compared.

In 2001, there was a preseason forecast for upriver spring Chinook salmon of 364,000 that was twice what it was in 2000 and three times what it had been in any year since 1979. The Parties reached an Interim Management Agreement for winter, spring, and summer fisheries that allowed for a variable harvest rate based on the aggregate upriver spring Chinook salmon runsize and the natural-origin Snake River spring/summer-run Chinook salmon runsize. This sequence of past consultations contributed to the evolution of the management framework contained in the 2005-2007 Interim Management Agreement, which was carried through into the 2008 Agreement.

Similar to other ESUs that pass through Zone 6 (Figure 1-1), policy commitments have provided guidance for consultations on fisheries, particularly as NMFS sought an appropriate balance between trust obligations and the imperative of meeting the conservation needs of the listed species. The policy commitment and guidance related to treaty rights was reiterated in other documents and correspondence, including the All-H paper (Caucus 2000) and subsequent consultations on harvest. Federal court decisions have clarified that the tribes have a treaty right to harvest up to 50% of the harvestable surplus of fish passing through a tribes' usual and accustomed fishing areas. A review of the baseline demonstrates unrestrained Native American fish harvest and consumption illustrating the expectation of the reservation of the treaty fishing right during treaty negotiations in the mid-1850's was presented in Section 2.4.5.2, Columbia River Mainstem Harvest. Non-treaty fisheries are second in priority to treaty fisheries when it comes to conservation restriction, and are therefore the fisheries that are first limited by conservation constraints. But here too NMFS will seek, as a matter of similar considerations, to provide some opportunity to access harvestable fish if the states and tribes can resolve critical questions related to allocation and with the provision that the impacts are very limited and all possible measures are taken to minimize the incidental impacts to listed species. The implementation of spring Chinook salmon mass-marking and selective, non-retention fisheries by the states serves as an example. Even so, the associated impacts must be accounted for and held to acceptable levels.

Since 2008, actual harvest rates have ranged between 8.8-16.7% (Table 2-87). In 2010, the Parties implemented a "Catch Balance Agreement" for mainstem spring season fisheries. The two provisions of this agreement included (1) a provision that total non-treaty mainstem fishery mortality cannot exceed the total allowed treaty harvest and (2) provision that the states of Oregon and Washington will use a 30% buffer to manage early season fisheries. This buffer is a requirement that non-treaty fisheries occurring prior to the first TAC run size update must be managed for the impacts associated with a run size 30% less than the pre-season forecast.

Continuing this modification into the 2018 Agreement sets fisheries on a lower abundance and restricts fisheries preseason relative to management prior to 2010.

In addition, recreational fisheries have been required to release unmarked, natural-origin spring Chinook salmon in the Columbia River. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries.

Fisheries affecting Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon will be the same as they have been in recent years, using the aggregate upriver spring Chinook salmon stock (See Table 2-89 for a definition). The proposed harvest schedule is the same as the 2008 Agreement (Table 2-93). The incidental take limit for Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon will therefore vary annually depending on the year specific estimates of run size. The maximum allowable harvest rates in non-treaty and treaty Indian fisheries are 2.7% and 14.3%, respectively. The upriver spring Chinook salmon stock includes all Chinook salmon passing Bonneville Dam during the spring management period from January 1 and June 15. The total combined abundance based harvest rate schedule allows the harvest rate on the stock to vary from 5.5% to 17% (Table 2-93). In most years, the year specific harvest rates will be less than the maximum allowed. The distribution of harvest mortality between non-treaty and treaty Indian fisheries may vary so long as the total harvest rate does not exceed the year specific maximum.

A recent report synthesizes the available information related to run timing, travel time, fallback, and survival using PIT tags (Crozier et al. 2016). The report distinguishes between groups of early and later timed fish. Overall, the median run timing of the late group is 2 - 4 weeks later than early group. As a consequence, a significant portion of the late group, is often still in Zone 6 after June 15 when the fishery transitions to summer season management and is thus vulnerable to higher harvest rates. While the proposed action uses the combination of the Upriver Spring Chinook salmon stock harvest rate schedule with a June 15 cutoff date as the suggested appropriate harvest management surrogate, additional factors that influence upriver spring Chinook salmon adult survival must first be considered in order for us to evaluate this surrogate combination's effects on the affected ESUs.

Temperature, spill, and catch are the factors that have the greatest influence on adult survival. It is not surprising that catch is also a significant contributor. On average 79 – 83% of the UCR and Snake River spring and summer fish survive passage from Bonneville to McNary Dam (Table 2-94). The average harvest rate on the upriver spring Chinook salmon stock in this area is 8.9%. So roughly half the mortality that occurs during upstream migration is attributable to the harvest that is associated with implementation of the proposed action. However, we consider the factors that influence the observed year-to-year variability in survival in more detail.

Temperature has the most consistent influence on the survival of all stocks, with high temperatures lowering survival. Survival from Bonneville to McNary Dam was also affected negatively by high spill. Spill had high importance for all stocks in Zone 6. The second lowest survival for late timed Snake River Chinook salmon occurred in 2011 when flows were 50% above normal.

High temperature and high spill typically occur later in the spring migration. Temperature increases steadily through the season. As noted earlier, the peak of the timing at Bonneville Dam for spring and summer migrants is around the May 1 and June 1, respectively. Peak flows typically occur around the first week in June (Figure 2-22). As a consequence, fish that enter the river at the end of the run nearly always experience more challenging conditions.

Catch also has the potential to have a greater impact on late timed fish. As discussed above, a significant portion of the late time fish are still in Zone 6 when the fishery transitions to summer season management (see Table 9 in Crozier et al. 2016). So for example, if half of a group of fish are subject to a 10% harvest rate in the spring season and the other half are subject to a harvest rate of 20% after the June 15 transition, the overall harvest rate, at least conceptually, would be 15% thus posing the possibility that late timed fish are consistently subject to higher harvest rates. The average proportion of the late timed populations still in Zone 6 after June 15 ranges from 27 – 42%, but in some years can be as high as 50% or 60%.

Figure 2-23 shows weekly catch along with the distribution of fish passage dates for the spring and summer groups at Bonneville Dam (Crozier et al. 2017). Figure 2-24 shows estimates of the weighted catch for the UCR spring-run and Snake River spring/summer Chinook salmon groups. It is apparent that the weighted catch in 2014 and 2015 were quite high (0.21 and 0.25) relative to the indices for UCR and Snake River spring stocks. However, it is also apparent that the weighted catch for the Snake River summer stock is actually lower than that for the spring stocks in eight of twelve years. In 2007, 2008, and 2009 in particular the weighted catch for summer fish is half or less of what it was for the early timed fish.

Recall that the spring season fishery is managed through the season based on evolving information. The forecast run size is adjusted continuously inseason based, in particular, on counts of fish at Bonneville Dam. Fisheries are set conservatively initially until there is more confidence in the inseason estimate. As a result, the timing of the catch from week-to-week varies considerably from year-to-year. In many years, there is an initial pulse of fishing early in the season, followed by an extended closure or much reduced harvest until more is known about the run size. In 2007, 2008 and 2009, when the weighted catch for Snake River summer fish was lowest, the fishery was closed during the peak of the run timing of the summer run fish. In 2014 and 2015, there was no midseason break in the fishery Figure 2-23. So what seems important in evaluating the effects of the proposed action on summer run fish is not so much what happens after June 15, but more how the fishery is structured and the cumulative effects of the fishery throughout the season. The proposed action incorporates a continued evaluation of using June 15 as it relates to affecting upriver spring and summer Chinook salmon populations over the course of the 2018 Agreement.

The analysis indicates that the survival rates of late timed fish are more variable ranging from 60 – 90%, even though the average survival rates for early and late timed fish are, on average, not significantly different. High temperatures and spill are more likely to adversely affect the survival of late timed fish because temperature increases with time and spill tends to peak coincident with the run timing of late timed fish. High catch rates after June 15 may also contribute to lower survival, particularly in years when migration is late or delayed.

One additional way to consider the effect of the proposed action on late timed populations is to consider the status of the populations, relative to others in the ESU, and how that has changed over time. As reviewed at the beginning of this section, NMFS' most recent five-year status review of ESA-listed salmonids (NWFSC 2015) indicates that the status of the ESUs has improved over the last five years, although the overall viability ratings remain unchanged. The abundance of natural-origin spawners has increased over the last five years for 25 of the 26 populations in the Snake River spring/summer-run Chinook Salmon ESU. The percent change in natural-origin spawners for the three late timed populations increased by 47 - 165%. Recent trends in productivity are also up for two of the three late timed populations. Ratings for spatial structure and diversity remain unchanged as they do for most of the other populations in the ESU. Under the proposed action, fisheries would continue to be managed using the abundance based harvest rate schedule and fishery management procedures in place since at least 2005, including the June 15 cutoff date. Under this regime, even though certain populations may be more vulnerable to harvest post June 15, the status of the late timed populations has improved along with others populations in the ESU.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations in both ESUs are currently now aligned with their respective recovery plans, primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UCR spring-run or Snake River spring/summer-run Chinook salmon.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on both Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the areas upstream, like the UCR and upper Snake River, not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-53 for Snake River spring/summer-run Chinook and Table 2-61 for UCR spring-run Chinook salmon take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to both Snake River spring/summer-run Chinook and UCR spring-run Chinook Salmon ESUs will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for each ESU. These changes in factors that were prior limitations on VSP criteria for each ESU are now resulting in much higher VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, the Snake River spring/summer-run Chinook Salmon ESU shows 88% of the populations increased in natural spawning abundance (Table 2-53) and the UCR spring-run Chinook Salmon ESU over the same time frame experienced an increase in each population’s natural spawning abundance along with productivity increases in 66% of the populations (Table 2-59). The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration in the estuary, mainstem and tributary areas of the action area, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the respective improved status of the Snake River spring/summer-run Chinook and UCR spring-run Chinook Salmon ESUs. Abundance based management in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management which is consistent with both the recovery strategies for Snake River spring/summer-run Chinook (NMFS 2017n) and UCR spring-run Chinook Salmon ESUs (UCSRB 2007) respectively. Current harvest, while still an adverse effect, therefore will not appreciably reduce the likelihood of either ESU's survival, either short or long term, as evidenced by the increases in abundance. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action's response to climate change is precautionary. Given the current circumstances, future decisions about the rate of harvest on both the Snake River spring/summer-run Chinook and UCR spring-run Chinook Salmon ESUs are made based on indicators of the abundance returning to the river mouth. This abundance based approach, using the Upriver Spring Chinook salmon stock for both treaty and non-treaty fisheries, provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. In the case of each ESU, the respective increase in status indicates this approach is contributing to the survival and recovery of each ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in either ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Productivity of both ESUs has improved. This is clear for all populations in the UCR spring-run Chinook Salmon ESU. In our review of status above, that productivity in 13 of the Snake River spring/summer-run Chinook salmon ESU has also improved, and that while productivity in 10 of the remaining populations decreased, seven of these populations experienced increased abundances. This indicates that while more natural-origin fish are making it to the spawning grounds, there is a density dependent effect that continues to limit the productivity of these 10 populations, but overall productivity is still positive and improving. The proposed action will contribute to alleviating this through fisheries removing surplus hatchery fish bound for these terminal areas. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for either of these ESUs given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of these ESUs, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for either of these ESUs for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of Snake River spring/summer-run Chinook salmon or UCR spring-run Chinook salmon or appreciably reduce the value of designated critical habitat.

2.7.3.3 Snake River Sockeye Salmon ESU

NMFS' recent review affirmed the status of this ESU as endangered (NWFSC 2015). In NMFS' 2011 status review update for Pacific salmon and steelhead listed under the ESA (Ford 2011), it was not possible to quantify the viability ratings for Snake River sockeye salmon. Ford (2011) determined that the Snake River sockeye salmon captive broodstock-based program has made substantial progress in reducing extinction risk, but that natural production levels of anadromous returns remain extremely low for this species.

In the most recent 2015 status update, NMFS determined that at this stage of the recovery efforts, the ESU remains at high risk for both spatial structure and diversity (NWFSC 2015). At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural program (NMFS 2015c). There is some evidence of very low levels of early timed returns in some recent years from out-migrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015).

The status of Snake River sockeye salmon is also likely to be affected by climate changes. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the Snake River Sockeye Salmon ESU. Because of the location of the ESU in the Snake River Basin and its life history, it is likely to be more affected by climate related effects in the mainstem affecting migration. Because sockeye yearling smolts spend a year in the freshwater rearing environment the ESU may be subject to additional affects from climate change at the stream ecosystem level.

The survival and recovery of Snake River sockeye salmon depends on our ability to rebuild the runs from near-extinction levels and improve overall survival to the point that they become self-sustaining. The initial effort to rebuild the run depends primarily on the success of the captive broodstock and reintroduction program. The year 2000 was the first year of substantial return from this experimental program, with a return of Snake River sockeye salmon to terminal areas in Idaho of 257. The returns from 2000-2008 averaged 193 salmon, ranging from 20 to 978 fish. Since 2008, from 2008-2016 returns averaged 1,566 sockeye salmon, ranging from 512 to 2,925 (TAC 2017, Table 3.3.28). The broodstock program has demonstrated its ability to be self-generating and has accumulated a backlog of broodstock and juveniles that can generate a continuing stream of adult returns if the program continues to prove successful. The initial success helps establish that the captive broodstock program can be used to rebuild the run to the point that it can begin to establish a natural reproduction cycle. A necessary next step will be to evaluate whether the returning adults can spawn successfully with sufficient productivity to be self-sustaining. Additionally, increased hatchery sockeye production in the Snake River Basin has been considered previously through an ESA evaluation, pursuant Section 4(d), and as a result increased releases of hatchery reared sockeye to boost abundance to releasing 1,000,000 smolts into Redfish Lake Creek, and approximately 400 adults released into Redfish and/or Pettit Lakes would not likely to jeopardize the continued existence of Snake River sockeye salmon or destroy or adversely modify its designated critical habitat (NMFS 2013d). This action is already underway, as indicated by Table 2-81 in Section 2.4.4.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected Snake River sockeye salmon and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on Snake River sockeye salmon. Regarding hatchery effects to Snake River sockeye salmon, The hatchery program was initiated in 1991, and the Snake River Sockeye Salmon ESU might now be extinct if not for the hatchery program (NMFS 2013d). The hatchery program is expected to accelerate recovery of the Snake River Sockeye Salmon ESU by increasing the number of natural-origin spawners faster than what may occur naturally (NMFS 2013d). In addition, the sockeye salmon hatchery program will continue to provide a genetic reserve for the Snake River Sockeye Salmon ESU to prevent the loss of unique traits due to catastrophes.

Although all these factors may have contributed to the listing of the ESU, all have also improved in the way they are managed/operated. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations). Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for interdam loss on ESUs that pass through mainstem Columbia and Snake rivers hydrosystem dams and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Similar to other ESUs that pass through Zone 6 (Figure 1-1), policy commitments have provided guidance for consultations on fisheries, particularly as NMFS sought an appropriate balance between trust obligations and the imperative of meeting the conservation needs of the listed species. The policy commitment and guidance related to treaty rights was reiterated in other documents and correspondence, including the All-H paper (Caucus 2000) and subsequent consultations on harvest. Federal court decisions have clarified that the tribes have a treaty right to harvest up to 50% of the harvestable surplus of fish passing through a tribes' usual and accustomed fishing areas.

The expected combined harvest rate on Snake River sockeye salmon in the proposed fisheries is from 2.8-8.0% based on possible range of run size projections (Table 2-95). The proposed 2018 Agreement fisheries are subject to a maximum harvest rate limit of 8.0%. Non-treaty fisheries are limited to a maximum harvest rate of 1%. Treaty fisheries are managed subject to a maximum harvest rate of 5% or 7%, depending on the anticipated return of upriver sockeye runs. Fisheries managed under these same provisions since sockeye were first listed in 1991 have resulted in harvest rates below those allowed. The total harvest rate over the last 5 years has averaged 6.3%. While the proposed fisheries will therefore reduce the number of returning sockeye through the expected harvest rate and thereby reduce proportionally future reproduction since there will be fewer potential spawners, the distribution of the species will not be affected by the proposed fisheries.

The effects of harvest activities on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River. The gear that are used include hook-and-line, seines, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for Snake River sockeye salmon.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations are currently now aligned with the recovery plan (NMFS 2015c), primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on Snake River sockeye salmon. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Overall, the recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. An important first step towards that objective has been the successful establishment of anadromous returns from natural-origin Redfish Lake resident stock gained through a captive broodstock program. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the areas upstream, like the upper Snake River, not subject to the 2018 Agreement. The 2008-2015 average escapement levels reviewed in Table 2-63 take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on Snake River sockeye salmon in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to the Snake River Sockeye Salmon ESU will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for this ESU. These changes in factors that were prior limitations on VSP criteria for this ESU are now resulting in higher levels of abundance that are likely to continue for the next 10 years, albeit within biologically occurring variation. Although the endangered Snake River Sockeye Salmon ESU must make substantial progress before it will meet the biological viability criteria (i.e., indication that the ESU is self-sustaining and naturally producing and no longer qualifies as a threatened species), annual returns of sockeye salmon through 2016 show that more fish are returning than before initiation of the captive broodstock program which began soon after the initial ESA listing. For example, the total ESU was averaging numbers of fish below a hundred prior to 2008, whereas after they averaged over 1,500 (Table 2-63). The current increases reflect substantial positive changes in biological status.

Our experience with the proposed action, which extends the harvest policies implemented over the last ten years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for large progress in rebuilding this particular ESU as indicated by the current status of the Snake River sockeye salmon ESU. The harvest management restrictions in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management which is consistent with the recovery strategy (NMFS 2015c). Current harvest, while still an adverse effect, is not negatively affecting the continued existence of this ESU in terms of survival, either short or long term. Here, we have a clear example of the benefit of abundance based management, where with increasing abundance the harvest rate average has increased since 2008 compared to what it was in the prior decade, but a slight increase tailored to abundance still contributed to a rebuilding effort within the context of other improvements..

The proposed action's response to climate change is precautionary. Given the current circumstances, future decisions about the rate of harvest on this ESU align with indicators of the abundance returning to Bonneville Dam. This abundance based approach reduces harvest during years of low abundance and provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. The respective increase in status indicates this approach is contributing to the survival and recovery of this ESU within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in the ESU's ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Improvement in individual population productivity for the ESU is difficult to determine with current data sources. What is clear for the populations we currently have data for in the Snake River Sockeye Salmon ESU is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. We expect productivity and spatial expansion of sockeye salmon to occur as their general abundance increases result in colonization of areas currently devoid or lacking sockeye salmon. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for the Snake River Sockeye Salmon ESU given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of the ESU, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for this ESU for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of Snake River sockeye salmon or appreciably reduce the value of designated critical habitat.

2.7.3.4 Snake River and Upper Columbia River Steelhead DPSs

NMFS' recent review affirmed the status of these DPSs, respectively, due to their individual risks of extinction as threatened (NWFSC 2015). They are combined here as they are managed as aggregate stocks in the 2018 Agreement, allowing us to evaluate them collectively, but taking account of their status and environmental baseline and cumulative effects independently.

Snake River Basin Steelhead DPS status

NMFS' recent five-year status review (NWFSC 2015) has improved our understanding regarding Snake River steelhead life history expressions and adaptation to varying natal habitat conditions. As explained previously, Snake River steelhead were historically commonly referred to as either "A-Index" or "B-Index" based on migration timing and differences in age and size at return. A-

Index steelhead occur throughout the steelhead-bearing streams in the Snake River basin and inland Columbia River, while research indicates that B-Index steelhead are found primarily in the Clearwater River basin and the lower and middle Salmon River basin (NWFSC 2015) (Table 2-65).

Based on its 2015 review, the NWFSC determined that some Snake River steelhead populations support both A-Index and B-Index life history expressions (NWFSC 2015). The NWFSC updated the Snake River steelhead life history pattern designations based on initial results from GSI studies of natural-origin returns (e.g. Ackerman et al. 2014; Vu et al. 2015). Using this new information, the NWFSC designated the populations as A-Index or B-Index based on length (less or more than 78 cm), but further assigned the populations with both A-Index and B-Index steelhead to different categories reflecting their mixtures of the run types (NWFSC 2015). The NWFSC determined that all but one of the populations previously designated by the ICTRT as A-Index steelhead populations had no or negligible B-Index returns and should remain as A-Index populations (Table 2-65). It reassigned the Lower Clearwater River population as a B-Index based on analyses showing a mix of A-Index and B-Index steelhead in the population. The remaining populations were assigned to one of three different B-Index categories reflecting the relative contribution of fish exceeding the B-Index size threshold (High >40%, Moderate 15 to 40%, Low <15%) (NWFSC 2015). It is worth emphasizing that populations are designated as B-Index because a significant proportion of the returns are B-Index type fish, but the populations are nonetheless a mix of A-Index and B-Index fish.

The status of Snake River steelhead is therefore correctly expressed as a total population estimate rather than A- or B-Index components. Table 2-67 indicates that steelhead in the Clearwater and Salmon Rivers have increased from a roughly 13,000 steelhead spawning abundance aggregate to 15,100 steelhead in 2016. Over the course of the previous 2008 Agreement, it is uncertain if fish from populations that tend to meet the B-Index categorization in the Snake River continued to exhibit characteristics that still categorized them as B-Index, or if they transitioned to A-Index criteria but it is clear total abundance of Snake River DPS steelhead increased indicating harvest management in the mainstem Columbia River is allowing increasing numbers of fish to return to the DPS.

Four out of the five MPGs are not meeting the specific objectives in the Snake River Recovery Plan (NMFS 2017n), and the status of many individual populations remain uncertain. The additional monitoring programs instituted in the early 2000s to gain better information on natural-origin abundance and related factors have significantly improved the ability to assess status at a more detailed level. The new information has resulted in an updated view of the relative abundance of natural-origin spawners and life history diversity across the populations in the DPS. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms (i.e., A-Index versus B-Index). A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations. The most recent five year geometric mean abundance estimates for the two long term data series of direct population estimates (Joseph Creek and Upper Grande Ronde Mainstem) were both increased over the prior review estimates (NWFSC 2015). Each of the populations increased an average of 2% per year over the past 15 years (NWFSC 2015). Hatchery-origin spawner estimates for both populations continued to be low. Both populations are approaching the peak abundance estimates observed in the mid-1980s (NWFSC 2015). Table 2-67 indicates increasing spawner abundances for all populations where data currently exists. However, while increases in abundances are a positive development,, overall, the information analyzed for the 2015 status review does not indicate a change in biological risk status (NWFSC 2015).

UCR Steelhead DPS status

All extant natural populations are considered to be at high risk of extinction (Table 2-70) based on the recent five-year status review (NWFSC 2015). The high risk ratings for SS/D are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery-origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations. UCR steelhead populations have increased in natural-origin abundance in recent years, but productivity levels remain unchanged (Table 2-71). The UCR steelhead populations sizes have increased relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remain below viability thresholds for three out of the four populations (Table 2-71). In 2015, the five-year review for the UCR steelhead concluded the species should maintain its threatened listing classification (NWFSC 2015).

Snake River steelhead populations are designated as both A-Index and B-Index, while UCR steelhead are primarily only A-Index stock (see Table 2-89 for stock definitions).

The status of both DPSs is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle, as described in Section 2.2.7. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations).

As explained in Section 2.2.7, Climate Change, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in these two steelhead DPSs. Because of their locations in the Columbia River Basin and relatively similar life histories, each DPS is likely to be more affected by climate related effects in the mainstem affecting migration. Because of their life history, yearling smolts spend a year in the freshwater rearing environment, and each DPS may be subject to additional affects from climate change at their respective stream ecosystem levels.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected Snake River steelhead and UCR steelhead and contributed to their current status. The environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on Snake River and UCR Steelhead DPSs. Regarding changes in hatchery effects to each DPS, first for the UCR Steelhead DPS, the hatchery programs funded by the public utility districts were reduced in size starting in 2014 because of a revised calculation of their mitigation responsibility bases on increased survivals through the Upper Columbia dams. Reducing hatchery production has reduced pHOS and associated genetic risk from steelhead that might stray into UCR steelhead populations. It has also reduced the number of natural-origin fish removed for the hatchery broodstocks. Also, as a result of site specific consultations now completed (see Table 2-81), several additional reform measures have been implemented including the following:

- There has been a change in the use of water at Leavenworth National Fish Hatchery, which has provided more stream flow in Icicle Creek in summer months, which has reduced the potential for dewatering; therefore, reducing risks to the UCR Steelhead DPS.
- The Methow component of the Wells Complex steelhead program made changes in their broodstock (i.e., developed a “stepping stone” program) to better link their hatchery fish genetically to natural-origin steelhead.
- Changes were made in the management of adult hatchery-origin steelhead returning to the Wenatchee River basin, which reduced pHOS and genetic risk to the UCR Steelhead DPS.

Second, for changes in hatchery effects to Snake River Basin steelhead, NMFS concluded in its 2017 site-specific biological opinion that straying is low for all of the segregated harvest steelhead programs in the Snake River basin, and is not expected to affect the abundance, productivity, diversity or spatial structure of the DPS because of the low potential for interbreeding and competition for spawning space between hatchery and natural-origin steelhead (NMFS 2017h). The East Fork Salmon River Natural program is the only integrated program. Genetic effects on the East Fork population are limited by the use of natural-origin broodstock, and an expected PNI of < 0.5 on average is a reasonable target for a population targeted for “maintained” in the recovery scenario (NMFS 2017n) and is likely to benefit the DPS through increased abundance and productivity for the East Fork population.

Although all of the factors considered in the environmental baseline have contributed to the listing of these DPSs, all have improved in the way they are managed and operated. As we continue to deal with a changing climate, adaptive management of these factors may also help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve for natural populations). Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for interdam loss on DPSs that pass through mainstem Columbia and Snake rivers hydrosystem dams and incorporate its effect in the environmental baseline.

Proposed actions for FCRPS in 2019 and beyond have not yet been the subject of consultation. Under our section 7 regulations, such future Federal actions are not considered in our jeopardy analysis. Nevertheless, because this is an on-going action, we anticipate that the effects of the FCRPS operations and associated actions would be similar to, or more protective than, those considered under the 2014 RPA.

Harvest mortality has been reduced substantially in response to evolving conservation concerns. Steelhead impacts associated with fall season treaty fisheries were managed from 1986 to 1998 pursuant to the guidelines contained in the now expired CRFMP. That plan allowed for a tribal harvest rate on B-Index steelhead during the fall season of 32%. The 32% cap was itself a reduced fishing level designed at the time to provide necessary protection to B-Index steelhead. The average B-Index harvest rate from 1985 to 1997 was 26.0%. Since 1998, when ESA constraints specific to B-Index steelhead were first applied, the harvest rate in the tribal fall season fishery averaged 11.5%. The 15% harvest rate cap represented a 42% reduction from the long-term average harvest rate for the tribal fishery, and a 53% reduction from the CRFMP allowed harvest rate of 32%. The expected harvest rate on B-Index steelhead in treaty fisheries under the 2018 Agreement is 3.4-15%.

Significant management actions in non-treaty fisheries related to steelhead occurred 40 years ago. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Prior to efforts during the last few years to promote commercial selective fisheries, time, area, and gear restrictions limit handling and mortality of steelhead by the non-treaty fishery to less than 2% of the run. In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10% will die from resulting injuries.

Similar to our previous discussions for other ESUs that pass through Zone 6 (Figure 1-1), policy commitments have provided guidance for consultations on fisheries, particularly as NMFS sought an appropriate balance between trust obligations and the imperative of meeting the conservation needs of the listed species. The policy commitment and guidance related to treaty rights was reiterated in other documents and correspondence, including the All-H paper (Caucus 2000) and subsequent consultations on harvest. Federal court decisions have clarified that the tribes have a treaty right to harvest up to 50% of the harvestable surplus of fish passing through a tribes' usual and accustomed fishing areas. A review of the baseline unrestrained Native American fish harvest and consumption illustrating the expectation of the reservation of the treaty fishing right during treaty negotiations in the mid-1850's was presented in Section 2.4.5.2, Columbia River Mainstem Harvest. Non-treaty fisheries are second in priority to treaty fisheries when it comes to conservation restriction, and are therefore the fisheries that are first limited by conservation constraints. But here too NMFS will seek, as a matter of similar considerations, to provide some opportunity to access harvestable fish if the states and tribes can resolve critical questions related to allocation and with the provision that the impacts are very limited and all possible measures are taken to minimize the incidental impacts to listed species. The implementation of steelhead mass-marking and selective, non-retention fisheries by the states serves as an example. Even so, the associated impacts must be accounted for and held to acceptable levels.

The effect of fisheries managed under the 2018 Agreement on natural-origin populations returning to the Snake River and UCR DPSs are discussed in detail in Section 2.5.1.3. The harvest rate limit proposed in the 2018 Agreement for non-treaty fisheries is 2% during the summer and subsequent winter and spring season fisheries (Figure 2-25). During the fall management period beginning August 1, there is a second 2% harvest rate limit on the natural-origin component of each Index (Figure 2-25). This fall harvest rate limit extends to fish caught from November 1 through December 31 in fisheries upstream of The Dalles Dam (Figure 2-25). The B-Index limit includes fish that may seek thermal refuge and dip into tributary mouths in the following areas: Drano Lake at the mouth of the Little White Salmon River, the lower Wind River, the lower Deschutes River (upstream to Sherars Falls), and the John Day River Arm of John Day Reservoir, which are added into the harvest rate annually. In total, each Index is subject to a maximum 4% harvest rate limit on natural-origin steelhead each run year. The yearly non-treaty harvest rate of unclipped A-Index steelhead in fisheries has averaged 1.9% and 2.0% for unclipped B-Index steelhead since 2008 (TAC 2017, Table 3.3.56).

Proposed treaty Indian fall season fisheries will be managed using the abundance based harvest rate schedule for B-Index steelhead. B-Index steelhead are therefore used as the indicator stock used for management purposes. This management approach was implemented because B-Index steelhead were generally considered to be the weaker stock and the most vulnerable to the treaty Indian fall fisheries due to their later timing, larger size, and upstream location which requires them to pass through the full range of fall season fisheries. A-Index steelhead, whether from the UCR, Snake River or other DPSs, benefit from the protections provided to B-Index steelhead because they are subject to relatively lower harvest rates, again because of their smaller size, and earlier timing.

Treaty Indian fisheries affecting B-Index steelhead will be managed using the agreed abundance-based harvest rate schedule (Table 2-98) in the fall management period. There are no explicit harvest management constraints on treaty Indian fisheries during the winter, spring, or summer seasons. The catch of steelhead during these periods occur during fisheries directed at other species and is generally quite low. The harvest rate on A-Index and B-Index steelhead during Treaty Indian winter/spring fisheries averages 0.1% and 0%, respectively. Summer fishery harvest rates have averaged 1.5% on unclipped A-Index and 2.4% on unclipped B-Index fish (Table 2-99). The harvest rate in fall fisheries averaged 6.5% on A-Index fish and 17.9% on B-Index fish since 2008. Annually harvest rates in the treaty Indian fisheries averaged 8.1% on A-Index fish and 20.2% on B-Index steelhead.

There are also limits proposed for treaty tributary fisheries affecting UCR steelhead in the Wenatchee River (Section 2.5.1.4). The proposed harvest rate limit for Icicle Creek is 0.5% per year. The limit would be a conservative approach to management because it is responsive to restricting tributary fisheries to lower numbers of fish harvested during years of low returns.

Proposed harvest rates on the populations are expected to be unchanged from recent historical levels as described in Section 2.4.5.3. Escapement information for these populations is limited but, based on available information (Table 2-67 and Table 2-69), the status of the populations related to abundance is improving, and has improved from 2008, and given the proposed fisheries and associated limits are not going to deviate from historical levels that allowed the status of these populations to increase along with the limit being adjusted to be more responsive during years of low returns indicates this approach is contributing to the survival and recovery of UCR steelhead populations.

In 2017, Columbia River Basin hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin. This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in NMFS' 1999 Hatchery Opinion (NMFS 1999e). There are no additional effects from the aggregate release of all of the hatchery releases included in the 2018 Agreement's production tables that were not considered in the site-specific consultations on HGMPs. The 2018 Agreement includes tables with production levels, release locations, and marking strategies, but it does not include the details of how the hatchery programs are operated. Therefore, NMFS evaluated hatchery production in site-specific consultations that are informed by detailed HGMPs for each hatchery program. Completing the section 7 consultations at a site-specific level allowed NMFS to understand the comprehensive effects of the hatchery programs that are included in the production tables of the 2018 Agreement (e.g., the effects of broodstock collection, competition, predation, and water withdrawals). These effects are described in detail within each of the biological opinions referenced in the environmental baseline (see Table 2-81). Those analyses are incorporated and an overview of effects are summarized as part of Section 2.4.4. In addition, a detailed description of how hatchery programs affect ESA-listed salmon and steelhead can be found in Appendix C. Additionally, hatchery operations in both DPSs are currently now aligned with their respective recovery plans, primarily by ensuring that the allowable level of genetic effects permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments.

The effects of harvest activities in the proposed action on critical habitat as indicated by the PCEs occur from boats or along the river banks, mostly in the mainstem Columbia River, but also in the Snake River up to the Washington/Idaho border during spring. The gear that are used include hook- and-line, drift and set gillnets, and hoop nets. These types of gear minimally disturb streambank vegetation or channel substrate. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for UCR or Snake River steelhead.

Considerations related to cumulative effects provide further perspective about future state or private activities and their effect on the Snake River and UCR Steelhead DPSs. Habitat restoration efforts are supported by Federal funding sources providing state, and local agencies; tribes; environmental organizations; and local communities additional opportunities to complete projects. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are reviewed in Section 2.4.3, Habitat Effects. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. Completion of habitat restoration projects, as reviewed in Section 2.4, Environmental Baseline, has occurred annually, albeit at sporadic intervals and scale, rather than consistent, evenly measured out intervals and scale. This pattern is likely due to funding variances and the time it takes to complete projects. The frequency, level of commitment, and interest in completing these projects indicates this pattern will continue. However, we do not factor in or rely on these beneficial effects in our jeopardy analysis.

Finally, in terms of cumulative effects, activities likely to continue include commercial and sport fisheries in the areas upstream, like the UCR and upper Snake River, not subject to the 2018 Agreement. The 2008-2016 average escapement levels reported in Table 2-67 for Snake River Basin steelhead and Table 2-69 for UCR steelhead take into account the anticipated effects of this harvest. NMFS also anticipates that human activities that are included as part of cumulative effects will continue to have adverse effects on Snake River Basin and UCR steelhead in the action area, but to a lesser extent than they have in the past and certainly lower than the positive effects to VSP criteria we expect from improvements to the baseline.

NMFS is certain that benefits to both Snake River Basin and UCR Steelhead DPSs will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions and site specific hatchery program ESA-reviews contribute to an overall upward trend in average escapement levels reported for each DPS. These changes in factors that were prior limitations on VSP criteria for each DPS are now resulting in higher VSP scores that are likely to continue for the next 10 years, albeit within biologically occurring variation. For example, in the Snake River steelhead DPS Table 2-67 indicates that steelhead in the Clearwater and Salmon Rivers have increased from a roughly 13,000 steelhead spawning abundance aggregate to 15,100 steelhead in 2016. As mentioned throughout this document, steelhead exhibit the most complex life history of all salmonids. While this increase is important for populations that are known to have higher proclivities for exhibiting a B-Index life history, that does not mean they returned in those years as B-Index fish. As mentioned in Section 2.2, steelhead life history can be viewed as a ‘‘developmental conflict’’ whereby juvenile steelhead are faced with three distinct possibilities every year: 1) undergo smoltification, followed by migration to the ocean; 2) begin maturation and attempt to spawn as a resident fish in the following winter (precocial residuals); and 3) remain in freshwater (natal streams, other tributaries, or the main channel of large rivers such as the Columbia River, etc.) and revisit these options in the following year (residuals, collectively). These possibilities represent a case of biological developmental plasticity where adoption of one of these three life-history strategies is initiated through the interplay of phenotypic expression with environmental and biological cues. The choice to take any one of these pathways eventually leading to adulthood as either an A- or B-Index fish is therefore complex and it is more appropriate to judge the effect of the proposed action on total population estimates. Similarly, the UCR Steelhead DPS from 2008-2016 experienced an increase in each population’s natural spawning abundance, for which both the Methow and Okanogan river populations doubled their average annual spawning abundance from the prior 10 years (Table 2-69). The current VSP scores reflect both changes in biological status and improved monitoring.

Our experience with the proposed action, which extends the harvest policies implemented over the last 10 years and adopts production programs that have now gone through site specific ESA-review processes, informs our expectation for performance into the future. It is clear the improvement to the environmental baseline, both in hydrosystem modification and habitat restoration, coupled with significant harvest reductions from historic levels, have allowed for progress in rebuilding as indicated by the respective improved status of the Snake River Basin and UCR Steelhead DPSs. Abundance based management in treaty fisheries coupled with low fixed harvest rates in non-treaty fisheries in the baseline restricted fish harvested in years of low abundance contributing to increased natural-origin fish escapements. The proposed action proposes to continue this approach for current harvest management which is consistent with both the recovery strategies for Snake River Basin (NMFS 2017n) and UCR Steelhead DPSs (UCSRB 2007), respectively. Current harvest, while still an adverse effect, is not negatively affecting the continued existence of each DPS in terms of survival, either short or long term. Hatchery production at the proposed action scale, while also responsible for some adverse effects, has also undergone substantive changes due to site specific ESA-review processes that result in improvements to hatchery practices that we expect will lead to similar increases in status as we move forward.

The proposed action’s response to climate change is precautionary. Given the current circumstances, future decisions about the rate of harvest on both the Snake River and UCR Steelhead DPSs restrict treaty fisheries during years of lower returns of B-Index steelhead based on the expected abundance to reach Bonneville Dam. Non-treaty fisheries are managed using selective catch regulations and low harvest rates that are fixed regardless of run size. This abundance based approach provides for more harvest opportunity only in response to year-specific circumstances. This type of management is responsive to environmental changes, resulting from climatic change or other periodic or persistent events, as the number of fish harvested is lower in years of low abundance. In the case of each DPS, the respective increase in status indicates this approach is contributing to the survival and recovery of each DPS within changing climatic conditions.

Projecting out over 50 years, the proposed action does not appreciably reduce the likelihood of recovery. The record clearly shows there has not been a reduction in either DPSs’ ability to reproduce, nor is there a decreasing trend line in status, and distribution of the populations are not restricted or modified in a measurable way that would alter their ability to recover. Productivity of one DPS is more clearly assessed than the other. Productivity for the populations in the UCR Steelhead DPS are relatively unchanged since the last status review. Data on productivity estimates for Snake River Basin steelhead are currently limited. What is clear for the large majority of populations in both DPSs is increased abundance. Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations. This indicates more natural-origin fish are currently making it to the spawning grounds, and the proposed action will continue to contribute to increasing productivity through fisheries removing surplus hatchery fish bound for terminal areas that may be contributing to density dependent effects. Therefore, implementing the terms of the proposed action will not appreciably reduce the likelihood of recovery for either of these ESUs given the improved conditions in the environmental baseline, the cumulative effects, and mechanisms (e.g., abundance based harvest management and improved site specific hatchery practices) that are responsive to the uncertainties of climate change. Although limited data does not allow for a precise long-term prediction, we have nevertheless projected out 50 years and have determined that the proposed action does not appreciably reduce the likelihood of recovery. We acknowledge the effects of climate change will adversely affect the status and environmental baseline of these ESUs, but there is uncertainty in the level. While there is uncertainty in our projection created by climate change effects we do not believe this alters our conclusion that the proposed action will not appreciably reduce the likelihood of recovery for either of these ESUs for the reasons already provided. An additional benefit of the 10-year term of the 2018 Agreement, is that it provides an opportunity to test the assumption that the status of the species in continuing to improve as expected.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of Snake River Basin or UCR steelhead or appreciably reduce the value of designated critical habitat.

2.7.4 Non-salmonid DPSs

2.7.4.1 Green Sturgeon - Southern DPS

To assess the effects of the proposed action on the survival and recovery of Southern DPS green sturgeon, we consider the effects on abundance, productivity, spatial structure, and diversity. The proposed action is not likely to further restrict the spatial structure of the species (e.g., extent of spawning habitat, geographic distribution along the coast), but may reduce the population abundance if individuals are killed as a result of being caught in the fishery and/or in research and monitoring activities. We considered these effects within the context of the status of the species and environmental baseline.

As described above in the "Rangewide Status of the Species and Critical Habitat" section, we conclude that Southern DPS green sturgeon are at moderate risk of extinction because of the low estimated adult abundance, restriction of spawning to one segment of the mainstem Sacramento River (and more recently confirmed in the lower Feather River), and potentially reduced productivity and genetic diversity due to the population's low abundance and restricted spawning habitat. However, there is uncertainty regarding the species' status because of the lack of information regarding productivity and abundance.

With respect to threats, the available information indicates that some threats, such as those posed by fisheries and impassable barriers, have been reduced. The prohibition of retention in commercial and recreational fisheries has reduced a known threat and likely had a very positive effect on the overall population, although incidental catch still occurs. Current levels of green sturgeon catch in fisheries are much reduced compared to historical levels, but continue to impose additional mortality on the species. In the fisheries for which data are available (excluding the proposed fishery), we estimate that up to 492 to 1,241 Southern DPS green sturgeon (adults and subadults) are incidentally captured each year. This represents an estimated

3 to 16% of the total adult and subadult population, depending on if we use the high estimates of abundance (i.e., 18,537 subadults and adults, combined) or the low estimates of abundance (i.e., 7,786 subadults and adults, combined). We also estimate that up to 24 to 90 Southern DPS green sturgeon (adults and subadults) may be killed each year because of incidental capture in the fisheries. This represents additional mortality of 0.1 to 1.2% on the combined subadult and adult population.

Beamesderfer et al. (2007) estimated that additional mortality of 5 to 10% on subadults to small adult life stages, or additional mortality of 7 to 25% on adults would reduce the species' reproductive potential below the minimum needed to maintain (20% of maximum potential; Goodyear 1993) or rebuild (50% of maximum potential; Boreman et al. 1984) sturgeon populations. Based on this, the estimated additional mortality imposed by incidental catch in these fisheries (excluding the proposed fisheries) is not likely affecting the continued survival and recovery of Southern DPS green sturgeon. There is a high degree of uncertainty regarding these estimates. Incidental catch may be overestimated, due to the use of historical data when green sturgeon catch levels were higher, or the potential for individual fish to be recaptured in the same or different fisheries. The population abundance of Southern DPS fish may also have been underestimated, because the estimates do not account for spawning adults in the lower Feather and lower Yuba Rivers. Additional information is needed to more accurately assess the effects of the status, environmental baseline, and cumulative effects on Southern DPS green sturgeon for future analyses.

Take of green sturgeon in the proposed fishery would occur from incidental catch in non-treaty recreational and commercial fisheries. Fishing regulations in Washington and Oregon for commercial and recreational fisheries prohibit retention of green sturgeon, though some retention occurs due to misidentification of green sturgeon as white sturgeon. As anglers become more proficient at identifying green sturgeon, mistaken retention numbers have decreased. Thus, lethal take in the proposed fishery may occur as a result of retention due to misidentification, as well as post-release mortality.

Incidental catch of green sturgeon in the recreational fisheries is not expected to exceed (and would likely be lower than) 250 green sturgeon per year, resulting in up to an estimated 17 green sturgeon mortalities per year. Of these, 80% (200 fish captured and 14 fish killed) are estimated to belong to the Southern DPS. Incidental catch of green sturgeon in the commercial fisheries is not expected to exceed (and would likely be lower than) 350 green sturgeon per year, resulting in up to an estimated 18 green sturgeon mortalities per year (TAC 2017). Of these, 80% (280 fish captured and 15 fish killed) are estimated to be from the Southern DPS. The total annual take of Southern DPS green sturgeon associated with fisheries implemented as part of the proposed action is estimated to be up to 480 fish captured (representing 2.6 to 6% of the total subadult and adult population combined) and 29 fish killed (representing 0.2 to 0.4% of the total subadult and adult population combined) per year. Green sturgeon are not known to occur upstream of Bonneville Dam and would not be impacted by treaty Indian fisheries (TAC 2008).

Incidental catch of Southern DPS green sturgeon as a result of white sturgeon gillnet tagging studies in the lower Columbia River is not expected to exceed 39 fish per year, resulting in up to an estimated two mortalities per year. This represents incidental catch of up to 0.2 to 0.5% of the total adult and subadult population combined and additional mortality of 0.01 to 0.03% per year on the Southern DPS population (TAC 2017). Catch of Southern DPS green sturgeon as a result of green sturgeon gillnet tagging studies in the lower Columbia River is not expected to exceed 63 fish per year, resulting in up to an estimated 3 mortalities per year. This represents incidental catch of up to 0.3 to 0.8% of the total adult and subadult population combined and additional mortality of 0.02 to 0.04% per year on the Southern DPS population (TAC 2017).

Overall, adding the effects of the proposed action to the status, environmental baseline, and cumulative effects would result in a comparatively small increase in the mortality imposed on the subadult and adult Southern DPS green sturgeon population. Sublethal effects resulting from incidental capture and release may affect the behavior (e.g., movements, feeding) of individuals, but the effects are expected to be temporary and short-lived.

After reviewing the effects of the implementation of the 2018 Agreement, the environmental baseline, and any cumulative effects, NMFS determines that the proposed action will not cause deterioration in the pre-action condition for the species. NMFS therefore concludes that implementation of the 2018 Agreement is not likely to jeopardize the continued existence of the Southern DPS of green sturgeon.

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, implementation of the 2018 Agreement, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the LCR Chinook Salmon, LCR Coho Salmon, UWR Chinook Salmon, Columbia River Chum Salmon, Snake River fall-run Chinook Salmon, UCR spring-run Chinook Salmon, Snake River spring/summer-run Chinook Salmon, and Snake River Sockeye Salmon ESUs, and the LCR Steelhead, UWR Steelhead, MCR Steelhead, UCR Steelhead, and Snake River Basin Steelhead DPSs, and the Southern DPS green sturgeon and or destroy or adversely modify their 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 endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

The take of the ESA-listed species will occur as a result of proposed fisheries managed pursuant to the 2018 Agreement. The incidental take occurs as a result of catch and retention, or mortalities resulting from catch and release, or mortalities resulting from encounter with fishing gear, as a consequence of fishing activity, or RM&E performed as part of the proposed action. In some cases, fisheries are managed subject to specific *incidental take limits* for an ESU, DPS, or a specific stock component. These may be fixed, as is the case with incidental take limits for steelhead in non-treaty fisheries, or may vary from year-to-year depending on application of an abundance-based harvest rate schedule, as is the case with Snake River spring/summer-run Chinook and Snake River fall-run Chinook salmon, for example. For other ESUs, DPSs, or stock components there are no specified limits. Instead, NMFS characterizes the *expected incidental take* that will occur associated with the proposed fisheries as a range based on observations from recent years. In some cases, the expected incidental take is less than the specified incidental take limit for a stock component due to conservative management. The incidental take limits and expected incidental take levels are expressed in terms of harvest rates unless indicated otherwise and are shown in Table 2-102 and Table 2-103.

Table 2-102. Incidental take limits of listed salmonids for non-treaty and treaty Indian fisheries under the 2018 Agreement expressed in terms of harvest rates unless otherwise indicated.

ESU or DPSs	Total Take Limits (%)	Treaty Indian (%)	Non-Treaty (%)
Lower Columbia River Chinook Salmon			
Spring Component	Managed For Hatchery Escapement Goals[1]	[1]	[1]
Tule Component (LRH stock)	30.0 - 41.0[2,3] Exploitation Rate	30.0 - 41.0[2,3] Exploitation Rate	
Bright Component (LRW stock)	Managed For Escapement Goal[3]	5,700 goal	
Lower Columbia Coho Salmon	10.0 - 30.0[2,3,4] Exploitation Rate	10.0 - 30.0[2,3,4] Exploitation Rate	
Willamette River Spring Chinook Salmon	15.0[3]	15.0[3]	
Upper Willamette River Steelhead	2.0[5]	[5]	2.0[5]
Lower Columbia River Steelhead			
Winter component	2.0[5]	[5]	2.0[5]
Summer component	4.0[6]	[6]	4.0[6]

Columbia River Chum Salmon	5.0	5.0	
Middle Columbia River Steelhead			
Winter component	2.0[5]	[5]	2.0[5]
Summer component	4.0[7]	[7]	4.0[7]
Snake River Basin Steelhead			
A-Index Component	4.0[7]	[7]	4.0[7]
B-Index Component	17.0 - 24.0[2,7]	13.0 - 20.0[2,8]	2.0[7]
Snake River fall-run Chinook Salmon	21.5 - 45.0[2]	20.0 - 30.0[2]	1.5 - 15.0[2]
Snake River spring/summer-run Chinook Salmon	5.5 - 17.0[2,9]	5.0 - 14.3[2,9]	0.5 - 2.7[2]
Snake River Sockeye Salmon	6.0 - 8.0[2]	5.0 - 7.0[2]	1.0
Upper Columbia River spring-run Chinook Salmon	5.5 – 17.0[2,9]	5.0 – 14.3[2,9]	0.5 – 2.7[2]
Upper Columbia River Steelhead			
Natural-origin Component	4.0[7]	[7]	4.0[7]
Hatchery Component	[10]	[10]	[10]
Research, Monitoring, and Evaluation	0.1 – 0.5[11]		

[1] Managed for hatchery escapement goals to the Cowlitz, Lewis, and Sandy hatchery complexes.
[2] Allowable take depends on run size.
[3] Based on the recovery plan scenario, this total limit including ocean and inriver fisheries up to Bonneville Dam. Fisheries in 2018-2027 will be managed consistent with NMFS annual guidance to PFMC.
[4] Recent year (2008-2016) average harvest rates of coho salmon taken in Bonneville pool relative to the total number of coho salmon that cross Bonneville Dam are expected to remain the same (range of 3.0-8.9%, with a 5.3% average).
[5] Applies to non-treaty fisheries only. 2% total harvest rate for all combined natural-origin winter steelhead, including Lower Columbia, Upper Willamette, and Mid-Columbia DPSs. There is no specific harvest rate limit proposed for treaty fisheries on winter steelhead above Bonneville Dam, but they are expected to remain within recent (2008 – 2017) average rates (0.0 – 1.4%).
[6] Applies to non-treaty fisheries only. Lower Skamania natural-origin stock surrogate will be kept to a harvest rate of 2% between May 1 and June 30 during seasons below Bonneville Dam, and Upriver Skamania natural-origin stock will be kept to a harvest rate of 2% from April 1 through June 30 above Bonneville Dam.
[7] Applies to non-treaty fisheries only. 2% in summer seasons below the I-395 Bridge to the mouth of the Columbia River, this includes the following year's winter/spring fisheries upstream of The Dalles Dam from January 1 through June 30 into the Snake River up to the Washington/Idaho border. A 2% limit also applies in the fall season in the same area below the I-395 Bridge to the mouth of the Columbia River from August 1 to October 31, and upstream of The Dalles Dam from November 1 through December 31. There is no specific harvest rate limit proposed for treaty fisheries on A-Index summer steelhead, but they are expected to remain within recent (2008 – 2016) average rates (0.5 – 3.0%).
[8] For fall treaty fisheries only, calculated for all fisheries included in the 2018 Agreement from the mouth of the Columbia River up to the I-395 Bridge from August 1 through October 31, and then from The Dalles Dam upstream to the I-395 Bridge from November 1 through December 31.
[9] Impacts in treaty fisheries on listed natural-origin fish can be up to 0.8% higher than the river mouth runsize harvest rates (indicated in table above) due to the potential for changes in the proportion natural-origin to hatchery-origin between the river mouth and Bonneville Dam due to mark selective fisheries.
[10] There is no take prohibition on ad clipped hatchery fish even if they part of a listed group.
[11] Includes research, monitoring and evaluation that is currently in place. For Chinook and coho ESU's, the range is 0.1-0.5% for each ESU. For Steelhead DPS' and the Snake River Sockeye Salmon ESU the range is 0.1-0.3%.

Table 2-103. Expected incidental take of listed salmonids for non-treaty and treaty Indian fisheries under the 2018 Agreement expressed in terms of harvest rates unless otherwise indicated.

ESU or DPSs	Total Expected Take (%)	Treaty Indian (%)	Non-Treaty (%)
Lower Columbia River Chinook Salmon			
Spring Component	0.2 – 2.0[1]	0	0.2 – 2.0
Tule Component (LRH stock)	7.7 – 14.9[1]	7.7 – 14.9[1]	
Bright Component (LRW stock)	6.0 – 18.8[1]	6.0 – 18.8[1]	
Lower Columbia Coho Salmon	n/a	3.0 – 8.9[2]	13.3 – 24.3[3]
Willamette River Spring Chinook Salmon	5.0 – 11.0[4]	0	5.0 – 11.0[4]

Upper Willamette River Steelhead	0.2 – 1.0[5]	0	0.2 – 1.0[5]
Lower Columbia River Steelhead			
Winter component	1.6 – 7.9[5]	1.4 – 6.9	0.2 – 1.0
Summer component	4.8 – 13.4[6]	4.6 – 12.9	0.2 – 0.4
Columbia River Chum Salmon	1.6	0	1.6
Middle Columbia River Steelhead			
Winter component	1.6 – 7.9[5]	1.4 – 6.9	0.2 – 1.0
Summer component	5.0 – 14.1[7]	4.1 – 12.4	0.9 – 1.7
Snake River Basin Steelhead			
A-Index Component	5.0 – 14.1[7]	4.1 – 12.4	0.9 – 1.7
B-Index Component	14.0 – 21.8	13.0 – 20.0	1.0 – 1.8
Snake River fall-run Chinook Salmon	17.5 – 32.0	11.6 – 23.0	5.9 – 9.0
Snake River spring/summer-run Chinook Salmon	7.0 – 14.6	5.8 – 12.5	1.2 – 2.1
Snake River Sockeye Salmon	5.0 – 8.0	5.0 – 7.0	0.0 – 1.0
Upper Columbia River spring-run Chinook Salmon	7.0 – 14.6	5.8 – 12.5	1.2 – 2.1
Upper Columbia River Steelhead	5.0 – 14.1[7]	4.1 – 12.4	0.9 – 1.7
Research, Monitoring, and Evaluation	0.1 - 0.5[8]		

[1] Inriver harvest rate range based on TAC (2017) Table 5.1.9. Expected impacts may increase under new abundance based management. This includes all treaty and non-treaty fisheries in the mainstem below Bonneville.
[2] Range based on 2008-2016 observed harvest rate for treaty fisheries in the Bonneville pool relative to coho passing Bonneville Dam (TAC 2017, Table 5.1.14).
[3] Range based on TAC (2017) Table 5.1.11 harvest rates for in-river fisheries.
[4] Range of harvest rate for Columbia River mainstem fisheries only.
[5] Steelhead impacts for winter steelhead are assumed to be the same across each DPS, but there are no winter impacts upstream of The Dalles Dam.
[6] Stock surrogate is Lower River and Upriver Skamania steelhead stock.
[7] Stock surrogate is A-Index steelhead stock.
[8] Includes research, monitoring and evaluation that is currently in place. For Chinook and coho ESU's, the range is 0.1-0.5% for each ESU. For steelhead DPSs and sockeye and chum ESU's the range is 0.1-0.3% for each DPS.

Notes:
- Fisheries are normally managed in season with buffers and other conservative management measures that typically result in impacts being less than allowed ESA limits.
- Allowed take for spring Chinook, fall Chinook, B-Index steelhead, sockeye, and coho varies by run size.
- Ranges represent recent year averages.
- Steelhead harvest rates assume equal harvest rates on any DPS present in fishery.

• n/a = impacts are not additive, because of different methods of calculating harvest rates between treaty Indian and non-treaty fisheries.

2.9.1.1 Lower River Stocks

Lower Columbia River Chinook Salmon

The spring component of the LCR Chinook Salmon ESU is being managed to achieve hatchery escapement goals in the Sandy, Cowlitz, and Lewis hatchery complexes (Section 2.2.2.1). The expected incidental take in non-treaty fisheries on the spring component of the LCR Chinook Salmon ESU in mainstem Columbia River fisheries ranges from 0.2 to 2.0%. Treaty tributary fisheries will affect one Gorge MPG spring population. The 2008-2016 incidental harvest rate average for the Hood River spring Chinook salmon population is 1.9% (TAC 2017, Table 3.4.8). The treaty tributary harvest limit for Hood River spring Chinook salmon is listed below in Section 2.9.1.4. The bright component of the LCR Chinook Salmon ESU is being managed to achieve the escapement goal for the North Fork Lewis population (Section 2.2.2.1). The expected incidental take in the non-Indian fisheries on the bright component of the LCR Chinook Salmon ESU has ranged from 6.0 to 18.8% in recent years.

Harvest on the tule component of this ESU is subject to an incidental take limit, expressed as a total exploitation rate limit for all ocean and in-river fisheries below Bonneville Dam. That rate will be defined annually using the abundance-based harvest rate schedule that is based on the annual forecast of LRH stock (Table 2-90) and is specified annually through NMFS' guidance letter to the PFMC. As a result, the incidental take limit for the tule component of the LCR Chinook Salmon ESU will vary annually depending on the year specific estimates of run size. Each year, fisheries in the Columbia River will be managed, after accounting for anticipated ocean harvest, so as not to exceed the total exploitation rate limit. After accounting for anticipated harvest in ocean fisheries, the associated exploitation rate for in-river fisheries has ranged in recent years from 7.7 to 14.9%. The distribution of harvest between ocean and in-river fisheries may vary from year-to-year and inseason so long as the total exploitation rate does not exceed the year specific total. Some additional harvest occurs in fisheries above Bonneville Dam that may affect three of the four Gorge MPG fall populations. The level of harvest is undetectable although the LCR recovery plan (NMFS 2013e) identified these populations as problematic, but primarily called for additional research and monitoring before prescribing harvest rates. The plan acknowledges the uncertainties related to populations in the Gorge MPG and, as discussed in section 2.2.2.1 of the opinion, sought to address those uncertainties by putting greater emphasis on recovery of additional populations in the Cascade MPG.

Lower Columbia Coho Salmon

Fisheries affecting LCR coho salmon will be managed subject to an incidental take limit, expressed as a total exploitation rate, that will be defined annually using the harvest matrix that is based on brood year escapement and marine survival (Table 2-91) and is specified annually through NMFS' guidance letter to the PFMC. The exploitation rate limit will apply to all ocean and in-river fisheries below Bonneville Dam. Each year, fisheries in the Columbia River will be managed, after accounting for anticipated ocean harvest, so as not to exceed the specified limit. After accounting for anticipated harvest in ocean fisheries, the associated exploitation rate limit for in-river fisheries has ranged in recent years from 13.3 to 24.3%. The distribution of harvest between ocean and in-river fisheries may vary from year-to-year and inseason so long as the total exploitation rate does not exceed the year specific total. The incidental take limit of LCR coho salmon in treaty Indian fisheries above Bonneville Dam will be the recent Bonneville Pool coho catch average, as measured against the number of coho that pass Bonneville Dam, which is an average harvest rate of 5.3% but ranges from 3.0 to 8.9%. Any single year harvest rate, calculated in this manner, would be limited to 8.9%.

Willamette River Spring Chinook Salmon

Fisheries affecting UWR spring Chinook salmon will be managed subject to an incidental take limit, expressed as a total harvest rate up to 15%, including terminal freshwater fisheries outside the mainstem Columbia River.

Upper Willamette River Steelhead

The incidental take limit for non-treaty fisheries for the aggregate of winter run natural-origin populations returning to the LCR (including the UWR Steelhead DPS) DPSs is 2%, with expected incidental take ranging from 0.2 to 1.0% harvest rate. These are natural-origin steelhead harvested in the LCR between November 1 and April 30 and steelhead caught in the Bonneville Pool between November 1 and March 31.

Lower Columbia River Steelhead

The incidental take limit for non-treaty fisheries for the aggregate of winter run natural-origin populations returning to the LCR (including the LCR Steelhead DPS) DPSs is 2%, with expected incidental take ranging from 0.2 to 1.0% harvest rate. These are natural-origin steelhead harvested in the LCR between November 1 through April 30 and steelhead caught in the Bonneville Pool between November 1 and March 31.

The incidental take limit for non-treaty fisheries for the summer run natural-origin populations returning to the LCR is 2%, with an expected incidental take range of from 0.2 to 0.4% harvest rate. These are natural-origin steelhead harvested below Bonneville Dam between May 1 and June 30 each year. Additionally, there are natural-origin LCR summer steelhead that exist above Bonneville Dam, and this same take limit applies to them. These are natural-origin steelhead harvested above Bonneville Dam from April 1 through June 30.

The expected incidental take for treaty Indian fisheries on the summer component of the LCR Steelhead DPS located above Bonneville Dam ranges from 4.6% to 12.9%. Some additional tributary specific harvest occurs in fisheries above Bonneville Dam that may affect three LCR steelhead populations. In the Wind River, the 2008-2016 average effect of the Wind River treaty spring Chinook salmon tributary fishery is a 1.5% harvest rate of steelhead, ranging from 0% to 8.4% (TAC 2017, Table 3.4.6).

Harvest that may affect the White Salmon River population occurs in the estuary portion of the river known as Drano Lake, and no take of the Skamania stock, the surrogate for the LCR steelhead, has been known to occur (TAC 2017).

In the Hood River, the incidental take limit for treaty tributary fisheries affecting the Hood River winter steelhead population is listed below in Section 2.9.1.4, with the expected incidental take annually averaging a 2% harvest rate on the Hood River winter steelhead population (TAC 2017, Table 3.4.8).

Columbia River Chum Salmon

The incidental take limit on Columbia River chum salmon from the proposed non-treaty fishery is limited to 5%, with an expected incidental take of 1.6%. No take of Columbia River chum salmon is expected in treaty Indian fisheries.

2.9.1.2 Middle River Stocks

Middle Columbia River Steelhead

The incidental take limit for non-treaty fisheries for the aggregate of winter run populations returning to the MCR Steelhead DPS is 2%, as it is represented by the limit for LCR steelhead, with the same expected incidental take ranges of 0.2 to 1.0% harvest rate. These are steelhead caught in the Bonneville Pool between November 1 and March 31.

The incidental take limit for non-treaty fisheries for the summer run natural-origin populations returning to the MCR is 2% during winter, spring, and summer season fisheries, as it is represented by the limit for A-Index steelhead limit with an expected incidental take range of from 0.2 to 0.4% harvest rate. These are natural-origin steelhead harvested in the Columbia River upstream of The Dalles Dam from January 1 to June 30.

Non-treaty fisheries in the fall season are subject to an additional harvest rate limit on summer run steelhead of 2%. The harvest limit on summer steelhead in non-treaty fisheries is therefore 4% per year, for all DPSs. The fall limit of 2% includes all natural-origin steelhead harvested in the mainstem Columbia River from July 1 through October 31, and natural-origin steelhead harvested in the Columbia River upstream of The Dalles Dam from November 1 through December 31.

The expected incidental take for mainstem treaty Indian fisheries on the summer component of the MCR steelhead DPS located above Bonneville Dam ranges from 4.6% to 12.9%.

Additional harvest occurs in tributary fisheries above Bonneville Dam that affect single MCR steelhead populations. Since the removal of Condit Dam there has not been a treaty fishery in the White Salmon River, but if there were the limit would be no more than 50 steelhead per year of a combination of natural- and hatchery-origin fish, which could be from the White Salmon River population or could include stray fish from other basins. The incidental take limits for each respective treaty tributary fishery affecting Klickitat River summer steelhead, Deschutes River steelhead populations, John Day River steelhead populations, Walla Walla River steelhead populations, and Yakima River populations are listed below in Section 2.9.1.4. The expected treaty tributary respective harvest rates for each population are: Klickitat River summer steelhead 9.6%, Deschutes River steelhead populations 1.6%, John Day River steelhead populations 0.5%, Walla Walla River steelhead populations 2.0%, and Yakima River steelhead populations 0.5%.

2.9.1.3 Upriver Stocks

Snake River fall-run Chinook Salmon

Fisheries affecting Snake River fall-run Chinook salmon will be managed using the agreed abundance-based harvest rate schedule (Table 2-92). The incidental take limit for Snake River fall-run Chinook salmon will therefore vary annually depending on the year specific estimates of run size. The maximum allowable harvest rates in non-treaty and treaty Indian fisheries are 15% and 30%, respectively. In most years, the actual harvest rates will be less than the maximum allowed. The distribution of harvest mortality between non-treaty and treaty Indian fisheries may vary so long as the total harvest rate does not exceed the year specific maximum, and ranges from 17.5 to 32.0%.

Snake River Spring/Summer-run Chinook & Upper Columbia River Chinook Salmon

Fisheries affecting Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon will be managed using the agreed to abundance based harvest rate schedule (Table 2-93). The incidental take limit for Snake River spring/summer-run Chinook and UCR spring-run Chinook salmon will therefore vary annually depending on the year specific estimates of run size. The maximum allowable harvest rates in non-treaty and treaty Indian fisheries are 2.7% and 14.3%, respectively. The non-treaty limit is for the natural-origin component and the treaty limit is for the total harvest rate. In most years, the year specific harvest rates will be less than the maximum allowed. The distribution of harvest mortality between non-treaty and treaty Indian fisheries may vary so long as the total harvest rate does not exceed the year specific maximum.

Snake River Sockeye Salmon

The non-treaty and treaty Indian fisheries will be managed subject to an incidental take limit that will be defined annually using the abundance-based harvest rate schedule (Table 2-97). The harvest rate limit on Snake River sockeye salmon in non-treaty fisheries is 1%. The harvest rate limit on Snake River sockeye salmon in treaty Indian fisheries is either 5% or 7%, depending on the year specific circumstances.

Snake River and Upper Columbia River Steelhead

The incidental take limit for non-treaty fisheries for the summer run natural-origin populations returning to the Snake River and UCR DPSs is 2% during winter, spring, and summer season fisheries, as it is represented by the limit for A-Index natural-origin steelhead with an expected incidental take range of from 0.2 to 0.4% harvest rate. These are natural-origin steelhead harvested in the Columbia River upstream of The Dalles Dam from January 1 to June 30.

Non-treaty fisheries in the fall season are subject to an additional harvest rate limit on summer run steelhead of 2%. The harvest limit on summer steelhead in non-treaty fisheries is therefore 4% per year, for all DPSs. The fall limit of 2% includes all natural-origin steelhead harvested in the mainstem Columbia River from July 1 through October 31, and natural-origin steelhead harvested in the Columbia River upstream of The Dalles Dam from November 1 through December 31.

The 2% limit for non-treaty fisheries applies separately to both the natural-origin A-Index and the B-Index component of the upriver steelhead run during both of the above mentioned time periods. It includes fish that may seek thermal refuge and dip into tributary mouths in the following areas: Drano Lake at the mouth of the Little White Salmon River, the lower Wind

River, the lower Deschutes River (upstream to Sherars Falls), and the John Day River Arm of John Day Reservoir.

The expected incidental take for treaty Indian fisheries on Upper Columbia River steelhead and Snake River A-Index steelhead ranges from 4.1% to 12.4% and are assumed to be equal.

Treaty Indian fisheries affecting Snake River B-Index steelhead will be managed using the agreed abundance-based harvest rate schedule (Table 2-98). The incidental take limit for Snake River B-Index steelhead will therefore vary annually between 13% and 20% depending on the year specific estimates of run size. Treaty Indian fisheries operating in the same tributary mouths as the non-treaty fisheries described above (Drano Lake at the mouth of the Little White Salmon River, the lower Wind River, the lower Deschutes River (upstream to Sherars Falls), and the John Day River Arm of John Day Reservoir) will also account for dip in impacts for B-Index impacts relative to the limit.

2.9.1.4 Treaty Indian tributary Fisheries

The 2018 Agreement includes proposed treaty Indian fisheries in several tributaries that may take listed natural-origin ESA-listed fish while targeting hatchery-origin fish. The take in each tributary is specific to that population and not the ESU or DPS in general. The number of natural-origin fish harvested by each fishery and the affected ESU and DPS are described in the BA (TAC 2017). The expected incidental take in the tributary fisheries, expressed as the average catch of natural-origin fish, is equivalent to what is presented below in Table 2-104.

Table 2-104. Take limit and expected incidental take of listed salmonids for treaty Indian tributary fisheries under the 2018 Agreement expressed in terms of harvest rates unless otherwise indicated.[1]

Tributary (state), fishery	ESU or DPSs, MPG, population affected	Take limit (HR% of annual return to that tributary)
Wind (WA), Spring Chinook salmon	Lower Columbia River Steelhead DPS, Cascade summer, Wind River population	3.25%, 3-year rolling average
Hood River (OR), Spring Chinook	Lower Columbia River Chinook Salmon ESU, Gorge, Hood River Spring Chinook salmon	3.0%, 3-year rolling average%
Hood River (OR), Steelhead	Lower Columbia River Steelhead DPS, Gorge Summer and Gorge Winter, Hood River steelhead	2%, 3-year rolling average
Klickitat River (WA), year long fishing	Middle Columbia River Steelhead DPS, Cascades Eastern Slope Tributaries, White Salmon Summer steelhead	9.6%, 3-year rolling average
Deschutes River (OR), year long	Middle Columbia River Steelhead DPS,	1.6%, 3-year rolling

fishing	Cascades Eastern Slope Tributaries, Deschutes River Eastside and Westside Summer steelhead	average
John Day River (OR), year long fishing	Middle Columbia River Steelhead DPS, John Day River populations	0.5%, 3-year rolling average
Umatilla River (OR), fall fishery	Middle Columbia River Steelhead DPS, Umatilla/Walla Walla Rivers, Umatilla River summer steelhead	6.2%, 3-year rolling average
Walla Walla River (OR), year long fishing	Middle Columbia River Steelhead DPS, Umatilla/Walla Walla Rivers, Walla Wall River summer steelhead	2.0%, 3-year rolling average
Yakima River (WA), April through June fishing	Middle Columbia River Steelhead DPS, Yakima River summer steelhead	0.5%, 3-year rolling average
Icicle Creek (WA), early-to-mid May through the end of July	UCR Steelhead DPS, North Cascades, Wenatchee summer steelhead	0.5% per year

[1] Fisheries in this table that use a rolling average limit will calculate the rate relative to the size of each specific year's return. This will require including prior performance from the previous two years. The prior two years' harvest rates would be added to the current year's expected harvest rate to calculate the 3-year rolling average (the expected harvest rate would use the upcoming preseason forecast until post season estimate became available). This allows for fisheries to begin estimating limit compliance beginning in 2018.

2.9.1.5 Hatchery Production

Hatchery operations are likely to cause take, and those forms of take have been analyzed and addressed in site-specific ITSs Table 2-81. Individual hatchery operators are held to the terms and conditions of their site-specific ITSs. On an annual basis, NMFS will review the annual reports associated with the site-specific consultations to ensure compliance with the site-specific ITSs and evaluate whether reinitiation is necessary.

Competition with and predation by hatchery-origin juveniles could result in take of listed salmon and steelhead. However, although we can use models to estimate how the natural-origin and hatchery-origin fish are interacting, it is not practical to directly measure take associated with competition and predation because we are unable to observe all of these interactions. Therefore, for take associated with ecological effects of competition and predation caused by emigrating hatchery steelhead, NMFS will apply a take surrogate that relies on the median travel time for hatchery salmon and steelhead migrating through the mainstem Snake and Columbia Rivers. These median travel times were used in the PCD model to estimate competition and predation interactions. Therefore, the extent of take from interactions between hatchery and natural-origin juvenile salmonids are as follows: the travel time[25] for emigrating juvenile hatchery steelhead is 5 days longer than the median value (which equates to 50% of the fish) identified in Table 2-105 for each species within each aggregate for 3 of the next 5 years of 5-year running medians. For

[25] NMFS recognizes that this metric can be influenced by factors other than hatchery operation

example, if the 5-year running median of the median (for 2012-2016) for spring/summer-run Chinook salmon within the Snake River aggregate in Table 2-105 is 10, and then the running median for the next three years (i.e., 2013-2017, 2014-2018, and 2015-2019) is 15, this would exceed the take threshold. This is a reasonable, reliable, and measurable surrogate for incidental take because if travel time increases, it is a sign that fish are not exiting the action area as quickly as expected, and indicates an increase in the opportunities for ecological effects to occur. This threshold will be monitored using emigration estimates from PIT tags compiled by NMFS.

Table 2-105. Median of medians (for 2012-2016) travel times for hatchery fish aggregated by species and lifestage based on data provided by the Fish Passage Center (DeHart 2017).

Aggregate	Mainstem Locations	Hatchery Species	Hatchery Lifestage	Median Travel time (days)
Snake River	Lower Granite Dam to McNary	Spring/summer-run Chinook	Yearling	10
		Fall-run Chinook	Yearling	10
		Fall-run Chinook	subyearling	11
		Steelhead	Smolt	8
		Sockeye	Smolt	8
		Coho	Yearling	7
Upper Columbia River	Rocky Reach Dam to McNary	Spring-run Chinook	Yearling	11
		Summer Chinook	Yearling	15
		Summer Chinook	subyearling	13
		Steelhead	Smolt	7
		Coho	Yearling	7

2.9.1.6 Green Sturgeon

Incidental take of ESA-listed Southern DPS green sturgeon adults and subadults is expected to occur from catch and release in non-treaty fisheries downstream of Bonneville Dam. Genetic studies suggest that about 72% of the green sturgeon in the Columbia River below Bonneville Dam during these fisheries belong to the ESA-listed Southern DPS, although the proportion may vary by year (Israel et al. 2009; Schreier et al. 2016). When retention of white sturgeon is allowed in recreational fisheries, some minor misidentification by anglers may occur and a small number of green sturgeon may be mistakenly retained. Some green sturgeon may also die as a result of being caught and released. For the recreational fisheries, we do not expect the incidental take of Southern DPS green sturgeon to exceed a five-year average of 104 fish caught and 10 fish killed per year, and a maximum of up to 184 fish caught and 12 fish killed in any single year. For the commercial fisheries, we do not expect incidental take of Southern DPS green sturgeon to exceed a five-year average of 99 fish caught and 5 fish killed per year, and a maximum of up to 252 fish caught and 13 fish killed in any single year. Overall, we do not expect the incidental take of Southern DPS green sturgeon associated with the proposed *US v Oregon* fisheries to exceed a five-year average of 203 fish caught and 15 fish killed per year, and a maximum of 436 fish caught and 25 fish killed in any single year. These estimates are based on historical catch numbers and are likely overestimates. Additional catch data is needed to refine our estimates. In particular, data are needed on the catch and release of green sturgeon in the commercial fisheries.

Southern DPS green sturgeon are also expected to be caught in white sturgeon gillnet tagging studies conducted in the lower Columbia River. We expect white sturgeon gillnet tagging studies to incidentally catch up to 35 and kill up to two Southern DPS green sturgeon per year. Lethal takes are expected to be delayed mortalities after release of the fish back into the water. Actual take numbers should be reported to NMFS to further refine these estimates.

2.9.2 Effect of the Take

In the biological 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" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize the impacts to listed species from fisheries considered in this biological opinion.

1. NMFS, in cooperation with the *US v Oregon* Parties, shall ensure harvest impacts on listed species are monitored using the best available measures. Although NMFS is the Federal agency responsible for seeing that this reasonable and prudent measure is carried out, in practical terms, it is the states and tribes that conduct monitoring of catch and non-retention impacts.

2. NMFS, in cooperation with the *US v Oregon* Parties, shall ensure in-season management actions taken during the course of fisheries managed pursuant to the 2018 *US v Oregon* Agreement remain consistent with the level of take specified in the Incidental Take Statement. NMFS shall consult with the states and tribes to account for the catch of ESA-listed salmon, steelhead, and green sturgeon in the action area as these occur through the season. NMFS will track the results of these monitoring activities, and in particular, any anticipated or actual increases in the incidental take from those expected preseason.

3. NMFS shall ensure that the *US v Oregon* Parties monitor competition and predation effects from hatchery impacts annually. Although NMFS is the Federal agency responsible for seeing that this reasonable and prudent measure is carried out, in

practical terms, it is the states and tribes that conduct monitoring with information compiled and supplied to NMFS from the other parties.

4. NMFS shall ensure that the *US v Oregon* Parties provide reports to NMFS annually accounting for all take limits, and for all RM&E activities associated with the proposed action.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the *US v Oregon* Parties or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The *US v Oregon* Parties 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 reasonable and prudent measure 1:

1a. NMFS, in cooperation with the *US v Oregon* parties, shall monitor the fisheries as needed to provide statistically valid estimates of the catch and other harvest related mortality. Catch monitoring shall be stratified by gear, time and management area. Monitoring commercial catch shall entail contact with wholesale buyers each business day regarding the catch of the previous day(s). The non-treaty recreational fishery, and all tribal ceremonial and subsistence (C&S) fisheries, platform fisheries, and commercial fisheries shall be sampled using effort surveys and suitable measures of catch rate.

1b. The purpose of catch monitoring is to estimate the catch and other harvest related mortality of salmon, steelhead, and other species. Catch monitoring is used to ensure that fisheries comply with catch and conservation related objectives contained in the *US v Oregon* Agreement including species and stock specific harvest rates, allocation provisions, and ESA related incidental take limits. Catch monitoring allows for both inseason management and post season accounting. To ensure that catch monitoring continues to use best available measures, NMFS, in cooperation with the *US v Oregon* Parties through a Strategic Work Group, shall ensure that catch monitoring is reviewed and documented, to the extent such documentation does not already exist. The documentation shall describe procedures used to manage each component of the treaty-Indian and non-treaty fisheries. The purpose of this effort is to provide for continuity of operation of this complex program and provide regular and ongoing assessment of its adequacy. This assignment shall be completed by December 31, 2018. The documentation shall be updated and revised thereafter to incorporate changes in the program as they occur.

2. The following terms and conditions implement reasonable and prudent measure 2:

2a. NMFS shall confer with the *US v Oregon* Parties to ensure that in-season management actions taken during the course of implementing fisheries managed pursuant to the 2018 *US v Oregon* Agreement are consistent with the level of take specified in the ITS above.

2b. NMFS shall ensure that the *US v Oregon* parties account for the catch throughout the season. If it becomes apparent in-season that specified take levels may be exceeded then NMFS, in consultation with the *US v Oregon* parties, shall take additional management measures to reduce the anticipated catch as needed to conform to those expectations.

3. The following terms and conditions implement reasonable and prudent measure 3:

3a. *US v Oregon* Parties shall compile the following data for each hatchery program in a queryable database (e.g., Excel workbook) and supply to NMFS by December 31 of each release year beginning with the 2018 release:

- Median travel time to dam
    - for programs above Lower Granite Dam, provide to Lower Granite Dam
    - for programs above Rocky Reach Dam, provide to Rocky Reach Dam
    - for programs below McNary Dam, provide to Bonneville Dam
- Mean survival to dam
- Temperature at release site
- Abundance and proportion of juvenile life stages of each listed species in juvenile rearing areas
- Smolt to adult survival rate for hatchery fish
- Smolt to adult survival rate for natural fish
- Proportion barged

3b. NMFS shall coordinate with the *US v Oregon* Parties to determine the best approach (e.g., work with NWFSC, Fish Passage Center, etc.), and to provide aggregated hatchery median travel times and mean survival by species and lifestage for each release year beginning in 2018. (See DeHart (2017) as an example).

3c. NMFS shall continue to refine the parameters used in PCD Risk model simulations.

4. The following terms and conditions implement reasonable and prudent measure 4:

4a. The *US v Oregon* Parties shall provide all reports and notifications required by the Biological Opinion and this incidental take statement. Such reports and notifications shall be submitted electronically to the NMFS point of contact on this consultation:

Jeromy Jording (360-753-9576, jeromy.jording@noaa.gov)

Written materials may also be submitted to:

NMFS – West Coast Region
Sustainable Fisheries Division
510 Desmond Drive, SE, Suite 103

Lacey, Washington 98503-1263

4b. On an annual basis, NMFS will review the annual reports associated with the site-specific consultations to ensure compliance with the site-specific ITSs and evaluate whether reinitiation is necessary

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. **Snake River fall-run Chinook Salmon**: Because of recovery options that would keep a large hatchery program in place, continue to investigate and monitor the effects of the hatchery program on ESU viability. These efforts will additionally allow co-managers to determine the effects of the proposed movement of subyearlings previously released in the Hells Canyon Dam into the Salmon River, as noted in the 2018 *US vs Oregon* Management Agreement.

2.11 Reinitiation of Consultation

This concludes formal consultation for Federal parties, NMFS, USFWS, and BIA, signing a new 2018-2027 *US v Oregon* Management Agreement.

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 Southern Resident Killer Whale

The Southern Resident killer whale DPS was listed as endangered on February 16, 2006 (70 FR 69903) and a recovery plan was completed in 2008 (NMFS 2008f). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016i). Critical habitat in inland waters of Washington was designated on November 29, 2006 (71 FR 69054). Because NMFS determined the action is not likely to adversely affect SKRWs, this document does not provide detailed discussion of environmental baseline or cumulative effects for the SRKW portion of the action area.

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008f).

Southern Resident killer whales consist of three pods (J, K, and L) and inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008f; Hanson et al. 2013; Carretta et al. 2017). During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford 2000; Krahn et al. 2002; Hauser et al. 2007; Hanson and Emmons 2010, Whale Museum unpubl. data). All three pods generally remain in the Georgia Basin through October and make frequent trips to the outer coasts of Washington and southern Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound (Ford 2000; Hanson and Emmons 2010, Whale Museum unpubl. data).

By late fall, all three pods are seen less frequently in inland waters. In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010; Hanson et al. 2013, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. Detection rates of K and L pods on the passive acoustic recorders indicate Southern Residents occur with greater frequency off the Columbia River and Westport and are most common in March (Hanson et al. 2013). J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast (Hanson et al. 2013). The limited range of the sightings/ acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012–2016 (NWFSC unpubl. data) indicate J pod's limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait.

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling from May to September indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). The diet data also indicates that the whales are consuming mostly larger (i.e., older) Chinook salmon. DNA quantification methods are also used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook and chum salmon are primarily contributors of the whale’s diet (NWFSC unpubl. data). Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009) and collection of prey and fecal samples have also occurred in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data).

NMFS has continued to fund the Center for Whale Research to conduct an annual census of the Southern Resident population. As of July 2017, Southern Residents totaled 77 individuals (24 in J pod, 18 in K pod, and 35 in L pod). Since the July census, an additional member died and the current population totals 76 individuals. The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and a science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 2-27, NMFS 2016i). Recent evidence indicates pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation.

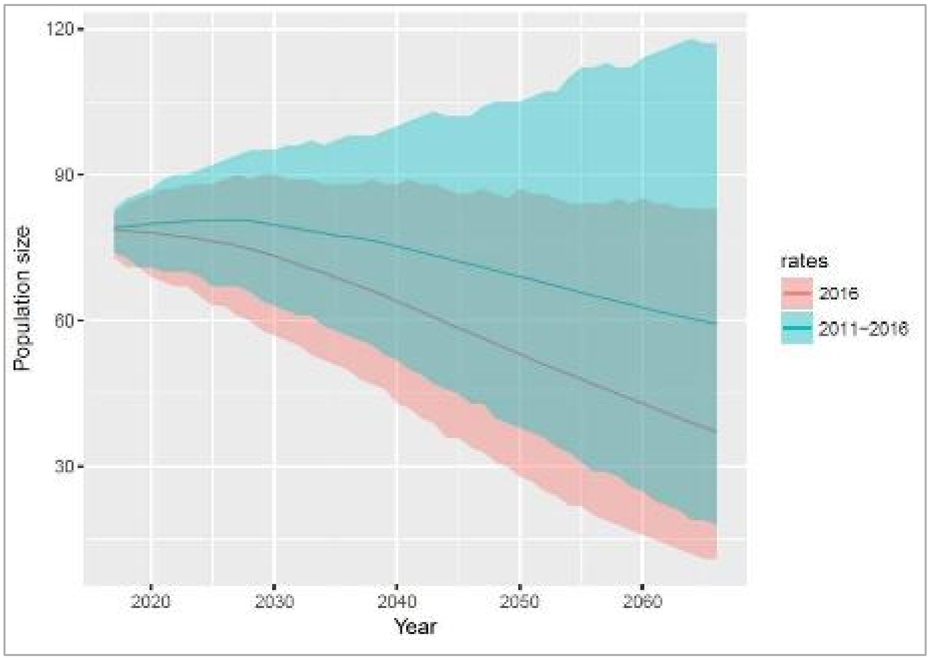

Figure 2-27. Southern Resident killer whale population size projections from 2016 to 2066 using two scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016i).

To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3% growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15% (Lacy et al. 2017).

As described above, the proposed action has two components: 1) the new management Agreement (2018 Agreement), which memorializes the harvest policies that the Parties have agreed should govern the amount of harvest; and 2) it formalizes hatchery program release expectations that augment harvest and are important to the conservation of salmon and steelhead runs above Bonneville Dam. The proposed action may affect Southern Resident killer whales through indirect effects to their primary prey. This analysis focuses on effects to Chinook salmon availability in the ocean because the best available information indicates that salmon are the preferred prey of Southern Resident killer whales year round, including in coastal waters, and that Chinook salmon are the preferred salmon prey species. To assess the indirect effects of the proposed action on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. For actions, including fisheries that may affect the prey base for the whales we evaluate the short-term and long-term effects from both the harvest and hatchery components of the proposed action.

Short-Term (Annual) Effects

Here we define short-term effects to mean annual effects. The terminal fisheries managed under the proposed 2018 Agreement would occur after the fish have returned to the river and are no longer available to the whales in the ocean. In addition, any fishing vessel activity would not overlap with the whales so there would be no short-term or direct impacts on the whales from fishing vessels. Since the majority of fish available for in-river harvest are hatchery fish, and the proposed action is to target hatchery fish and healthy runs of salmon (i.e., non-listed) (TAC 2017), the majority of salmon caught will be hatchery salmon. For example, the 2008-2016 average proportion of natural-origin fish for upriver spring Chinook salmon was 25% of the run (75% of the run was hatchery). Even with the proposed harvest levels on Chinook salmon, most hatchery programs will continue to operate at full production with no effect on the future availability of hatchery Chinook salmon in the ocean. Thus, we do not anticipate an effect on the Southern Resident killer whales' prey base from in-river harvest on hatchery Chinook salmon (i.e., the substantial majority of the catch). The effects on naturally spawning Chinook salmon and their contributions to population abundance and prey availability for the whales in future years is considered below under long-term effects. Hatchery production as part of the action is also not anticipated to have short-term effects on the whales as they prefer older larger Chinook salmon prey. Contributions of hatchery production to the prey base will be available to the whales several years after fish are released and have matured into older, larger adults that the whales prefer to consume.

Long-Term Effects

Since the fishery occurs in the river and does not reduce prey immediately available to the whales the pathway for indirect effects to the whales is through long-term effects on prey. Here we define long-term effects as those that occur beyond a year. The proposed action includes some take of ESA-listed Chinook salmon of both hatchery- and natural-origin LCR Chinook salmon, UCR spring-run Chinook salmon, Snake River spring/summer-run Chinook salmon, Snake River fall-run Chinook salmon, and UWR Chinook salmon. Non-ESA-listed Chinook salmon are also taken in the fisheries managed under the 2018 Agreement. As described in Section 2.5.1, various conservation and allocation goals have led managers to adopt stock units that do not align perfectly with the ESU or DPS delineations. The Parties group salmon into stocks using various attributes that define the group (i.e., run timing and general geographic distribution). Stock descriptions and corresponding ESA-listed surrogates in the 2018 Agreement are listed in Table 2-89.

Although the harvest action is constrained by take limitations on natural-origin salmon, some are incidentally caught. Furthermore, not all naturally spawning Chinook salmon escape at levels that allow the natural spawning habitat to be fully seeded. Thus, there is likely to be some reduction of natural-origin Chinook salmon available as killer whale prey in the ocean in subsequent years as a result of the in-river harvest of returning adults. Between 2008 and 2016, the average return of natural-origin spring, summer, and fall Chinook salmon returning to the Columbia River was approximately 72,000 fish, ranging from 43,000 – 101,000 (data averaged from total returns of UCR spring-run, Snake River spring/summer-run, Snake River fall-run, LRW, and LR brights; ODFW and WDFW 2008; 2009a; 2009b; 2010b; 2010a; ODFW and WDFW 2011; WDFW and ODFW 2011; ODFW and WDFW 2012; WDFW and ODFW 2012; ODFW and WDFW 2013; WDFW and ODFW 2013; ODFW and WDFW 2014; WDFW and

ODFW 2014; ODFW and WDFW 2015; WDFW and ODFW 2015; ODFW and WDFW 2016; WDFW and ODFW 2016; ODFW and WDFW 2017; WDFW and ODFW 2017). The average in-river harvest of these natural-origin stocks was approximately 6,900 and ranged from approximately 4,400 – 12,000 fish. A conservative assumption is that spawner-to-spawner rates are on the order of one-to-one. Given this assumption, the average annual return to the river mouth would be approximately 6,900 (maximum 12,000) additional natural-origin Chinook salmon had there been no fishing. The effects of reduced natural-origin Chinook salmon would be spread across a large portion of the coastal geographic range of Southern Resident killer whales in future years as fish become mature. It is also extremely unlikely that Southern Residents would have encountered and consumed all those replacements of natural-origin fish in the absence of the proposed action.

Although there are reductions to natural-origin Chinook, we do not anticipate this to affect the overall net prey availability because the hatchery production, as part of the action (not including FCRPS), more than offsets the reduction from harvest. For example, hatchery production described in Appendix A is estimated to be approximately 81,000 adult equivalents per year (adult equivalents were derived based on production levels described in the 2018 Agreement and SAR values for each run described in Table 2-106), similar to previous years. Currently, hatchery production is a significant component of the salmon prey base returning to watersheds within the range of Southern Residents (Barnett-Johnson et al. 2007; NMFS 2008g). For example, hatchery programs on the Columbia River funded by the Mitchell Act (NMFS 2017j) and as part of the Federal Columbia River Power System (NMFS 2008g) produce significant numbers of Chinook salmon. Hatchery produced fish likely benefit Southern Residents by enhancing prey availability as scarcity of prey is identified as a threat to their survival and hatchery fish often contribute to the salmon stocks consumed by the whales (Hanson et al. 2010).

Table 2-106. Estimated smolt-to-adult returns (SARs) for spring, summer, and fall runs in Snake, Upper Columbia, and Mid-Columbia basins used to estimate Chinook salmon adult equivalents.

Subbasin	Run	Lifestage	Proposed Released	SAR	Adult Equivalents
Snake	Spring/summer	Yearling	14,802,000	0.004	59,208
	Fall	Yearling	4,600,000	0.007-0.0125	32,200
	Fall	Subyearling	900,000	0.003-0.011	2,700
Upper Columbia	Spring	Yearling	3,264,000	0.003725	12,158
	Fall	Yearling	450,000	0.007	3,150
	Fall	Subyearling	12,999,504	0.005	64,998
	Summer	Yearling	2,488,669	0.010625	26,442
	Summer	Subyearling	1,627,570	0.0024	3,906
Mid-Columbia	Spring	Yearling	5,132,000	0.00385	19,758
	Fall	Yearling	1,500,000	0.007	10,500
	Fall	Subyearling	21,600,000	0.004	86,400

Under the 2008 Agreement, recovery plans were not yet in place for most Chinook salmon ESUs, only the UCR spring-run Chinook Salmon ESU had been completed. Currently, final recovery plans have been published for UCR spring-run Chinook Salmon, UWR Chinook Salmon, LCR Chinook Salmon, Snake River fall-run Chinook Salmon, and Snake River spring/summer-run Chinook Salmon ESUs. Therefore, the proposed action and its impacts to listed Chinook salmon ESUs was evaluated in the context of the recovery plans and criteria. Based on the analysis for the listed Chinook salmon ESUs in this Opinion, the proposed action is in line with recovery planning as it relates to eventual delisting criteria for each salmon ESU. As described in Section 2.8, over the long term, NMFS' analysis concluded that the proposed action is not likely to jeopardize the continued existence of the listed Chinook salmon ESUs and or destroy or adversely modify their designated critical habitat.

Prior to 2008, most harvest rates in the Columbia River were fixed and therefore not tied to the returning abundance of salmon. Thus, the harvest rate was not responsive to the actual return of fish. Under the proposed 2018 Agreement, and similar to the 2008 Agreement, the fisheries would be managed using an abundance-based harvest rate schedule, which allows the catch to be adaptive (i.e., when the run size is low, the harvest rate decreases). Under this regime, the status of several stocks and ESUs have improved. For example, the percent change in natural-origin spawners for the three late timed populations in the UCR spring-run Chinook Salmon ESU increased by 47-165% and over the last five years the abundance of natural-origin spawners has increased for 25 of the 26 populations in the ESU. As described in Section 2.5.1, fisheries directed at upriver spring Chinook salmon can be managed with relative precision. Catch is tracked on a daily basis and run size estimates can be adjusted in-season using counts at Bonneville dam. Early implementation of the 2008 Agreement was found to require modification and by 2010, the Parties implemented a “Catch Balance Agreement”. By continuing this modification into the 2018 Agreement, benefits to spring management are retained as compared to management prior to 2010. Improved status of stocks is not confined to the upper Columbia River. In fact, the spring component of the LCR Chinook Salmon ESU also has a long history of healthy returns under this regime. In addition, escapement of the bright component of the LCR ESU (a late-fall timed component) under the harvest regime has exceeded the escapement goal, averaging 12,000 spawners over the past 10 years. We anticipate these improvements in stocks will continue into the future under the 2018 Agreement.

Healthy natural-origin salmon populations are important to the long-term maintenance of prey populations available to Southern Resident killer whales. Although hatchery production has contributed some offset of the historical declines in the abundance of natural-origin salmon within the range of the whales, as described in Section 2.5.2, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007). However, hatchery programs are often modifying various program elements to be able to adaptively manage the program in ways that minimize effects on listed species and allow operators to achieve program goals. As described in Section 2.4.4, program modifications that are likely to lead to beneficial effects on listed ESUs/DPSs include changes in production, release sites, number of natural-origin broodstock, broodstock composition, and in adult management.

In summary, hatchery production more than offsets in-river harvest reductions, Columbia River salmon stocks are currently managed in line with recovery planning, the status of several stocks and ESUs have improved under the fishing regime, and hatchery programs are managed in ways to minimize effects to listed species. NMFS concludes that the long-term effects to prey availability are insignificant.

Critical habitat

The final designation of critical habitat for the Southern Resident killer whale DPS was published on November 29, 2006 (71 Fed. Reg. 69054). Critical habitat consists of three specific areas: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified the following physical or biological features essential to conservation: (1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging.

The proposed action occurs outside designated critical habitat. However, a relatively very small amount of Columbia River Chinook salmon are recovered in Puget Sound, especially relative to the proportion of Puget Sound Chinook salmon present (Weitkamp 2010). Because the hatchery production offsets the in-river harvest, and only a small proportion of Columbia River fish are recovered in Puget Sound, the impact of the proposed action is insignificant.

On January 21, 2014, NMFS received a petition requesting that we revise critical habitat citing recent information on the whales habitat use along the West Coast of the United States. Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include areas of the Pacific Ocean between Cape Flattery, WA, and Point Reyes, CA, extending approximately 47 miles (76 km) offshore. NMFS published a 90 day finding on April 25, 2014 (79 FR 22933) that the petition contained substantial information to support the proposed measure and that NMFS would further consider the action. We also solicited information from the public. Based upon our review of public comments and the available information, NMFS issued a 12 month finding on February 24, 2015 (80 FR 9682) describing how we intended to proceed with the requested revision, which is still in development.

Conclusions

Short-term effects are not anticipated and long-term effects to the prey base and prey feature of critical habitat are insignificant. Based on this analysis, NMFS concludes that the proposed action is not likely to adversely affect Southern Resident killer whales or their designated critical habitat.

2.12.2 Eulachon

Eulachon in the listed southern DPS are primarily a marine, pelagic species that spawn in the lower reaches of coastal rivers and whose primary prey is zooplankton (Gustafson et al. 2010). They are typically found "in near-benthic habitats in open marine waters" of the continental shelf between 20 and 150 meters in depth (Hay and McCarter 2000). Since 1988, the states of Washington and Oregon have maintained a commercial and recreational fishery for eulachon. In the commercial fishery, eulachon were caught using small-mesh gillnets (i.e., $\leq$2 inches) and small mesh dipnets (although small trawl gear is legal, it is rarely used). However, in 2010, following the listing of eulachon under the ESA, the states of Washington and Oregon permanently closed the commercial and recreational eulachon fishery. In 2014 the states of Washington and Oregon adopted a limited-opportunity recreational and commercial fishery on eulachon in the Columbia River as well as the Cowlitz and Sandy Rivers, but that was not associated with implementation of the proposed action, and required using the small mesh fishing gear described here (TAC 2017). Salmon fisheries in the Columbia River use nets with large mesh sizes (i.e., >4 ¼ inches at all times) and hook and line gear designed to catch the much larger salmon species. Encounters of eulachon in salmon fisheries would be extremely unlikely given the general differences in temporal distribution and gear characteristics (TAC 2017). NMFS is not aware of any record of eulachon caught in either commercial or recreational salmon fisheries in the Columbia River operated as part of the proposed action. NMFS' Recovery Plan for Southern Distinct Population Segment of Eulachon lists the level of threat for fisheries in the Columbia River as "low" (NMFS 2017c). Given all of the above, it is extremely unlikely that eulachon will be caught or otherwise affected by the proposed fisheries, making any such effects discountable.

Eulachon may be impacted by hatchery fish through competition for space, and possibly predation on eulachon by salmon and steelhead juveniles. Predation by hatchery salmon and steelhead juveniles on newly hatched juvenile eulachon is assumed to occur if hatchery salmonid juveniles overlap with juvenile eulachon emigrating from tributary basins. The actual level of predation and the effects of that predation on eulachon are unknown and were not considered substantive compared to other factors identified as limiting the recovery of eulachon in the Columbia River (Gustafson et al. 2010).

Releases of hatchery salmon and steelhead under the proposed action are not expected to overlap with emerging eulachon juveniles in the lower Columbia River because the emergence and outmigration of juvenile eulachon generally occurs in January through March before hatchery juveniles reach the lower mainstem Columbia River in April and May. Predation by juvenile salmonids, if it occurs at all, would be limited by the small size and transparency of the emergent eulachon fry, the distribution of eulachon fry in the water column, and the rapid emigration of eulachon juveniles from the lower Columbia River (Gustafson et al. 2010) – for these same reasons, competition would not be expected.

Based on the above information, the release of hatchery salmon and steelhead under the proposed action would not be expected to result in encounters with juvenile eulachon, making any interactions unlikely and therefore, the proposed action is not likely to adversely affect ESA-listed Pacific eulachon of the southern DPS.

2.12.3 Southern DPS Green Sturgeon Critical Habitat

Designated critical habitat for Southern DPS green sturgeon includes the lower Columbia River estuary from the river mouth to RKm 74 (74 Fed. Reg. 52300, October 9, 2009). The physical and biological features, or PBFs, essential for species conservation are: (a) food resources, including benthic invertebrates (crangonid and callianasid shrimp, Dungeness crab, mollusks, amphipods) and small fish such as sand lances (*Ammodytes* spp.) and anchovies (*Engraulidae*) (Moyle 2002; Dumbauld et al. 2008); (b) suitable water quality (e.g., temperature, salinity, oxygen levels necessary for normal behavior, growth, and viability); (c) migratory corridors necessary for safe and timely passage; (d) a diversity of depths necessary for shelter, foraging, and migration; and (e) sediment quality necessary for normal behavior, growth, and viability.

The proposed action would occur in designated critical habitat for green sturgeon, but would not be expected to measurably change the PBFs or disrupt the ability of Southern DPS green sturgeon to use these habitats for feeding and migration. The proposed fisheries and research/monitoring activities include the use of gillnets and hook and line gear, as well as potentially purse seines, beach seines, traps, pound nets, and other gear types. These fishing gears have the potential to alter benthic habitats by snagging structure, and some gear could be lost. However, we expect impacts to benthic habitat to be minimal, short-term, transitory, and limited to very small spatial scales. In addition, we would expect minimal impacts of the proposed fishing on green sturgeon prey resources, because the fish species typically caught in the fishery are not species preyed upon by green sturgeon. We conclude that any effects on green sturgeon critical habitat would be insignificant, and therefore the proposed action is not likely to adversely affect designated green sturgeon critical habitat.

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

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 the NMFS and descriptions of EFH for Pacific Coast salmon (PFMC 2016d), Pacific Coast groundfish (PFMC 2016c), coastal pelagic species (CPS) (PFMC 2016a), and highly migratory species (HMS) (PFMC 2016b) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

For this EFH consultation, the proposed action and action area are described in detail above in Sections 2.3. Briefly, the proposed action is NMFS signing of the 2018-2027 *US v Oregon* Management Agreement and issuance of an associated ITS. The action area is the migratory corridor and includes the foot print of the proposed fisheries, and accessible salmonid spawning and rearing areas in the Columbia River Basin. The estuarine and offshore marine waters are designated EFH for various life stages of Pacific Coast salmon, Pacific Coast groundfish, coastal pelagic species, and highly migratory species managed by the PFMC.

Pursuant to the MSA, the PFMC has designated EFH for six coastal pelagic species (PFMC 2016a), 11 highly migratory species (PFMC 2016b), over 90 species of groundfish (PFMC 2016c), and three species of Federally-managed Pacific salmon: Chinook salmon (*O. tshawytscha*); coho salmon (*O. kisutch*); and Puget Sound pink salmon (*O. gorbuscha*) (odd-numbered years only) (PFMC 2016d). The PFMC does not manage the fisheries for even-numbered year pink salmon, chum salmon (*O. keta*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), or spring run Chinook salmon from the mid-Columbia River tributaries (White Salmon, Klickitat, Yakima, Deschutes, John Day, Umatilla, and Walla Walla basins). Therefore, EFH has not been designated for these species (PFMC 2016d).

Marine EFH for Chinook, coho, and Puget Sound pink salmon in Washington, Oregon, and California includes all estuarine, nearshore and marine waters within the western boundary of the EEZ, 200 miles offshore. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers, and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). Designated EFH within the action area includes the Columbia River plume described in Section 2.3.

In particular, freshwater EFH for Chinook and coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Marine EFH for Chinook and coho salmon consists of three components, (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Freshwater EFH for pink salmon consists of three components, (1) spawning and incubation; (2) juvenile migration corridors; and (3) adult migration corridors and adult holding habitat. However, pink salmon do not exist in the Columbia River. Marine EFH for pink salmon consists of three components, (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. A more detailed description and identification of EFH for salmon is found in Appendix A to Amendment 19 to the Pacific Coast Salmon Plan (PFMC 2016d). Assessment of potential adverse effects to these species' EFH from the proposed action is based, in part, on this information.

EFH for groundfish includes all waters, substrates and associated biological communities from the mean higher high water line, or the upriver extent of saltwater intrusion in river mouths, seaward to the 3500 meters in depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of Amendment 25 to the Pacific Coast Groundfish Management Plan (PFMC 2016c).

EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10 °C to 26 °C. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 15 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2016a).

EFH for highly migratory species range from vertical habitat within the upper ocean water column from the surface to depths generally not exceeding 200 meters to vertical habitat within the mid-depth ocean water column, from depths between 200 and 1000 meters. These range from coastal waters primarily over the continental shelf; generally over bottom depths equal to or less than 183 meters to the open sea, beyond continental and insular shelves. A more detailed description and identification of EFH for highly migratory species can be found in Appendix F of Amendment 3 to the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species (PFMC 2016b).

3.2 Adverse Effects on Essential Fish Habitat

While harvest related activities do affect passage in that fish are intercepted, those impacts are accounted for explicitly in the ESA analyses regarding harvest related mortality. Most of the harvest related activities occur from boats or along river banks. Gears that are used include primarily hook- and-line, drift and set gillnets, and hoop nets that do not substantially affect the habitat. There will be minimal disturbance to vegetation, and negligible harm to spawning or rearing habitat, or to water quantity and water quality, particularly since most of the fishing activity occurs in Zones 1-6 on the Lower mainstem Columbia River. Thus, there will be minimal effects on the essential habitat features of the affected species from the action discussed in this biological opinion, certainly not enough to contribute to a decline in the values of the habitat.

Regarding hatchery elements of the proposed action, they will generally not have effects on the saltwater components of all species' EFH, though it is likely to have an effect on freshwater EFH for Chinook and coho salmon. Potential effects on freshwater EFH (particularly through water withdrawal, effluent discharge, temporary and weir operations, increased competition for spawning and rearing sites, and removal of MDNs) are only likely to occur in areas that spring Chinook and coho salmon spawn naturally and in the migration corridor.

The proposed action is not likely to have adverse effects on EFH for the coastal pelagic species and highly migratory species. Of the potential adverse effects listed in (PFMC 2016a) and (PFMC 2016b) effects of hatchery operations could be analogous to adverse effects of aquaculture. Particularly, effects of organic waste from farms and release of high levels of antibiotics, disease, and escapee are listed as major concerns of aquaculture on coastal pelagic species EFH and highly migratory species EFH. However, these analogous concerns for hatchery operations are not likely to adversely affect coastal pelagic species nor highly migratory species because all relevant facilities have NPDES permits to minimize effects of organic waste, and antibiotics would be diluted to manufacturer labeling. Concerns of disease transfer from and escapee of salmonid species are not likely to be a concern because coastal pelagic species and highly migratory species are not closely related to the salmonid species; therefore, disease transfer is not likely, and salmonid escapees would not raise concerns of genetic effects on coastal pelagic species and highly migratory species.

The proposed action is not likely to have adverse effects on EFH for groundfish. Of the potential adverse effects listed in (PFMC 2016c), effects of hatchery operations can have similar effects as commercial and domestic water use. Particularly, effects on water quality is listed as major concern of water use. However, this analogous concern for hatchery operations is not likely to adversely affect groundfish EFH because all relevant facilities have NPDES permits to minimize effects on water quality. Also, other potential adverse effects on EFH are not applicable to hatchery operations. Altering natural flows and the process associated with flow rates is not a concern associated with hatchery operations because the hatcheries are not altering the flow rate of the Columbia River enough for the effects to be detectable in the groundfish EFH. Affecting prey base and entrapping fish, both from withdrawal of water, is not a potential adverse effect of hatchery operations because water is not withdrawn within the groundfish EFH, so these effects would not occur from hatchery operations. Finally, adverse effects associated with dams are not relevant to hatchery operations because hatchery operations do not affect how dams are operated.

The proposed action is likely to affect freshwater EFH for Chinook and coho salmon through hatchery facilities that will withdraw stream water at hatchery facilities. Water withdrawal for hatchery operations can adversely affect salmon (through affecting the EFH) by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects; the minimum flows will be maintained to provide for juvenile and adult migration through the sections of stream from the point of withdrawal to the hatchery outfall, and the intake is screened in compliance with NMFS criteria. These impacts are accounted for explicitly in ESA analyses regarding site specific operations of each hatchery program, reviewed in Section 2.4.4 of the above opinion.

The proposed action is likely to affect freshwater EFH for Chinook and coho salmon through the effluent discharge from the hatchery facilities. Effluent discharge from hatchery facilities can adversely affect water quality by raising temperatures, reducing dissolved-oxygen levels, and potentially affecting pH. The proposed hatchery programs minimize each of these effects through compliance with the NPDES permits, where applicable. These impacts are also accounted for explicitly in ESA analyses regarding site specific operations of each hatchery program, reviewed in Section 2.4.4 of the above opinion.

The proposed action is likely to affect freshwater EFH for Chinook and coho salmon through the use of temporary and permanent weirs. This includes displaced spawning, migration delay, and increased mortality from handling of fish at the trap. Any effects on EFH associated with weirs would be minimized through implementation of best management practices, including: use of a removable weir structure that rests on the river bottom and banks with minimal disruption of riverine habitat; placement and operation of removable weirs for only when they are needed; continuous surveillance of some weirs by staff residing on-site to ensure proper operation and to safeguard fish trapped; frequent sorting of fish from the trap to minimize trap holding times; and implementation of fish capture and handling methods that protect the health of fish retained as broodstock or released back into the river. These impacts are also accounted for explicitly in ESA analyses regarding site specific operations of each hatchery program, reviewed in Section 2.4.4 of the above opinion.

The proposed action is likely to affect freshwater EFH for Chinook and coho salmon through increased competition for spawning and rearing sites. The PFMC (2003b) recognized that these effects pertain to EFH because of the concerns about “genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations.” Greater detail on possible effects of hatchery programs can be found in NMFS (2017j). A small proportion of hatchery fish returning to the natal rivers is expected to spawn and may compete for space with Chinook or coho salmon. Some hatchery-origin fish may stray into non-natal rivers but not in numbers that would cause the carrying capacities of natural production areas to be exceeded, or that would result in increased incidence of disease or increases in predators. Predation by adult hatchery-origin fish on juvenile natural-origin salmonids will be limited because of timing differences, because adult salmon stop feeding by the time they reach spawning areas, and because predation by juvenile offspring of hatchery-origin fish on juvenile natural-origin salmonids would not occur. These impacts are also accounted for explicitly in ESA analyses regarding site specific operations of each hatchery program, reviewed in Section 2.4.4 of the above opinion.

3.3 Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the proposed action on EFH for Chinook and coho salmon, NMFS believes that the proposed action, as described in Section 1.3 and the ITS

(Section 2.9, above) includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (2003a) provided an overarching recommendation that hatchery programs:

> "[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

The opinion explicitly discusses the potential risks of hatchery fish on native fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook and coho salmon in the action area (Section 2.3, above).

Pursuant to the MSA, NMFS is required to provide EFH conservation recommendations to Federal agencies regarding actions which may adversely affect EFH. Because NMFS concludes that the proposed Federal action would not adversely affect designated EFH, it has not identified any additional conservation recommendations.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, NMFS 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, 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 NMFS 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 Data Quality Act (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 users of this consultation are the applicants and funding/action agencies listed on the first page. Other interested users could include the agencies, applicants, and the American public. Individual copies of this opinion were provided to the BIA, NMFS, USFWS and the applicants. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pctsweb/homepage.pcts). 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,' Office of Management and Budget 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, if applicable] 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, if applicable], and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

Ackerman, M. W., N. V. Vu, J. McCane, C. A. Steele, M. R. Campbell, A. P. Matala, J. E. Hess, and S. R. Narum. 2014. Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam. January 2014. Idaho Department of Fish and Game Report 14-01. Annual Report, BPA Project 2010-026-00. 68p.

ACOE. 2017. U.S. Army Corps of Engineers Northwestern Division, Bureau of Reclamation Pacific Northwest Region, and Bonneville Power Administration. 2017. Endangered Species Act. Federal Columbia River Power System, 2016 Comprehensive Evaluation. 346p.

Anchor QEA, LGL Limited - environmental research associates, and Turnstone Environmental Consultants. 2017. Double-crested Cormorant (DCCO) Monitoring Report: Avian Predation Program Monitoring. April 2017. Prepared for the U.S. Army Corps of Engineers, Portland, Oregon. 83p.

Araki, H., W. R. Ardren, E. Olsen, B. Cooper, and M. S. Blouin. 2007. Reproductive success of captive-bred steelhead trout in the wild: Evaluation of three hatchery programs in the Hood River. Conservation Biology. 21(1): 181-190.

Araki, H., B. A. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. Evolutionary Applications. 1: 342-355.

Asch, R. G. 2015. Climate change and decadal shifts in the phenology of larval fishes in the California Current ecosystem. PNAS. 112(30): E4065–E4074.

Ayllon, F., J. L. Martinez, and E. Garcia-Vazquez. 2006. Loss of regional population structure in Atlantic salmon, *Salmo salar* L., following stocking. ICES Journal of Marine Science. 63: 1269-1273.

Bachman, R. A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout in a stream. Transactions of the American Fisheries Society. 113(1): 1-32.

Bakun, A., B. A. Black, S. J. Bograd, M. García-Reyes, A. J. Miller, R. R. Rykaczewski, and W. J. Sydeman. 2015. Anticipated effects of climate change on coastal upwelling ecosystems. Current Climate Change Reports. 1(2): 85-93.

Barnett-Johnson, R., C. B. Grimes, C. F. Royer, and C. J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Canadian Bulletin of Fisheries and Aquatic Sciences. 64(12): 1683-1692.

Barnett, H. G. 1937. Culture Element Distributions: VII Oregon Coast. December 13, 1937. University of California Press; Anthropological Records. Volume 1, No. 3, 115-204. 53p.

Barnhart, R. A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - steelhead. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.60). U.S. Army Corps of Engineers, TR EL-82-4. 31p.

Beacham, T. D., K. L. Jonsen, J. Supernault, Michael Wetklo, L. Deng, and N. Varnavskaya. 2006. Pacific Rim population structure of Chinook salmon as determined from microsatellite analysis. Transactions of the American Fisheries Society. 135(6): 1604-1621.

Beamesderfer, R., T. Cooney, P. Dygert, S. Ellis, M. Falcy, L. LaVoy, C. LeFleur, H. Leon, G. Norman, J. North, T. Stahl, and C. Tracy. 2011. Exploration of Abundance-Based Management Approaches for Lower Columbia River Tule Chinook. October 2011. 96p.

Beamesderfer, R. C. P., M. L. Simpson, and G. J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes. 79(3-4): 315-337.

Beauchamp, D. A. 1990. Seasonal and diet food habit of rainbow trout stocked as juveniles in Lake Washington. Transactions of the American Fisheries Society. 119: 475-485.

Beckman, B. R., D. A. Larsen, C. S. Sharpe, B. Lee-Pawlak, C. B. Schreck, and W. W. Dickhoff. 2000. Physiological status of naturally reared juvenile spring Chinook salmon in the Yakima River: Seasonal dynamics and changes associated with smolting. Transactions of the American Fisheries Society. 129: 727-753.

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, J. Kimball, J. Stanford, G. Pess, P. Roni, P. Kiffney, and N. Mantua. 2013. Restoring Salmon Habitat for a Changing Climate. River Research and Applications. 29(8): 939-960.

Bell, E. 2001. Survival, Growth and Movement of Juvenile Coho Salmon (*Oncorhynchus kisutch*) Over-wintering in Alcoves, Backwaters, and Main Channel Pools in Prairie Creek, California. September, 2001. A Thesis presented to the faculty of Humboldt State University. 85p.

Bentzen, P., J. B. Olsen, J. E. McLean, T. R. Seamons, and T. P. Quinn. 2001. Kinship analysis of Pacific salmon: Insights into mating, homing, and timing of reproduction. Journal of Heredity. 92: 127-136.

Berejikian, B. A., and M. J. Ford. 2004. Review of Relative Fitness of Hatchery and Natural Salmon. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-61. 43p.

Bergman, P. K., K. B. Jefferts, H. F. Fiscus, and R. C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Fisheries Research Papers, Washington Department of Fisheries. 3(1): 63-84.

Berntson, E. A., R. W. Carmichael, M. W. Flesher, E. J. Ward, and P. Moran. 2011. Diminished reproductive success of steelhead from a hatchery supplementation program (Little Sheep Creek, Imnaha Basin, Oregon). Transactions of the American Fisheries Society. 140: 685-698.

Bevan, D., J. Harville, P. Bergman, T. Bjornn, J. Crutchfield, P. Klingeman, and J. Litchfield. 1994. Snake Salmon Recovery Team: Final Recommendations to the National Marine Fisheries Service: Summary. 33p.

Bigg, M. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission. 32(65): 655-666.

Bilby, R. E., T. Bennett, and P. Roni. 2002. Utilization of nitrogen from spawning salmon by juvenile Chinook salmon and steelhead from two tributaries of the Columbia River. Final Report. April 2002. BPA Contract #99-041-00. Report to Bonneville Power Administration by the National Marine Fisheries Service, Seattle, Washington. 38p.

Bilby, R. E., B. R. Fransen, J. K. Walter, C. J. Cederholm, and W. J. Scarlett. 2001. Preliminary evaluation of the use of nitrogen stable isotope ratios to establish escapement levels for Pacific salmon. Fisheries. 26(1): 6-14.

Bilton, T., D. F. Alderdice, and J. T. Schnute. 1982. Influence of time and size at release of juvenile coho salmon (*Oncorhynchus kisutch*) on returns at maturity. Canadian Journal of Fisheries and Aquatic Sciences. 39(3): 426-447.

Bisson, P. A., and R. E. Bilby. 1998. Organic Matter and Trophic dynamics in River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Naiman R. J. and R.E. Bilby, editors. 1998. Chapter 15. Springer-Verlag. Pages 373-393

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society. Special Publication 19.

Black, B. A., W. J. Sydeman, D. C. Frank, D. Griffin, D. W. Stahle, M. García-Reyes, R. R. Rykaczewski, S. J. Bograd, and W. T. Peterson. 2014. Six centuries of variability and extremes in a coupled marine-terrestrial ecosystem. Science. 345(6203): 1498-1502.

Blankenship, S. M., M. P. Small, J. Bumgarner, M. Schuck, and G. Mendel. 2007. Genetic relationships among Tucannon, Touchet, and Walla Walla river summer steelhead (*Oncorhynchus mykiss*) receiving mitigation hatchery fish from Lyons Ferry Hatchery. WDFW, Olympia, Washington. 39p.

Bograd, S. J., I. Schroeder, N. Sarkar, X. Qiu, W. J. Sydeman, and F. B. Schwing. 2009. Phenology of coastal upwelling in the California Current. Geophysical Research Letters. 36(1).

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters. 42(9): 3414–3420.

Bordner, C. E., S. I. Doroshov, D. E. Hinton, R. E. Pipkin, R. B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity. American Fisheries Society Symposium. 7: 293-303.

Boreman, J., W. J. Overholtz, and M. P. Sissenwine. 1984. A preliminary analysis of the effects of fishing on shortnose sturgeon. NMFS Northeast Fisheries Science Center, Woods Hole Laboratory. Reference Document 84-17. 26p.

Bottom, D. L., G. Anderson, A. Baptista, J. Burke, M. Burla, M. Bhuthimethee, L. Campbell, E. Casillas, S. Hinton, K. Jacobson, D. Jay, R. McNatt, P. Moran, G. C. Roegner, C. A. Simenstad, V. Stamatiou, D. Teel, and J. E. Zamon. 2008. Salmon life histories, habitat, and food webs in the Columbia River estuary: an overview of research results, 2002–2006. Report of Research by Northwest Fisheries Science Center, NMFS, Seattle, Washington. 52p.

Bottom, D. L., K. K. Jones, C. A. Simenstad, C. L. Smith, and R. Cooper. 2011. Pathways to resilience. Oregon Sea Grant. Pathways to resilience: sustaining salmon ecosystems in a changing world (Vol. 11, No. 1). Oregon Sea Grant.

Boyd, R. T. 1985. The Introduction of Infectious Diseases Among the Indians of the Pacific Northwest, 1774-1874. Ph.D. thesis, University of Washington, Seattle, Washington.

BPA, USBR, and USACE. 2001. The Columbia River System Inside Story, Second Edition. April 2001. BPA, Portland, Oregon. 80p.

Braatne, J. H., and B. Jamieson. 2001. The Impact of Flow Regulation on Riparian Cottonwood Forests along the Kootenai and Yakima Rivers. Northwest Power Planning Council and Bonneville Power Administration, Portland, Oregon.

Bradford, M. J., B. J. Pyper, and K. S. Shortreed. 2000. Biological responses of sockeye salmon to the fertilization of Chilko Lake, a large lake in the interior of British Columbia. North American Journal of Fisheries Management. 20: 661-671.

Brakensiek, K. E. 2002. Abundance and Survival Rates of Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Prairie Creek, Redwood National Park. January 7, 2002. MS Thesis. Humboldt State University, Arcata, California. 119p.

Brodeur, R. D., R. C. Francis, and W. G. Pearcy. 1992. Food consumption of juvenile coho (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*) on the continental shelf off Washington and Oregon. Canadian Journal of Fisheries and Aquatic Sciences. 49: 1670-1685.

Brown, D. E. 1975. An Analysis of Conflict for the Columbia River Salmon Fishery. November 1975. 60p.

Brown, K. 2007. Evidence of spawning by green sturgeon, Acipenser medirostris, in the upper Sacramento River, California. Environmental Biology of Fishes. 79: 297–303

Brynildson, O. M., and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society. 96(3): 353-355.

Buckland-Nicks, J. A., M. Gillis, and T. E. Reimchen. 2011. Neural network detected in a presumed vestigial trait: ultrastructure of the salmonid adipose fin. Proceedings of the Royal Society B: Biological Sciences. 297: 553-563.

Bumgarner, J. 2017a. Tucannon_WDFW_Spring Chinnook Travel Time and Survival excel report. August 9, 2017.

Bumgarner, J. D. 2017b. FAll Chinook to LGR excel report. August 17, 2017.

Bumgarner, J. D., and J. T. Dedloff. 2013. Evaluation of the Tucannon River Summer Steelhead Endemic Stock Hatchery Supplementation Program 2011 Annual Report. March 25, 2013. BPA Project Number 2010-050-00. WDFW, Dayton, Washington. 22p.

Burgner, R. L. 1987. Factors influencing age and growth of juvenile sockeye salmon (*Oncorynchus nerka*) in lakes. *In* Volume 96, Sockeye Salmon (*Oncorhynchus nerka*) Population Biology and Future Management. H. D. Smith, L. Margolis, and C. C. Wood editors. Canadian Special Publication of Fisheries and Aquatic Science.

Burgner, R. L., J. T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and origins of steelhead trout (*Oncorhynchus mykiss*) in offshore waters of the North Pacific Ocean. International North Pacific Fisheries Commission Bulletin 51. 239p.

Burke, B. J., M. C. Liermann, D. J. Teel, and J. J. Anderson. 2013. Environmental and geospatial factors drive juvenile Chinook salmon distribution during early ocean migration. Canadian Journal of Fisheries and Aquatic Sciences. 70: 1167-1177.

Busack, C. 2007. The impact of repeat spawning of males on effective number of breeders in hatchery operations. Aquaculture. 270: 523-528.

Busack, C. 2015. Extending the Ford model to three or more populations. August 31, 2015. Sustainable Fisheries Division, West Coast Region, National Marine Fisheries Service. 5p.

Busack, C., and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: Fundamental concepts and issues. AFS Symposium 15: 71-80.

Busack, C., and C. M. Knudsen. 2007. Using factorial mating designs to increase the effective number of breeders in fish hatcheries. Aquaculture. 273: 24-32.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status Review of West Coast steelhead from Washington, Idaho, Oregon, and California. August 1996. U.S. Dept. Commer. NOAA Tech. Memo., NMFS-NWFSC-27. NMFS, Seattle, Washington. 275p.

California HSRG. 2012. California Hatchery Review Report. Prepared for the U.S. Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 110p.

Campbell, S. K., and V. L. Butler. 2010. Archaeological evidence for resilience of Pacific Northwest salmon populations and the socioecological system over the last ~7,500 years. Ecology and Society. 15(1): 17.

Cannamela, D. A. 1992. Potential Impacts of Releases of Hatchery Steelhead Trout "Smolts" on Wild and Natural Juvenile Chinook and Sockeye Salmon, Appendix A. A White Paper. March 1992. Idaho Department of Fish and Game, Boise, Idaho. 26p.

Carls, M. G., R. A. Heintz, G. D. Marty, and S. D. Rice. 2005. Cytochrome P4501A induction in oil-exposed Pink Salmon *Oncorhynchus gorbuscha* embryos predicts reduced survival potential. Marine Ecology Progress Series. 301: 253-265.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and Robert L. Brownell Jr. 2017. U.S. Pacific Marine Mammal Stock Assessments: 2016. June 2017. U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-577. 414p.

Caucus, F. 2000. Conservation of Columbia Basin Fish: Final Basinwide Recovery Strategy Volume 1. 92p.

CBFWA. 1996. Draft Programmatic Environmental Impact Statement. Impacts of Artificial Salmon and Steelhead Production Strategies in the Columbia River Basin. December 10, 1996. Prepared by the Columbia Basin Fish and Wildlife Authority, Portland, Oregon. 475p.

CBFWA. 2010. 2010 Status of Fish and Wildlife Resources in the Columbia River Basin. Columbia Basin Fish & Wildlife Authority, Portland, Oregon. 26p.

CCSP. 2014. U.S. Global Change Research Program. Northwest Report. https://nca2014.globalchange.gov/report/regions/northwest. Accesed 12/14/2017.

Chandler, C., and S. Richardson. 2005. Biological and Physical Habitat Assessment of Streams within the Big Canyon Creek and Lapwai Creek Watersheds- 2005; Nez Perce, Lewis, and Clearwater Counties of Idaho. Document ID #P104795, Nez Perce Tribe Department, Lapwai, Idaho.

Chapman, D. W. 1986. Salmon and steelhead abundance in the Columbia River in the Nineteenth Century. Transactions of the American Fisheries Society. 115: 662-670.

Chapman, D. W., C. Peven, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of Summer Steelhead in the Mid-Columbia River. July 25, 1994. Don Chapman Consultants, Inc., Boise, Idaho. 480p.

Chapman, D. W., W. S. Platts, D. Park, and M. Hill. 1990. Status of Snake River Sockeye Salmon. Final Report. June 26, 1990. Pacific Northwest Utilities Conference Committee, Portland, Oregon. 96p.

Cheung, W. W. L., R. D. Brodeur, T. A. Okey, and D. Pauly. 2015. Projecting future changes in distributions of pelagic fish species of Northeast Pacific shelf seas. Progress in Oceanography. 130: 19-31.

Chockley, B. R. 2015. Memorandum to Bill Brignon (USFWS) from Brandon Chockley (FPC). January 9, 2015. 2015 FPC Gorge PIT report. FPC, Portland, Oregon. 18p.

Chockley, B. R. 2017. Memorandum to Travis Collier (USFWS) from Brandon Chockley (FPC). January 4, 2017. LNFH spring Chinook Travel Time and Survival. FPC, Portland, Oregon. 6p.

Christie, M. R., M. J. Ford, and M. S. Blouin. 2014. On the reproductive successs of early-generation hatchery fish in the wild. Evolutionary Applications. 7: 883-896.

Christie, M. R., M. L. Marine, R. A. French, and M. S. Blouin. 2011. Genetic adaptation to captivity can occur in a single generation. Proceedings of the National Academy of Sciences. 109(1): 238–242.

Claiborne, A. M., J. A. Miller, L. A. Weitkamp, D. J. Teel, and R. L. Emmett. 2014. Evidence for selective mortality in marine environments: the role of fish migration size, timing, and production type. Marine Ecology Progress Series. 515: 187–202.

Clarke, L. 2017. Travel_Time_Release Years 2012-2016_ODFW_Umatilla Chinook and steelhead excel report. September 26, 2017.

Clarke, L. R., M. W. Flesher, S. M. Warren, and R. W. Carmichael. 2011. Survival and straying of hatchery steelhead following forced or volitional release. North American Journal of Fisheries Management. 31: 116-123.

Climate Impacts Group. 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest. July 29, 2004. Climate Impacts Group, University of Washington, Seattle, Washington. 13p.

Connor, W. P., J. G. Sneva, K. F. Tiffan, R. K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River basin. Transactions of the American Fisheries Society. 134(2): 291-304.

Corbett, C. 2013. Characterization of net habitat change on the floodplain below Bonneville Dam. Communication from C. Corbett (Lower Columbia Estuary Partnership) to L. Krasnow (NMFS) RE: Habitat change and priority habitat maps available on EP Website, June 28, 2013.

Courter, I. I., D. B. Child, J. A. Hobbs, T. M. Garrison, J. J. G. Glessner, and S. Duery. 2013. Resident rainbow trout produce anadromous offspring in a large interior watershed. Canadian Bulletin of Fisheries and Aquatic Sciences. 70(5): 701-710.

Craig, J. A., and R. L. Hacker. 1940. The History and Development of the Fisheries of the Columbia River. Bulletin No. 32. U.S. Bureau of Fisheries. 89p. 133-216.

Crozier, L., E. Dorfmeier, T. Marsh, B. Sandford, and D. Widener. 2016. Refining our understanding of early and late migration of adult Upper Columbia spring and Snake River spring/summer Chinook salmon: passage timing, travel time, fallback and survival. March 2016. NWFSC, Seattle, Washington. 57p.

Crozier, L., L. Wiesebron, E. Dorfmeier, and B. Burke. 2017. River Conditions, Fisheries and Fish History Drive Variation in Upstream Survival and Fallback for Upper Columbia River spring and Snake River spring/summer Chinook salmon. May 2017. NWFSC, Seattle, Washington. 47p.

Crozier, L., and R. W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Journal of Animal Ecology. 75(5): 1100-1109.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008a. Potential responses to climate change in organisms with complex life histories: Evolution and plasticity in Pacific salmon.

Crozier, L. G., M. D. Scheuerellnd, and R. 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.

Crozier, L. G., R. W. Zabel, and A. F. Hamlet. 2008b. Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon. Global Change Biology. 14(2): 236–249.

CTWSR. 2009. Hood River Production Program Monitoring and Evaluation (M&E) - Confederated Tribes of Warm Springs Annual Report for Fiscal Year October 2007 – September 2008. June 2009. Project No. 1988-053-03. Confederated Tribes of Warm Springs Reservation, Parkdale, Oregon. 64p.

Dalton, M., P. W. Mote, and A. K. S. [Eds.]. 2013. Climate Change in the Northwest, Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press. 271p.

Daly, E. A., R. D. Brodeur, J. P. Fisher, L. A. Weitkamp, D. J. Teel, and B. R. Beckman. 2012. Spatial and trophic overlap of marked and unmarked Columbia River Basin spring Chinook salmon during early marine residence with implications for competition between hatchery and naturally produced fish. Environmental Biology Fisheries. 94: 117-134.

Daly, E. A., J. A. Scheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman, and J. A. Miller. 2014. Juvenile steelhead distribution, migration, feeding, and growth in the Columbia River Estuary, plume, and coastal waters. Marine and Coastal Fisheries. 6(1): 62-80.

Dammerman, K. J. 2016. 2015 Migration Year Juvenile Upriver Bright Fall Chinook Release Report from Little White Salmon and Willard National Fish Hatcheries 2016 Progress Report. July 2016. USFWS, Vancouver, Washington. 14p.

Dammerman, K. J., D. Hand, D. Olson, J. Poirier, S. Pastor, and J. Rivera. 2016. Monitoring and Evaluation Updates for John Day/The Dalles Dam Mitigation Programs at Spring Creek and Little White Salmon National Fish Hatcheries. FY 2016 Annual Report. October 2016. USFWS, Vancouver, Washington. 26p.

Dammerman, K. J., B. Silver, D. Hand, D. Olson, J. Rivera, T. Gilmore, and D. Hines. 2017. Draft Mitchell Act Report Tables for Charlene Hurst. USFWS, Vancouver, Washington. 3p.

Davis, B., J. Poirier, and D. Hand. 2016. Migration Timing and Survival of Warm Springs National Fish Hatchery Juvenile Spring Chinook Salmon in the Deschutes Basin, 2012-2014 Final Report. USFWS, Vancouver, Washington. 20p.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, C. W. Sims, J. T. Durkin, R. A. Kirn, A. E. Rankis, G. E. Monan, and F. J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Contract DE-A179-84BP39652, Project No. 81-102. April 1986. Final report prepared for Bonneville Power Administration by NMFS, Seattle, Washington. 263p.

Deagle, B. E., D. J. Tollit, S. N. Jarman, M. A. Hindell, A. W. Trites, and M. J. Gales. 2005. Molecular scatology as a tool to study diet: analysis of prey DNA in scats from captive Steller sea lions. Molecular Ecology. 14(6): 1831–1842.

DeHart, M. 2017. Memorandum to Charlene Hurst (NOAA) from Michele DeHart (FPC). September 14, 2017. Juvenile survival and travel times for Snake River hatchery yearling spring/summer Chinook, yearling fall Chinook, subyearling fall Chinook, steelhead, sockeye, and coho and Upper Columbia hatchery yearling spring Chinook, yearling summer Chinook, subyearling summer Chinook, steelhead, and coho (2012-2016). 11p.

Di Lorenzo, E., and N. Mantua. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change.

Diefenderfer, H. L., G. E. Johnson, R. M. Thom, K. E. Buenau, L. A. Weitkamp, C. M. Woodley, A. B. Borde, and R. K. Kropp. 2016. Evidence-based evaluation of the cumulative effects of ecosystem restoration. Ecosphere. 7(3).

Dietrich, W. 1995. Northwest Passage: The Great Columbia River. University of Washington Press, Seattle, Washington. ISBN: 9780295999326.

Dittman, A. H., D. May, D. A. Larsen, M. L. Moser, M. Johnston, and D. E. Fast. 2010. Homing and spawning site selection by supplemented hatchery- and natural-origin Yakima River spring Chinook salmon. Transactions of the American Fisheries Society. 139(4): 1014-1028.

Dittman, A. H., and T. P. Quinn. 2008. Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations. A component of Yakima River Basin Water Storage Feasibility Study, Washington. Technical Series No. TS-YSS-13. U.S. Department of the Interior, Denver, Colorado. 179p.

DuBois, J. 2013. 2012 Sturgeon Fishing Report Card: Preliminary data report. July 12, 2013. CDFW Bay Delta Region (East), Stockton, California. 13p.

DuBois, J., and A. Danos. 2017. 2016 Sturgeon Fishing Report Card: Preliminary data report. March 22, 2017. CDFW Bay Delta Region (East), Stockton, California. 16p.

DuBois, J., M. Gingras, and R. Mayfield. 2009. Draft 2008 Sturgeon Fishing Report Card: Preliminary data report. June 17, 2009. CDFG Bay Delta Region, Stockton, California. 12p.

DuBois, J., M. Harris, and J. Mauldin. 2014. 2013 Sturgeon Fishing Report Card: Preliminary data report. May 8, 2014. CDFW Bay Delta Region, Stockton, California. 14p.

DuBois, J., and M. D. Harris. 2015. 2014 Sturgeon Fishing Report Card: Preliminary data report. February, 10, 2015. CDFW Bay Delta Region, Stockton, California. 14p.

DuBois, J., and M. D. Harris. 2016. 2015 Sturgeon Fishing Report Card: Preliminary data report. March 16, 2016. CDFW Delta Bay Region, Stockton, California. 14p.

DuBois, J., T. MacColl, and E. Haydt. 2012. 2011 Sturgeon Fishing Report Card: Preliminary data report. March 23, 2012. CDFG Bay Delta Region (East), Stockton, California. 13p.

DuBois, J., T. Matt, and B. Beckett. 2010. 2009 Sturgeon Fishing Report Card: Preliminary data report. March 29, 2010. CDFG Bay Delta Region (East), Stockton, California. 13p.

DuBois, J., T. Matt, and T. MacColl. 2011. 2010 Sturgeon Fishing Report Card: Preliminary data report. April 20, 2011. CDFG Bay Delta Region (East), Stockton, California. 14p.

Dumbauld, B. R., D. L. Holden, and O. P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest Estuaries? Enviromental Biology Fishes. 83(3): 283–296.

Dunnigan, J. L. 1999. Feasibility and Risks of Coho Reintroduction to Mid-Columbia Tributaries: 1999 Annual Report. Project number 1996-040-00. BPA, Portland, Oregon. 61p.

Dygert, P. 2011. Memorandum to Bob Turner (NMFS) from Peter Dygert (NMFS). Report on Task H from the 2010 Lower Columbia Chinook Harvest Biological Opinion. February 3, 2011. NMFS, Seattle, Washington. 32p.

Dygert, P. 2018. Memorandum to Mike Ford (NWFSC) from Peter Dygert (NMFS). Integrated Population Modeling Analysis to Evaluate Fishery and Environmental Impacts on Pacific Salmon Viability. February 9, 2018. 3p.

Edmands, S. 2007. Between a rock and a hard place: Evaluating the relative risks of inbreeding and outbreeding for conservation and management. Molecular Ecology. 16: 463-475.

EPA. 2003. Columbia/Snake Rivers Temperature TMDL Preliminary Draft July, 2003. 79p.

Everest, F. H., and D. W. Chapman. 1972. Habitat selection and spatial Interaction by juvenile Chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29: 91-100.

Falcy, M. 2017. Population Viability of Willamette River Winter Steelhead: An assessment of the effect of sea lions at Willamette Falls. July 7, 2017. Oregon Department of Fish and Wildlife. 18p.

Fast, D. E., J. D. Hubble, M. S. Kohn, and B. D. Watson. 1991. Yakima spring Chinook enhancement study. Project completion report to Bonneville Power Administration. Project 82-16. 345P.+appendices.

Faulkner, J. R., M. S. Morris, D. L. Widener, P. J. Bentley, T. M. Marsh, S. G. Smith, and R. W. Zabel. 2016a. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2015. BPA Project # 1993-029-00. 1/1/2015 - 12/31/2015. Report to the Bonneville Power Administration. 139p

Faulkner, J. R., S. G. Smith, D. M. Marsh, and R. W. Zabel. 2013a. Draft Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2012. April 2013. Project 199302900. NWFSC, Seattle, Washington. 114p.

Faulkner, J. R., S. G. Smith, W. D. Muir, D. M. Marsh, and R. W. Zabel. 2012. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2011. Project 199302900. February 2012. NWFSC, Seattle, Washington. 112p.

Faulkner, J. R., S. G. Smith, D. L. Widener, T. M. Marsh, and R. W. Zabel. 2013b. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2013. December 2013. Project 199302900. NWFSC, Seattle, Washington. 115p.

Faulkner, J. R., S. G. Smith, D. L. Widener, T. M. Marsh, and R. W. Zabel. 2015. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2014. May 2015. NWFSC, Seattle, Washington. 117p.

Faulkner, J. R., D. L. Widener, S. G. Smith, T. M. Marsh, and R. W. Zabel. 2016b. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2015. April 2016. NWFSC, Seattle, Washington. 121p.

Feldhaus, J. 2017. NE Oregon_SE Washingotn_ODFW_Chinook excel report. September 4, 2017.

Ferguson, J. W., G. M. Matthews, R. L. McComas, R. F. Absolon, D. A. Brege, M. H. Gessel, and L. G. Gilbreath. 2005. Passage of Adult and Juvenile Salmonids through Federal Columbia River Power System Dams. March 2005. U.S. Department of Commerce, NOAA Tech. Memo., NMFS-NWFSC-64. 183p.

Fisher, J. L., W. T. Peterson, and R. R. Rykaczewski. 2015. The impact of El Niño events on the pelagic food chain in the northern California Current. Global Change Biology. 21(12): 4401–4414.

Fisher, J. P., L. A. Weitkamp, D. J. Teel, S. A. Hinton, J. A. Orsi, E. V. F. Jr., J. F. T. Morris, M. E. Thiess, R. M. Sweeting, and M. Trudel. 2014. Early ocean dispersal patterns of Columbia River Chinook and coho salmon. Transactions of the American Fisheries Society. 143: 252-272.

Fisheries and Oceans Canada. 2016. Management Plan for the Green Sturgeon *(Acipenser medirostris*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. 43p.

Fiumera, A. C., B. A. Porter, G. Looney, M. A. Asmussen, and J. C. Avise. 2004. Maximizing offspring production while maintaining genetic diversity in supplemental breeding programs of highly fecund managed species. Conservation Biology. 18(1): 94-101.

Fletcher, D. H., F. Haw, and P. K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management. 7: 436-439.

Ford, J. K. B. 2000. Killer whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. Vancouver, British Columbia, UBC Press, 2nd Edition.

Ford, J. K. B., and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316: 185–199.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R. S. Palm, and K. C. Balcomb. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology. 76(8): 1456-1471.

Ford, M., A. Murdoch, and S. Howard. 2012. Early male maturity explains a negative correlation in reproductive success between hatchery-spawned salmon and their naturally spawning progeny. Conservation Letters. 5: 450-458.

Ford, M. J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology. 16(3): 815-825.

Ford, M. J. 2011. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. November 2011. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-113. 307p.

Ford, M. J., P. Budy, C. Busack, D. Chapman, T. Cooney, T. Fisher, J. Geiselman, T. Hillman, J. Lukas, C. Peven, C. Toole, E. Weber, and P. Wilson. 2001. Upper Columbia River Steelhead and Spring Chinook Salmon Population Structure and Biological Requirements. Final report, March 2001. NMFS, Seattle, Washington. 64p.

Ford, M. J., J. Hempelmann, B. Hanson, K. L. Ayres, R. W. Baird, C. K. Emmons, J. I. Lundin, G. S. Schorr, S. K. Wasser, and L. K. Park. 2016. Estimation of a killer whale (*Orcinus orca*) population’s diet using sequencing analysis of DNA from feces. PLoS ONE. 11(1): e0144956.

Ford, M. J., A. Murdoch, and M. Hughes. 2015. Using parentage analysis to estimate rates of straying and homing in Chinook salmon (*Oncorhynchus tshawytscha*). Molecular Ecology. 24: 1109-1121.

Foreman, M. G. G., W. Callendar, D. Masson, J. Morrison, and I. Fine. 2014. A model simulation of future oceanic conditions along the British Columbia continental shelf. Part II: results and analyses. Atmosphere-Ocean. 52(1): 20-38.

Fraser, G. 2017a. Email to Emi Kondo (NMFS) from Gregory Fraser (USFWS). August 28, 2017. Entiat summer Chinook Survival. 1p.

Fraser, G. 2017b. Email to Emi Kondo (NMFS) from Gregory Fraser (USFWS). August 29. 2017. Entiat summer Chinook travel time. 1p.

Frazier, P. 2011. Washington Report on Task E from the 2010 Lower Columbia Chinook Harvest Biological Opinion. March 7, 2011. Memorandum to Bob Turner (NMFS), from P. Frazier, WDFW, Vancouver, Washington. 19p. Available at: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Willamette-Lower-Columbia/LC/BO-tasks.cfm.

Fresh, K. L., E. Casillas, 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. September 2005. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-69. 125p.

Friesen, T. A., and D. L. Ward. 1999. Management of northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake rivers. Transactions of the American Fisheries Society. 19(2): 406-420.

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 Water Resources Investigations Report 95-4294. 168p.

Fukushima, M., T. J. Quinn, and W. W. Smoker. 1998. Estimation of eggs lost from superimposed pink salmon (*Oncorhynchus gorbuscha*) redds. Canadian Journal of Fisheries and Aquatic Sciences. 55: 618-625.

Fuller, R. K., J. H. Johnson, and M. A. Bear. 1984. Biological and physical inventory of the streams within the lower Clearwater River basin, Idaho. 1983 Annual report. Project 198201000, (DOE/BP-0005-H). Bonneville Power Administration, Portland, Oregon. 206p.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and Homing Experiments on salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, in the Columbia River System: Fish of the 1939-44 broods. July 1981. NOAA Technical Memorandum NMFS F/NWC-12. 109p.

Galbreath, P. F., C. A. Beasley, B. A. Berejikian, R. W. Carmichael, D. E. Fast, M. J. Ford, J. A. Hesse, L. L. McDonald, A. R. Murdoch, C. M. Peven, and D. A. Venditti. 2008. Recommendations for Broad Scale Monitoring to Evaluate the Effects of Hatchery Supplementation on the Fitness of Natural Salmon and Steelhead Populations. October 9, 2008. Final report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup (AHSWG). 87p.

Gargett, A. E. 1997. The optimal stability `window': a mechanism underlying decadal fluctuations in North Pacific salmon stocks? Fisheries Oceanography. 6(2): 109-117.

Geiger, R. D. 1973. Streamflow Requirements of Salmonids. July 1, 1971 through June 30, 1973. Final report. Project AFS 62-1. Oregon Wildlife Commission, Portland, Oregon. 122p.

Gharrett, A. J., and S. M. Shirley. 1985. A genetic examination of spawning methodology in a salmon hatchery. Aquaculture. 47: 245-256.

Gjerde, B., and T. Refstie. 1988. The effect of fin-clipping on growth rate, survival and sexual maturity of rainbow trout. Aquaculture. 73(1-4): 383-389.

Gleason, E., M. Gingras, and J. DuBois. 2008. Draft 2007 Sturgeon Fishing Report Card: Preliminary data report. CDFG, Bay Delta Region, Stockton, California. 13p.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. June 2005. U.S. Dept. of Commer., NOAA Tech. Memo., NMFS-NWFSC-66. Accessed 11/03/2016. https://swfsc.noaa.gov/publications/fed/00749.pdf 637p.

Goodman, D. 2005. Selection equilibrium for hatchery and wild spawning fitness in integrated breeding programs. Canadian Journal of Fisheries and Aquatic Sciences. 62(2): 374-389.

Goodyear, C. P. 1993. Spawning stock biomass per recruit in fisheries management: Foundation and current use. Canadian Special Publication of Fisheries and Aquatic Sciences. 67-82.

Grant, W. S. 1997. Genetic Effects of Straying of Non-Native Hatchery Fish into Natural Populations. Proceedings of the workshop, June 1-2, 1995, Seattle, Washington. U.S. Department of Commerce, NOAA Tech. Memo., NMFS-NWFSC-30. 157p.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific Ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest Fisheries Habitat. Fisheries. 25(1): 15-21.

Groot, C., and L. Margolis. 1991. Pacific Salmon Life Histories. UBC Press. Vancouver, British Columbia, Canada. 588p.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-105. 307p.

Hager, R. C., and R. E. Noble. 1976. Relation of size at release of hatchery-reared coho salmon to age, size, and sex composition of returning adults. The Progressive Fish-Culturist. 38(3): 144-147.

Haigh, R., D. Ianson, C. A. Holt, H. E. Neate, and A. M. Edwards. 2015. Effects of ocean acidification on temperate coastal marine ecosystems and fisheries in the Northeast

Pacific. PLOS One. 10(2): e0117533.

Hanson, J. 2017. Summary for Umatilla River Juvenile Hatchery Coho Salmon, 2001 to 2017. 6p.

Hanson, M. B., R. W. Baird, J. K. B. Ford, J. Hempelmann-Halos, D. M. V. Doornik, J. R. Candy, C. K. Emmons, G. S. Schorr, B. Gisborne, K. L. Ayres, S. K. Wasser, K. C. Balcomb, K. Balcomb-Bartok, J. G. Sneva, and M. J. Ford. 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research. 11 69-82.

Hanson, M. B., and C. K. Emmons. 2010. Annual Residency Patterns of Southern Resident Killer Whales in the Inland Waters of Washington and British Columbia. Revised Draft - 30 October 10. 11p.

Hanson, M. B., C. K. Emmons, and E. J. Ward. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hard, J. J., and W. R. Heard. 1999. Analysis of straying variation in Alaskan hatchery Chinook salmon (*Oncorhynchus tshawytscha*) following transplantation. Canadian Journal of Fisheries and Aquatic Sciences. 56: 578- 589.

Hargreaves, N. B., and R. J. LeBrasseur. 1986. Size selectivity of coho (*Oncorhynchus kisutch*) preying on juvenile chum salmon (*O. keta*). Canadian Journal of Fisheries and Aquatic Science 43: 581-586.

Harper, B. L., and J. Deward E. Walker. 2015. Columbia Basin Heritage Fish Consumption Rates. Human Ecology. 43(2): 237-245.

Harrison, J. 2008. Salmon and steelhead. October 31, 2008. The Northwest Power and Conservation Council. https://www.nwcouncil.org/history/SalmonAndSteelhead. Last accessed 10/24/2017.

Hartman, G. F., and J. C. Scrivener. 1990. Impacts of forestry practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223. 80p.

Haskell, C. A., D. A. Beauchamp, and S. M. Bollens. 2017. Trophic interactions and consumption rates of subyearling Chinook salmon and nonnative juvenile American shad in Columbia River reservoirs. Transactions of the American Fisheries Society. 146: 291-298.

Hatch, D. R., R. Branstetter, J. Stephenson, A. Pierce, J. Newell, W. Bosch, S. Everett, N. Graham, L. Medeiros, L. Jenkins, T. T. Bull, M. Elliott, K. Huggler, T. Cavileer, J. Nagler, M. Fiander, C. Frederickson, J. Blodgett, D. Fast, R. Lessard, J. Whiteaker, and

R. Johnson. 2017. Kelt Reconditioning and Reproductive Success Evaluation Research. Project Number 2007-401-00. January, 2016 - December, 2016. January 2017. CRITFC, Portland, Oregon. 113p.

Hauser, D. D. W., M. G. Logsdon, E. E. Holmes, G. R. VanBlaricom, and R. W. Osborne. 2007. Summer distribution patterns of Southern Resident Killer Whales *Orcinus orca*: core areas and spatial segregation of social groups. Marine Ecology Process Series. 351: 301-310.

Hawkins, S. 1998. Residual Hatchery Smolt Impact Study: Wild Fall Chinook Mortality 1995-97. Columbia River Progress Report #98-8. WDFW, Vancouver, Washington. 24p.

Hawkins, S. W., and J. M. Tipping. 1999. Predation by juvenile hatchery salmonids on wild fall Chinook salmon fry in the Lewis River, Washington. California Fish and Game. 85(3): 124-129.

Hay, D. E., and P. B. McCarter. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. DFO Canadian Stock Assessment Secretariat, Research Document 2000-145. Fisheries and Oceans Canada, Nanaimo, B.C. 92p.

Healey, M. C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha*) *in* C. Groot and L. Margolis (eds.), Life history of Pacific Salmon, pages 311-393. University of British Columbia Press. Vancouver, B.C.

Hecht, B., R. Enkeboll, C. Ivor, and P. Baldwin. 1982. Sediment Transport, Water Quality, and Changing Bed Conditions, Tucannon River, Southeastern Washington. USDA, Soil Conservation Service, Spokane, Washington.

Heintz, R. A., J. W. Short, and S. D. Rice. 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of Pink Salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. Environmental Toxicology and Chemistry. 18(3): 494–503.

Helfield, J. M., and R. J. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. Ecology. 82(9): 2403-2409.

Henderson, R. C., E. K. Archer, B. A. Bouwes, M. S. Coles-Ritchie, and J. L. Kershner. 2005. PACFISH/INFISH Biological Opinion (PIBO): Effectiveness Monitoring Program seven-year status report 1998 through 2004. Gen. Tech. Rep. RMRS-GTR-162. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 16 p.

Hess, M. A., C. D. Rabe, J. L. Vogel, J. J. Stephenson, D. D. Nelson, and S. R. Narum. 2012. Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of a wild population of Chinook salmon. Molecular Ecology. 21: 5236-5250.

HETT. 2014. NTTOC.accdb. (database for NTTOC simulations). Douglas County Public Utility District ftp site.

Hewes, G. W. 1947. Aboriginal Use of Fishery Resources in Northwestern North America. University of California, Berkeley.

Hickey, B., S. Geier, N. Kachel, and A. MacFadyen. 2005. A bi-directional river plume: The Columbia in summer. Continental Shelf Research. 25: 1631-1656.

Hilborn, R., S. P. Cox, F. M. D. Gulland, D. G. Hankin, N. T. Hobbs, D. E. Schindler, and A. W. Trites. 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. November 30, 2012. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for NMFS, Seattle, Washington and Fisheries and Oceans Canada (Vancouver. BC). 87p.

Hillman, T. W., and J. W. Mullan. 1989. Effect of Hatchery Releases on the Abundance of Wild Juvenile Salmonids. Chapter 8 *in* Summer and Winter Ecology of Juvenile Chinook salmon and steelhead trout in the Wenatchee River, Washington. Report to Chelan County PUD by D.W. Chapman Consultants, Inc. Boise, Idaho. 22p.

Hillson, T., K. Bentley, D. Rawding, and J. Grobelny. 2017. Lower Columbia River Juvenile chum Salmon Monitoring: Abundance estimates for chum, Chinook, coho, and steelhead. April 2017. FPT 17-02. 630p.

Hoar, W. S. 1976. Smolt transformation: Evolution, behavior and physiology. Journal of the Fisheries Research Board of Canada. 33: 1233-1252.

Hockersmith, E. E., W. D. Muir, S. G. Smith, and B. P. Sandford. 2000. Comparative performance of sham radio-tagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282. 25p.

Hollowed, A. B., N. A. Bond, T. K. Wilderbuer, W. T. Stockhausen, Z. T. A'mar, R. J. Beamish, J. E. Overland, and M. J. Schirripa. 2009. A framework for modelling fish and shellfish responses to future climate change. ICES Journal of Marine Science. 66: 1584–1594.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 45: 502-515.

Horner, N. J. 1978. Survival, Densities and Behavior of Salmonid Fry in Stream in Relation to Fish Predation. July 1978. A Master's Thesis, University of Idaho, Moscow, Idaho. 132p.

Howe, N. R., and P. R. Hoyt. 1982. Mortality of juvenile brown shrimp Penaeus aztecus associated with streamer tags. Transactions of the American Fisheries Society. 111(3): 317-325.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra, and D. Ortmann. 1985. Stock assessment of Columbia River anadromous salmonids volume II: Steelhead stock summaries stock transfer guidelines - information needs. Final report to Bonneville Power Administration, Contract DE-AI79-84BP12737, Project 83-335. 481p.

HSRG. 2004. Hatchery reform: Principles and Recommendations of the Hatchery Scientific Review Group. April 2004. 329p.

HSRG. 2009. Columbia River Hatchery Reform System-Wide Report. February 2009. Prepared by Hatchery Scientific Review Group. 278p.

HSRG. 2014. On the Science of Hatcheries: An Updated Perspective on the Role of Hatcheries in Salmon and Steelhead Management in the Pacific Northwest. June 2014. 160p.

Hulett, P. L., C. W. Wagemann, and S. A. Leider. 1996. Studies of hatchery and wild steelhead in the Lower Columbia Region. Report No. RAD 96-01. Progress report for Fiscal Year 1995. 30p.

Humling, M. 2017. Email to Emi Kondo (NMFS) from Michael Humling (USFWS). August 16, 2017. Winthrop National Fish Hatchery Chinook travel times and survival. 3p.

ICTRT. 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs. Review draft. March 2007. 93p.

ICTRT. 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. 167p.

IDEQ. 2001. Middle Salmon River-Panther Creek Subbasin Assessment and TMDL. Idaho Department of Environmental Quality, Boise, Idaho. 114p

IDEQ. 2003. Idaho Department of Environmental Quality and U.S. Environmental Protection Agency. 2003. South Fork Clearwater River Subbasin Assessment and Total Maximum Daily Loads. IDEQ, Boise, Idaho. 680p.

IDEQ. 2014. Idaho's 2012 Integrated Report. January 2014. Idaho Department of Environmental Quality, Boise, Idaho.

IDFG. 2015. Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam. IDFG Report Number 15-02. January 2015. Annual Progress Report - January 1, 2014 - December 31, 2014. IDFG, Boise, Idaho. 69p.

IHOT. 1995. Policies and procedures for Columbia basin anadromous salmonid hatcheries. Annual report 1994 to Bonneville Power Administration, project No. 199204300, (BPA Report DOE/BP-60629). 119 electronic pages Available at: http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi.

IMST. 2010. Urban and Rural-residential Land Uses: Their Roles in Watershed Health and the Recovery of Oregon's Wild Salmonids. Technical Report 2010-1. December 31, 2010. Oregon Plan for Salmon and Watersheds, Oregon Watershed Enhancement Board. Salem, Oregon. 259p.

ISAB. 2003. ISAB Review of Salmon and Steelhead Supplementation. ISAB 2003-3 Supplementation Report. 120p.

ISAB. 2007. Climate change impacts on Columbia River Basin Fish and Wildlife. May 11, 2007. Report ISAB 2007-2. Northwest Power and Conservation Council, Portland, Oregon. 146p

ISAB. 2011. Columbia River Food Webs: Developing a broader scientific foundation for fish and wildlife restoration. Document ISAB 2011-1, January 7, 2011. Northwest Power and Conservation Council, Portland, Oregon 364p.

ISAB. 2012. Review of the Comparative Survival Study's Draft 2012 Annual Report. ISAB 2012-7. October 15, 2012. ISAB, Portland, Oregon. 24p.

ISAB. 2015. Density Dependence and Its Implications for Fish Management and Restoration Programs in the Columbia River Basin. ISAB 2015-1. Februrary 25, 2015. 246p.

ISAB. 2016. Predation Metrics Report: Developing and Assessing Standardized Metrics to Measure the Effects of Predation on Columbia River Basin Salmon and Steelhead. October 5, 2016. ISAB 2016-1. 84p.

Israel, J. A., K. J. Bando, E. C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (*Acipenser medirostris*). Canadian Bulletin of Fisheries and Aquatic Sciences. 66: 1491-1504.

ISRP. 2008. Review of the Revised Hood River Production Program Master Plan. Step One of the Northwest Power and Conservation Council's Three-Step Review Process. August 21, 2008, ISRP 2008-10. Independent Scientific Review Panel, Portland, Oregon. 13p.

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. December 2014. Oregon Department of Fish and Wildlife, Corvallis, Oregon. 27p.

Jay, D. A., and T. Kukulka. 2003. Impacts of Columbia River Discharge on Salmonids Habitat: 2. Changes in Shallow-Water Habitat. Journal of Geophysical Research. 108(C9): 3294.

Jepson, M. A., M. L. Keefer, C. C. Caudill, and T. S. Clabough. 2014. Migratory Behavior, Run Timing, and Distribution of Radio-Tagged Adult Winter Steelhead, Summer Steelhead, and Spring Chinook Salmon in the Willamette River – 2013. Technical Report 2014-4.

ODFW, Corvallis, Oregon. 114p.

Jepson, M. A., M. L. Keefer, C. C. Caudill, T. S. Clabough, C. S. Erdman, and T. Blubaugh. 2015. Migratory Behavior, Run Timing, and Distribution of Radio-Tagged Adult Winter Steelhead, Summer Steelhead, Spring Chinook Salmon, and Coho Salmon in the Willamette River: 2011-2014. Technical Report 2015-1. ODFW, Corvallis, Oregon. 117p.

Jepson, M. A., M. L. Keefer, T. S. Clabough, and C. C. Caudill. 2013. Migratory Behavior, Run Timing, and Distribution of Radio-Tagged Adult Winter Steelhead, Summer Steelhead, and Spring Chinook Salmon in the Willamette River – 2012. Technical Report 2013-1. ODFW, Corvallis, Oregon. 130p.

Johnson, E. 2017. Sockeye_juvenile_Travel_Time_IDFG excel report. August 16, 2017.

Johnson, K. 1983. A History of Coho Fisheries and Management in Oregon through 1982. Information Reports Number 84-12. November 1983. ODFW, Corvallis, Oregon. 82p.

Johnson, M. A., T. A. Friesen, D. J. Teel, and D. M. V. Doornik. 2013. Genetic Stock Identification and Relative Natural Production of Willamette River Steelhead. Work Completed for Compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2012. August 2013. Prepared for U. S. Army CORPS of Engineers Portland District - Willamette Valley Project, Portland, Oregon. 87p.

Johnson, O. W., W. S. Grant, R. G. Cope, K. Neely, F. W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Dept. Commer., NOAA Technical Memorandum NMFS-NWFSC-32. 298p.

Johnston, N. T., C. J. Perrin, P. A. Slaney, and B. R. Ward. 1990. Increased juvenile salmonid growth by whole-river fertilization. Canadian Journal of Fisheries and Aquatic Sciences. 47: 862-872.

Jones & Stokes Associates. 2009. Lewis River Hatchery and Supplementation Plan (FERC Project Nos. 935, 2071, 2111, 2213). December 23, 2009. 180p.

Jones Jr., R. P. 2015. Memorandum to Chris Yates from Rob Jones 2015 5-Year Review - Listing Status under the Endangered Species Act for Hatchery Programs Associated with 28 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments. September 28, 2015. NMFS West Coast Region, Sustainable Fisheries Division, Portland, Oregon. 54p.

Jones, K. K., T. J. Cornwell, D. L. Bottom, L. A. Campbell, and S. Stein. 2014. The contribution of estuary-resident life histories to the return of adult *Oncorhynchus kisutch*. Journal of Fish Biology. 85: 52-80.

Jonsson, B., N. Jonsson, and L. P. Hansen. 2003. Atlantic salmon straying from the River Imsa.

Journal of Fish Biology. 62: 641-657.

Kamphaus, C. 2017. Yakima Nation_MCCRP_TravelTime_McNary_Survival_13-17 excel report. October 19, 2017.

Keefer, M. L., and C. C. Caudill. 2013. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Reviews in Fish Biology and Fisheries. 24: 333-368.

Keefer, M. L., C. C. Caudill, C. A. Peery, and C. T. Boggs. 2008. Non-direct homing behaviours by adult Chinook salmon in a large, multi-stock river system. Journal of Fish Biology. 72: 27-44.

Kenaston, K. R., R. B. Lindsay, and R. K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management. 21: 765-773.

Kennedy, V. S. 1990. Anticipated effects of climate change on estuarine and coastal fisheries. Fisheries. 15(6): 16-24.

Kinne, E. 2016. Email to James Dixon (NMFS) from Eric Kinne (WDFW) regarding updated summer steelhead salmon data for the Lewis River. May 10, 2016.

Kirwan, M. L., G. R. Guntenspergen, A. D'Alpaos, J. T. Morris, S. M. Mudd, and S. Temmerman. 2010. Limits on the adaptability of coastal marshes to rising sea level. Geophysical Research Letters. 37(23).

Kline, T. C., Jr., J. J. Goering, O. A. Mathisen, P. H. Poe, and P. L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I, δ15N and δ13C evidence in Sashin Creek, Southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences. 47(1): 136-144.

Knudsen, C. M., M. V. Johnston, S. L. Schroder, W. J. Bosch, D. E. Fast, and C. R. Strom. 2009. Effects of passive integrated transponder tags on smolt-to-adult recruit survival, growth, and behavior of hatchery spring Chinook salmon. North American Journal of Fisheries Management. 29: 658-669.

Kock, T. J., K. F. Tiffan, W. P. Connor, R. K. Steinhorst, and D. W. Rondorf. 2007. Evidence for Behavioral Thermoregulation by Subyearling all Chinook salmon in a Thermally Regulated Reservoir. November 2007 review draft. U.S. Geological Survey, Western Fisheries Research Center, Cook, Washington. 12p.

Koenings, J. P., and G. B. Kyle. 1997. Consequences to juvenile sockeye salmon and the zooplankton community resulting from intense predation. 18p. Alaska Fishery Research Bulletin. 4(2).

Kohler, A., A. Rugenski, and D. Taki. 2008. Stream food web response to a salmon carcass analogue addition in two central Idaho, U.S.A. streams. Freshwater Biology. 53: 446–460.

Kostow, K. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. Reviews in Fish Biology and Fisheries. 19: 9-31.

Kozfkay, C. 2017. Outmigration total for natural-origin sockeye salmon_IDFG excel report. August 3, 2017.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2004. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-62. NMFS, Seattle, Washington. 95p.

Krahn, M. M., M. B. Hanson, G. Schorr, C. K. Emmons, D. G. Burrows, J. L. Bolton, R. W. Baird, and G. M. Ylitalo. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in ‘‘Southern Resident” killer whales. Page 427. Marine Pollution Bulletin. 58(10): 1522–1529.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2002. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-54. 159p.

Kruzic, L. 2001a. Complete decision package for concurrence of the Willamette River spring Chinook FMEP. Memorandum to the Hatcheries and Inland Fisheries Branch Files from Lance Kruzic, National Marine Fisheries Service, Portland, Oregon. February 12, 2001. 36p.

Kruzic, L. 2001b. Completed decision package for concurrence of the Upper Willamette River steelhead FMEP. Memorandum to the Hatcheries and Inland Fisheries Branch Files, from L. Kruzic, National Marine Fisheries Service, Portland, Oregon. November 15, 2001. 82p.

Kucera, P. A., and D. B. Johnson. 1986. A Biological and Physical Inventory of Streams within the Nez Perce Reservation. Final report. Project number 82-l. August 1986. Juvenile Steelhead Survey and Factors that Affect Abundance in Selected Streams in the lower Clearwater River Basin, Idaho. 223p.

Lacy, R. C. 1987. Loss of genetic variation from managed populations: Interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology. 1: 143-158.

Lacy, R. C., R. Williams, E. Ashe, Kenneth C. Balcomb III, L. J. N. Brent, C. W. Clark, D. P.

Croft, D. A. Giles, M. MacDuffee, and P. C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific Reports. 7: 1-12.

Laetz, C., D. Baldwin, V. Hebert, J. Stark, and N. Scholz. 2007. Synergistic Toxicity in Juvenile Coho Salmon Exposed to Mixtures of Organophosphate and Carbamate Insecticides. Proceedings of 2007 Puget Sound/Georgia Basin Research Conference

Lande, R. 1987. Extinction thresholds in demographic models of territorial populations. The American Naturalist. 130(4): 624-635.

LaPatra, S. E. 2003. The lack of scientific evidence to support the development of effluent limitations guidelines for aquatic animal pathogens Aquaculture. 226: 191–199.

Larkin, G. A., and P. A. Slaney. 1996. Trends in Marine-Derived Nutrient Sources to South Coastal British Columbia Streams: Impending Implications to Salmonid Production. Report No. 3. Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests. 59p.

Laufle, J. C., G. B. Pauley, and M. F. Shepard. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) - coho salmon. TR EL-82-4. U.S. Fish and Wildlife Service. Biol. Rep. 82(11.48).

LCFRB. 2010. Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. May 28, 2010. Lower Columbia Fish Recovery Board, Longview, Washington. 788p.

LCREP. 2007. Lower Columbia River and Estuary Ecosystem Monitoring: Water Quality and Salmon Sampling Report. Prepared by the Lower Columbia River Estuary Partnership, Portland, Oregon. 76p.

Lee, Y.-W., R. Gustafson, J. Jannot, J. McVeigh, N. Riley, K. Somers, V. Tuttle, S. Wang, and E. Ward. 2017. Observed and Estimated Bycatch of Green Sturgeon in 2002–2015 US West Coast Groundfish Fisheries. West Coast Groundfish Observer Program. National Marine Fisheries Service, NWFSC, Seattle, Washington. 46p.

LeFleur, C. 2014. Letter to James Dixon (NMFS) from Cindy LeFleur (WDFW), July 11, 2014. Supplemental Information for 17 Lower Columbia River segregated Mitchell Act funded Hatchery and Genetic Management Plans submitted on March 12, 2014. WDFW, Vancouver, Washington. 12p.

Leider, S. A., M. W. Chilcote, and J. J. Loch. 1986. Comparative life history characterisitics of hatchery and wild steelhead trout (*Salmo gairdneri*) of summer and winter races in the Kalama River, Washington. Canadian Journal of Fisheries and Aquatic Sciences. 43(7): 1398-1409.

Leider, S. A., P. L. Hulett, J. J. Loch, and M. W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture. 88(3-4): 239-252.

Lemmen, D. S., F. J. Warren, T. S. James, and C. S. L. M. Clarke. 2016. Canada's Marine Coasts in a Changing Climate; Government of Canada, Ottawa, Ontario. 280p.

Levin, P. S., and J. G. Williams. 2002. Interspecific effects of artifically propagated fish: An additional conservation risk for salmon. Conservation Biology. 16(6): 1581-1587.

Limburg, K., R. Brown, R. Johnson, B. Pine, R. Rulifson, D. Secor, K. Timchak, B. Walther, and K. Wilson. 2016. Round-the-Coast: snapshots of estuarine climate change effects. Fisheries. 41(7): 392-394.

Lind, D. 2017a. Email to Rich Turner (NMFS) from David Lind (YKFP). October 10, 2017. Yakama programs. 3p.

Lind, D. 2017b. Yakima Nation_Survivaland travel Analysis Coho MY2015-MY2017 excel report. October 24, 2017.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. M. Jr., M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society. 140(1): 108-122.

Litz, M. N. C., A. J. Phillips, R. D. Brodeur, and R. L. Emmett. 2011. Seasonal occurrences of Humboldt Squid *(Dosidicus Gigas*) in the northern California current system. CalCOFI Rep. 52: 97-108.

Lucey, S. M., and J. A. Nye. 2010. Shifting species assemblages in the Northeast US continental shelf large marine ecosystem. Marine Ecology Progress Series. 415: 23-33.

Lynch, A. J., B. J. E. Myers, C. Chu, L. A. Eby, J. A. Falke, R. P. Kovach, T. J. Krabbenhoft, T. J. Kwak, J. Lyons, C. P. Paukert, and J. E. Whitney. 2016. Climate Change Effects on North American Inland Fish Populations and Assemblages. Fisheries. 41(7): 346-361.

Lynch, M., and M. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics. 2: 363-378.

Magnuson, J. J., L. B. Crowder, and P. A. Medvick. 1979. Temperature as an ecological resource. American Zoologist 19: 331-343.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the american Meteorological Society. 78(6): 1069-1079.

Marcoe, K., and S. Pilson. 2017. Habitat Change in the Lower Columbia River and Estuary, 1870 - 2011. Journal of Coastal Conservation. 214: 505-525.

Martins, E. G., S. G. Hinch, S. J. Cooke, and D. A. Patterson. 2012. Climate effects on growth, phenology, and survival of sockeye salmon (*Oncorhynchus nerka*): a synthesis of the current state of knowledge and future research directions. Reviews in Fish Biology and Fisheries. 22(4): 887-914.

Martins, E. G., S. G. Hinch, D. A. Patterson, M. J. Hague, S. J. Cooke, K. M. Miller, M. F. LaPointe, K. K. English, and A. P. Farrell. 2011. Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (*Oncorhynchus nerka*). Global Change Biology. 17(1): 99-114.

Mathis, J. T., S. R. Cooley, N. Lucey, S. Colt, J. Ekstrom, T. Hurst, C. Hauri, W. Evans, J. N. Cross, and R. A. Feely. 2015. Ocean acidification risk assessment for Alaska's fishery sector. Progress in Oceanography. 136: 71-91.

Matthews, G. M., and R. S. Waples. 1991. Status Review for Snake River spring and summer Chinook salmon. NOAA Tech. Memo. NMFS F/NWC-200. National Marine Fisheries Service, Seattle, Washington. 82p.

Matthews, K. R., and R. H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium. 7: 168-172.

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring Chinook salmon. Oregon Fish Commission Research Briefs. 1(2): 21-32.

Mattson, C. R. 1963. An Investigation of Adult Spring Chinook Salmon of the Willamette River system, 1946-51. Fish Commission, Portland, Oregon. 43p.

McCarthy, S. G., J. P. Incardona, and N. L. Scholz. 2008. Coastal storms, toxic runoff, and the sustainable conservation of fish and fisheries. American Fisheries Society Symposium. 64: 7-27.

McClelland, E. K., and K. A. Naish. 2007. What is the fitness outcome of crossing unrelated fish populations? A meta-analysis and an evaluation of future research directions. Conservation Genetics. 8: 397-416.

McClure, M., T. Cooney, and ICTRT. 2005. Memorandum to NMFS NW Regional Office, Co-managers and other interested parties. May 11, 2005. Updated population delineation in the interior Columbia Basin. 14p.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward, and T. Whitesel. 2003. Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. March 31, 2003.

Willamette/Lower Columbia Technical Recovery Team. 331p.

McElhany, P., C. Busack, M. Chilcote, S. Kolmes, B. McIntosh, J. Myers, D. Rawding, A. Steel, C. Steward, D. Ward, T. Whitesel, and C. Willis. 2006. Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins. Review Draft. April 1, 2006. 178p.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability status of Oregon salmon and steelhead populations in the Willamette and lower Columbia basins. September 2007. 414p.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42. 174p.

McMichael, G. A., A. C. Hanson, R. A. Harnish, and D. M. Trott. 2013. Juvenile salmonid migratory behavior at the mouth of the Columbia River and within the plume Animal Biotelemetry. 1(14). http://www.animalbiotelemetry.com/content/1/1/14.

McMichael, G. A., R. A. Harnish, J. R. Skalski, K. A. Deter, K. D. Ham, R. L. Townsend, P. S. Titzler, M. S. Hughes, J. Kim, and D. M. Trott. 2011. Final 2011 Migratory behavior and survival of juvenile salmonids in the lower Columbia River, estuary, and plume in 2010. PNNL-20443. September 2011. Pacific Northwest National Laboratory, Richland, Washington. 170p.

McNeil, F. I., and E. J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge *(Esox masquinongy)*. Transactions of the American Fisheries Society. 108: 335-343.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater Fishes of Northwestern Canada and Alaska (No. 173). Fisheries Research Board of Canada, Ottowa. 381p.

Meengs, C. C., and R. T. Lackey. 2005. Estimating the size of historical Oregon salmon runs. Reviews in Fisheries Science. 13: 51-66.

Mobrand, L., J. A. Lichatowich, L. C. Lestelle, and T. S. Vogel. 1997. An approach to describing ecosystem performance "through the eyes of salmon". Canadian Journal of Fisheries and Aquatic Sciences. 54: 2964-2973.

Montgomery, D. R., J. M. Buffington, N. P. Peterson, D. Schuett-Hames, and T. P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influecne of salmonid spawning on bed surface mobility and embryo survival. Canadian Journal of Fisheries and Aquatic Sciences. 53: 1061-1070.

Moring, J. R. 1990. Marking and tagging intertidal fishes: Review of techniques. American Fisheries Society Symposium. 7: 109-116.

Morris, J. F. T., M. Trudel, J. Fisher, S. A. Hinton, E. A. Fergusson, J. A. Orsi, and J. Edward V. Farley. 2007. Stock-specific migrations of juvenile coho salmon derived from coded-wire tag recoveries on the continental shelf of Western North America. American Fisheries Society Symposium. 57: 81.

Morrison, J., and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management. 7: 439-441.

Morrison, W. E., M. W. Nelson, R. B. Griffis, and J. A. Hare. 2016. Methodology for assessing the vulnerability of marine and anadromous fish stocks in a changing climate. Fisheries. 41(7): 407-409.

Moser, M. L., and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes. 79(3-4): 243–253.

Mote, P. W., E. A. Parson, A. F. Hamlet, W. S. Keeton, D. Lettenmaier, N. Mantua, E. L. Miles, D. W. Peterson, D. L. Peterson, R. Slaughter, and A. K. Snover. 2003. Preparing for climatic change: the water, salmon, and forests of the Pacific Northwest. Climatic change. 61(1-2): 45-88.

Moyle, P. B. 2002. Inland Fishes of California, 2nd edition. University of California Press, Berkeley and Los Angeles, California. 173p.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and Habitat of Salmonids in Mid-Columbia Tributary Streams. U.S. Fish and Wildlife Service, Leavenworth, Washington.

Murota, T. 2003. The marine nutrient shadow: A global comparison of anadromous fishery and guano occurrence. Pages 17-31 *in* J.G. Stockner, ed. Nutrients in salmonid ecosystems. American Fisheries Society Symposium 34, Bethesda, Maryland. AFS Symposium 34: 17-31.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2003. Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids. October 2003. NOAA Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 195p.

Myers, J. M., C. Busack, D. Rawding, A. R. Marshall, D. J. Teel, D. M. V. Doornik, and M. T. Maher. 2006. Historical population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins. February 2006. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-73. 341p.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. February 1998. U.S. Dept. Commer., NOAA Tech Memo., NMFS-NWFSC-35. 476p.

Naiman, R. J., J. R. Alldredge, D. A. Beauchamp, P. A. Bisson, J. Congleton, C. J. Henny, N. Huntly, R. Lamberson, C. Levings, E. N. Merrill, W. G. Pearcy, B. E. Rieman, G. T. Ruggerone, D. Scarnecchia, P. E. Smouse, and C. C. Wood. 2012. Developing a broader scientific foundation for river restoration: Columbia River food webs PNAS. 109(52): 21201–21207.

Naiman, R. J., R. E. Bilby, D. E. Schindler, and J. M. Helfield4. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems. 5: 399–417.

Naish, K. A., Joseph E. Taylor III, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology. 53: 61-194.

Naish, K. A., J. E. Taylor, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2008. An Evaluation of the Effects of Conservation and Fishery Enhancement Hatcheries on Wild Populations of Salmon Advances in Marine Biology in Advances in Marine Biology, Volume 53. David W. Sims, Series Editor. 318p.

Naman, S. W., and C. S. Sharpe. 2012. Predation by hatchery yearling salmonids on wild subyearling salmonids in the freshwater environment: A review of studies, two case histories, and implications for management. Environmental Biology of Fisheries. 94(1): 21-28.

Narver, D. W. 1969. Age and size of steelhead trout in the Babine River, British Colurnbia. Journal Fisheries Research Board of Canada. 26(10): 2754-2760.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries. 16(2): 4-21.

Netboy, A. 1974. The Salmon, Their Fight for Survival. Houghton Mifflin Company. Boston Massachusetts.

Nicholas, J. 1995. Status of Willamette Spring-run Chinook Salmon Relative to Federal Endangered Species Act Consideration. November 30, 1995. Report to the National Marine Fisheries Service by the Oregon Department of Fish and Wildlife, Salem, Oregon. 45p.

Nickelson, T. E., M. F. Solazzi, and S. L. Johnson. 1986. Use of hatchery coho salmon (*Oncorhynchus kisutch*) presmolts to rebuild wild populations in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences. 43: 2443-2449.

Nicola, S. J., and A. J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout *(Salmo gairdneri)* in a natural environment. Transactions of the American Fisheries Society. 102: 753-759.

NMFS. 1992. Endangered Species Act section 7 Consultation - Biological Opinion: The 1992 fisheries conducted under the Fishery Management Plan for the salmon fisheries off Washington, Oregon, and California. May 1, 1992. National Marine Fisheries Service, Northwest Region. 19p.

NMFS. 1996a. Conclusions Regarding the Updated Status of West Coast Coho Salmon. NMFS-NWFSC Status Review Update Memo. Prepared by the West Coast Coho Salmon Biological Review Team. Available at: http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/Salmon.cfm (accessed May 31, 2006).

NMFS. 1996b. Endangered Species Act - section 7 Consultation Biological Opinion. March 8, 1996. The Fishery Management Plan for Commercial and Recreational Salmon Fisheries Off the Coasts of Washington, Oregon and California.

NMFS. 1996c. Endangered Species Act – section 7 Consultation Biological Opinion. Impacts of the 1996-1998 Management Agreement for Upper Columbia River Spring Chinook, summer Chinook, and sockeye on listed Snake River salmon. National Marine Fisheries Service, Northwest Region. February 16, 1996. 54p.

NMFS. 1999a. Biological Opinion on the effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel Fisheries in 2009 on the Lower Columbia River Chinook Evolutionary Significant Unit Listed Under the Endangered Species Act and Magnuson-Stevens Act Essential Fish Habitat Consultation. NWR-2009-2074. March 29, 1999.

NMFS. 1999b. Endangered Species Act - Reinitiated section 7 Consultation. Biological Opinion. Fishing Conducted under the Pacific Coast groundfish FMP. December 15, 1999. 67p.

NMFS. 1999c. Endangered Species Act – section 7 Consultation. Biological Opinion and Incidental Take Statement. 1999 Treaty Indian and Non-Indian Fall Season Fisheries in the Columbia River Basin. National Marine Fisheries Service, Northwest and Southwest Regions. July 30, 1999. 70p.

NMFS. 1999d. Endangered Species Act Reinitiated section 7 Consultation Biological Opinion. Approval of the Pacific Salmon Treaty by the U.S. Department of State and Management of the Southeast Alaska Salmon Fisheries Subject to the Pacific Salmon Treaty. November 18, 1999. 105p.

NMFS. 1999e. Endangered Species Act section 7 Consultation Biological Opinion on Artificial Propagation in the Columbia River Basin. Incidental Take of Listed Salmon and Steelhead from Federal and non-Federal Hatchery Programs that Collect, Rear and Release Unlisted Fish Species. March 29, 1999. NMFS Consultation No.: NWR-1999-01903. 231p.

NMFS. 2000a. Endangered and Threatened Species; Final Rule Governing Take of 14 Threatened Salmon and Steelhead Evolutionarily Significant Units (ESUs). Federal

Register 65: 132 (July 10, 2000): 42422-42481.

NMFS. 2000b. Endangered Species Act Reinitiated section 7 Consultation Biological Opinion Effects of Pacific Coast Ocean and Puget Sound Salmon Fisheries during the 2000-2001 Annual Regulatory Cycle. April 28, 2000. NMFS Consultation No.: NWR-2000-560

NMFS. 2000c. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Northwest Region, Portland, Oregon.

NMFS. 2001a. 4(d) Rule Limit 6 Evaluation and Recommended Determination. Lake Ozette Sockeye Salmon Resource Management Plan, Hatchery and Genetic Management Plan Component. NMFS Consultation No.: NWR-2001-003. 55p.

NMFS. 2001b. Endangered Species Act - section 7 Consultation Biological Opinion on Impacts of the Interim Management Agreement for Upriver Spring Chinook, Summer Chinook, and Sockeye on Salmon and Steelhead. March 21, 2001. 101p.

NMFS. 2001c. Endangered Species Act Reinitiated section 7 Consultation Biological Opinion and Incidental Take Statement Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel fisheries on Upper Willamette River Chinook, Lower Columbia River Chinook, Lower Columbia River chum. April 30, 2001. Consultation No.: NWR-2001-609. 57p.

NMFS. 2001d. Status Review Update for Lower Columbia River Coho Salmon. May 18, 2001. NMFS, Northwest Fisheries Science Center, Seattle, Washington. 71p.

NMFS. 2003a. Biological Opinion and Magnuson-Stevens Fishery Conservation Management Act on Issuance of Permit 1395 jointly to WDFW, Chelan PUD, and Douglas PUD, Issuance of Permit 1396 to the USFWS, and Issuance of Permit 1412 to the Confederated Tribes of the Colville Reservation. October 2, 2003. NMFS Consultation No.: NWR-2002-000981. 92p.

NMFS. 2003b. Endangered Species Act section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*) Columbia River chum salmon (*O. keta*) Lower Columbia River steelhead (*O. kisutch*). NMFS's determination regarding five proposed Fisheries Management Evaluation Plans (FMEP) submitted by the WDFW and the ODFW under ESA 4(d) Rule Limit 4. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2003-00482. 56p.

NMFS. 2003c. Endangered Species Act section 7 Consultation Biological Opinion Unlisted Species Analysis and Magnuson-Stevens Fishery Conservation and Management Act Consultation. Proposed Issuance of a Section 10 Incidental Take Permit to Public Utility District No. 1 of Chelan County for the Rock Island Hydroelectric Project (FERC No. 943) Anadromous Fish Agreement and Habitat Conservation Plan and Construction of a Small Turbine Unit in the Attraction Water Conduit of the Left Bank Adult Fishway. August 12, 2003. NMFS Consultation No.: NWR-2002-01898. 110p.

NMFS. 2003d. Endangered Species Act section 7 Consultation, Biological Opinion Unlisted Species Analysis, and Magnuson-Stevens Fishery Conservation and Management Act Consultation for Proposed Issuance of a Section 10 Incidental Take Permit to Public Utility District No. 1 of Douglas County for the Wells Hydroelectric Project (FERC No. 2149) Anadromous Fish Agreement and Habitat Conservation Plan. August 12, 2003. NMFS Consultation No.: NWR-2002-01896. 150p.

NMFS. 2003e. National Marine Fisheries Service's Determination Regarding Five Proposed Fisheries Management Evaluation Plans (FMEP) submitted by the Washington Department of Fish and Wildlife and the Oregon Department of Fish and Wildlife under ESA 4(d) Rule limit 4. December 29, 2003. 56p.

NMFS. 2004a. Endangered Species Act section 7 Consultation Programmatic Biological and Conference Opinion & Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, NOAA Restoration Center Programs All Pacific Northwest ESUs Oregon, Washington, and Idaho. July 12, 2004. NMFS Consultation No.: NWR-2002-01967. 227p.

NMFS. 2004b. Salmonid Hatchery Inventory and Effects Evaluation Report (SHIEER). An Evaluation of the Effects of Artificial Propagation on the Status and Likelihood of Extinction of West Coast Salmon and Steelhead under the Federal Endangered Species Act. Technical Memorandum NMFS-NWR/SWR. May 28, 2004. U.S. Dept. of Commerce, National Marine Fisheries Service, Portland, Oregon. 557p.

NMFS. 2005a. Biological Opinion on Impacts of Treaty Indian and Non-Indian Fisheries in the Columbia River Basin in years 2005-2007. May 4, 2005. NMFS Consultation No.: NWR-2005-00388. 145p.

NMFS. 2005b. Endangered and Threatened Species: Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. Federal Register, Volume 70 No. 170(September 2, 2005):52630-52858. Final Rule.

NMFS. 2005c. Final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead. NMFS NWR Protected Resources Division, Portland, Oregon. 587p.

NMFS. 2005d. Policy on the consideration of hatchery-origin fish in Endangered Species Act listing determinations for Pacific salmon and steelhead. Federal Register, Volume 70 No. 123(June 28, 2005):37204-37216.

NMFS. 2006. Endangered Species Act (ESA) section 7 Consultation - Supplemental Biological Opinion. Reinitiation regarding the PFMC groundfish FMP. March 11, 2006. NMFS Consultation No.: NWR-2006-00754. 34p.

NMFS. 2007a. Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Consultation Operation of PacifiCorp and Cowlitz PUD's Lewis River Hydroelectric Projects for 50 years from the new licenses issued date(s). Merwin FERC No. 935 Yale FERC No. 2071 Swift No. 1 FERC No. 2111 Swift No. 2 FERC No. 213 Lewis River, HUC 17080002, Cowlitz, Clark, and Skamania Counties, Washington. Consultation No.: NWR-2005-05891. 248p.

NMFS. 2007b. Endangered Species Act section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River. November 27, 2007. NMFS Consultation No.: NWR-2004-02625. 256p.

NMFS. 2007c. Endangered Species Act section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Habitat Restoration Program submitted by the State of Washington, Governor's Salmon Recovery Office, or ESA Section 4(d) Limit 8. February 28, 2007. NMFS Consultation No.: NWR-2006-05601. NMFS, Portland, Oregon. 70p.

NMFS. 2007d. Report to Congress: Pacific Coastal Salmon Recovery Fund. FY 2000–2006. U.S. Department of Commerce. 56p.

NMFS. 2008a. Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs consistent with Conservation and Sustainable Fisheries Mandates. Appendix C of Supplementary Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions. May 5, 2008. NMFS, Portland, Oregon.

NMFS. 2008b. Biological Opinion and Magnuson-Steven Fishery Conservation and Management Act. New License for the Priest Rapids Hydroelectric Project FERC Project No. 2114 Columbia River. February 1, 2008. Grant, Yakima, Kittitas, Douglas, Benton, and Chelan Counties, Washington. Northwest Region, Hydro Division. NMFS Consultation No.: NWR-2006-01457. 74p.

NMFS. 2008c. Endangered Species Act section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation. Consultation on the "Willamette River Basin Flood Control Project". July 11, 2008. NMFS Consultation No.: NWR-2000-02117. 1205p.

NMFS. 2008d. Endangered Species Act section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation on Treaty Indian and Non-Indian Fisheries in the Columbia River Basin Subject to the 2008-2017 *U.S. v. Oregon* Management Agreement. May 5, 2008. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2008-02406. 685p.

NMFS. 2008e. Endangered Species Act section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat

Consultation: Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order *NWF v. NMFS* Civ. No. CV 01-640-RE (D. Oregon)). May 5, 2008. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2005-05883. 929p.

NMFS. 2008f. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Seattle, Washington. 251p.

NMFS. 2008g. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions. May 5, 2008. NMFS, Portland, Oregon. 1230p.

NMFS. 2009. Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. November 30, 2009. NMFS, Portland, Oregon. 260p.

NMFS. 2010a. Biological Opinion on the Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel Fisheries in 2010 and 2011 on the Lower Columbia River Chinook Evolutionarily Significant Unit and Puget Sound/Georgia Basin Rockfish Distinct Populations Segments Listed Under the Endangered Species Act and Magnuson-Stevens Act Essential Fish Habitat Consultation. April 30, 2010. Consultation No.: NWR-2010-01714. 155p.

NMFS. 2010b. Endangered Species Act section 7(a)(2) Consultation Supplemental Biological Opinion Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. May 20, 2010. NMFS Consultation No.: NWR-2010-02096. 246p.

NMFS. 2010c. Federal Recovery Outline North American Green Sturgeon Southern Distinct Population Segment. December 2010. 23p.

NMFS. 2011a. 5-Year Review: Summary & Evaluation of Snake River Sockeye, Snake River Spring/Summer Chinook, Snake River Fall-run Chinook, Snake River Basin Steelhead. NMFS, Portland, Oregon. 65p.

NMFS. 2011b. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. January 2011. NMFS, Northwest Region. 260p.

NMFS. 2011c. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Umatilla River Spring Chinook Salmon, Fall Chinook Salmon, and Coho Salmon Hatchery Programs. April 19, 2011. NMFS, Portland, Oregon. NMFS Consultation No.: 2010-06511. 113p.

NMFS. 2011d. Section 10(a)(1)(A) Permit for Takes of Endangered/Threatened Species. Permit 16578. Adult Salmonid Monitoring on the Grays River, Elochoman River, and Coweeman River, Washington, through the use of Instream Weirs. 10p.

NMFS. 2012a. Draft Idaho Snake River spring/summer Chinook and steelhead recovery plan. NMFS. Boise, Idaho.

NMFS. 2012b. Effects of Hatchery Programs on Salmon and Steelhead Populations: Reference Document for NMFS ESA Hatchery Consultations. December 3, 2012. Northwest Region, Salmon Managment Division, Portland, Oregon. 50p.

NMFS. 2012c. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Effects of the Pacific Coast Salmon Plan Fisheries on the Lower Columbia River Chinook Evolutionarily Significant Unit. April 26, 2012. NMFS Consultation No.: NWR-2011-06415. 128p.

NMFS. 2012d. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Snake River Fall Chinook Salmon Hatchery Programs, ESA section 10(a)(l)(A) permits, numbers 16607 and 16615. October 9, 2012. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2011-03947 and NWR-2011-03948. 175p.

NMFS. 2012e. Jeopardy and Destruction or Adverse Modification of Critical Habitat Endangered Species Act Biological Opinion for Environmental Protection Agency's Proposed Approval of Certain Oregon Administrative Rules Related to Revised Water Quality Criteria for Toxic Pollutants. August 14, 2012. NMFS Consultation No.: NWR-2008-00148. 784p.

NMFS. 2012f. Proposed ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. April 2012. National Marine Fisheries Service, Northwest Region. 506p. Available at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/lower_columbia_river/lower_columbia_river_salmon_recovery_sub_domain.html.

NMFS. 2013a. Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Yakima River Spring Chinook Salmon, Summer/Fall Chinook Salmon, and Coho Salmon Hatchery Programs. November 25, 2013. NMFS Consultation No.: NWR-2011-06509. 118p.

NMFS. 2013b. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation on issuance of three section 10(a)(1)(A) permits for the Upper Columbia

Chiwawa River, Nason Creek, and White River spring Chinook salmon Hatchery Programs. July 3, 2013. NMFS Consultation No.: NWR-2013-9707. NMFS, Portland, Oregon. 145p.

NMFS. 2013c. Endangered Species Act section 7(a)(2) Biological Opinion, section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Entiat National Fish Hatchery Summer Chinook Hatchery Program. April 18, 2013. NMFS Consultation No.: NWR-2012-00841. 79p.

NMFS. 2013d. Endangered Species Act section 7(a)(2) Biological Opinion, section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. September 28, 2013. Snake River Sockeye Salmon Hatchery Program. NMFS Consultation No.: NWR-2013-10541. 90p.

NMFS. 2013e. ESA Recovery Plan for Lower Columbia River coho salmon, Lower Columbia River Chinook salmon, Columbia River chum salmon, and Lower Columbia River steelhead. 503p.

NMFS. 2013f. ESA Recovery Plan for the White Salmon River Watershed. June 2013. Prepared by National Marine Fisheries Service Northwest Region.

NMFS. 2013g. Lower Columbia River coho salmon Evolutionarily Significant Unit map.

NMFS. 2013h. National Marine Fisheries Serivce Section 10(a)(1)(A) permit for takes of Endangered/Threatened species. Permit No. 18118; Operation, monitoring, and evaluation of the Nason Creek spring Chinook salmon hatchery program. July 3, 2013. Salmon Management Division, Portland, Oregon. 25p.

NMFS. 2013i. National Marine Fisheries Service Section 10(a)(1)(A) permit for takes of Endangered/Threatened species. Permit 18121; Operation, monitoring, and evaluation of the Chiwawa River spring Chinook salmon hatchery program. July 3, 2013. Northwest Region, Portland, Oregon. 25p.

NMFS. 2014a. Draft ESA Recovery Plan for Northeast Oregon Snake River Spring and Summer Chinook Salmon and Snake River Steelhead Populations. October 2014. National Marine Fisheries Service, West Coast Region, Portland, Oregon. 529p.

NMFS. 2014b. Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Effects of the Pacific Coast Salmon Plan on the Lower Columbia River Coho Evolutionarily Significant Unit Listed Under the Endangered Species Act. 67 p. .

NMFS. 2014c. Endangered Species Act section 7(a)(2) Biological Opinion and Conference Report, and Magnuson-Stevens Fishery Conservation and Management Act Essential

Fish Habitat (EFH) Consultation. Issuance of Section 10(a)(1)(A) Permit 18928 for the Chief Joseph Hatchery Okanogan Spring Chinook Salmon. West Coast Region, Sustainable Fisheries. October 27, 2014. NMFS Consultation No.: WCR-2014-607. 131p.

NMFS. 2014d. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Idaho Water Quality Standards for Toxic Substances. May 7, 2014. NMFS Consultation No.: NWR-2000-1484. 528p.

NMFS. 2014e. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Mid-Columbia Coho Salmon Restoration Program. Operation and Construction. June 26, 2014. NMFS Consultation No.: NWR-2011-05645. 144p.

NMFS. 2014f. Endangered Species Act section 7(a)(2) Biological Opinion, section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead Hatchery Programs. August 7, 2014. NMFS Consultation No:. WCR-2014-300. 200p.

NMFS. 2014g. Endangered Species Act section 7(a)(2) Supplemental Biological Opinion. Consultation in Remand for Operation of the Federal Columbia River Power System. January 17, 2014. NMFS Consultation No.: NWR-2013-9562. 610p.

NMFS. 2014h. Final Environmental Impact Statement to inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs. West Coast Region. National Marine Fisheries Service. Portland, Oregon.

NMFS. 2015a. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation (Reinitiation 2015). Reinitiation of the Issuance of Three Section 10(a)(1)(A) Permits for the Upper Columbia River Chiwawa River, Nason Creek, and White River Spring Chinook Salmon Hatchery Programs. May 29, 2015. NMFS Consultation No.: NWR-2013-9707. 128p.

NMFS. 2015b. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Effects of the Pacific Coast Salmon Plan on the Lower Columbia River Coho Evolutionarily Significant Unit Listed Under the Endangered Species Act. April 9, 2015. NMFS Consultation No.: WCR-2015-2026. 67p.

NMFS. 2015c. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*). June 8, 2015. NMFS, West Coast Region. 431p.

NMFS. 2015d. Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*) 5-Year Review: Summary and Evaluation. NMFS, Long Beach, California. 42p.

NMFS. 2016a. 2015 Adult Sockeye Salmon Passage Report. September 2016. 72p.

NMFS. 2016b. 2016 5-Year Review: Summary & Evaluation of Snake River Sockeye Snake River Spring-Summer Chinook Snake River Fall-Run Chinook Snake River Basin Steelhead. National Marine Fisheries Service, West Coast Region, Portland, Oregon. 128p.

NMFS. 2016c. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Six Lower Snake River Spring/Summer Chinook Salmon Hatchery Programs. June 24, 2016. NMFS Consultation No.: WCR-2013-21. 142p.

NMFS. 2016d. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Issuance of a Section 10(a)(1)(A) Permit 18583 for the Upper Columbia Wenatchee River Summer Steelhead Hatchery Program. July 20, 2016. NMFS Consultation No.: WCR-2017-7367. 202p.

NMFS. 2016e. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Issuance of Four Section 10(a)(1)(A) Permits for Spring Chinook Salmon Hatchery Programs in the Methow Subbasin. October 13, 2016. NMFS Consultation No.: WCR-2015-3845. 116p.

NMFS. 2016f. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Umatilla River Spring Chinook Salmon, Fall Chinook Salmon, and Coho Salmon Hatchery Programs. August 19, 2016. NMFS, Portland, Oregon. NMFS Consultation No.: WCR-2010-06511. 45p.

NMFS. 2016g. Endangered Species Act section 7(a)(2) Biological Opinion section 7(a)(2) Not Likely to Adversely Affect Determination and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Carson National Fish Hatchery Spring Chinook Salmon Program, Little White Salmon National Fish Hatchery Upriver Bright Fall Chinook Salmon Program, Little White Salmon National Fish Hatchery Spring Chinook Salmon Program, Eagle Creek National Fish Hatchery Coho Salmon Program, and Eagle Creek National Fish Hatchery Winter Steelhead Biological Opinion. August 30, 2016. NMFS Consultation No.: WCR-2016-5397. 210p.

NMFS. 2016h. Endangered Species Act section 7(a)(2) Jeopardy and Destruction or Adverse Modification of Critical Habitat Biological Opinion and section 7(a)(2) Not Likely to Adversely Affect Determination for the Implementation of the National Flood Insurance Program in the State of Oregon. April 14, 2016. NMFS, Seattle, Washington. Consultation No.: NWR-2011-3197. 410p.

NMFS. 2016i. Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation. December 2016. NMFS, West Coast Region, Seattle, Washington. 74p.

NMFS. 2017a. Biological Assessment for NMFS' Implementation of the Final Mitchell Act EIS Preferred Alternative and Funding for Operation, Maintenance; and Monitoring, Evaluation and Reform of Columbia River Basin Hatchery Programs. NMFS, West Coast Region, January 2017.

NMFS. 2017b. Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Leavenworth National Fish Hatchery Spring Chinook Salmon Program (Reinitiation 2016). September 29, 2017. NMFS Consultation No.: WCR-2017-7345. 261p.

NMFS. 2017c. Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*). September 6, 2017. National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, Oregon. 132p.

NMFS. 2017d. Endangered Species Act section 7 Consultation Biological Opinion. Four Salmon River Basin Spring/Summer Chinook Salmon Hatchery Programs in the Upper Salmon River Basin. NMFS Consultation No.: WCR 2017-7432.

NMFS. 2017e. Endangered Species Act section 7 Consultation Biological Opinion. Hood River Spring Chinook Salmon and Winter Steelhead Programs. NMFS Consultation No.: WCR-2017-7316.

NMFS. 2017f. Endangered Species Act section 7 Consultation Biological Opinion. Middle Columbia River Summer Steelhead and Spring Chinook Programs. NMFS Consultation No.: WCR-2017-7615.

NMFS. 2017g. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Mid-Columbia Coho Salmon Restoration Program. Operation and Construction. February 28, 2017. NMFS Consultation No.: WCR-2015-3778. 123p.

NMFS. 2017h. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Four Lower Snake River Steelhead Hatchery Programs. July 11, 2017. NMFS Consultation No.: WCR-2017-6358. 134p.

NMFS. 2017i. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Issuance of a Tribal 4(d) Rule Determination for a Tribal Resource Management Plan (TRMP) submitted by the Confederated Tribes of the Colville

Reservation, and Funding and Carrying Out Activities Pursuant to that TRMP. February 24, 2017. NMFS Consultation No.: WCR-2014-388. 129p.

NMFS. 2017j. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. January 15, 2017. NMFS Consultation No.: WCR-2014-697. 535p.

NMFS. 2017k. Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Two Steelhead Hatchery Programs in the Methow River. October 10, 2017. NMFS Consultation No.: WCR-2017-6986. 117p.

NMFS. 2017l. Endangered Species Act section 7(a)(2) Biological Opinion, section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Little White Salmon National Fish Hatchery Upriver Bright Fall Chinook Salmon Program. October 5, 2017. NMFS Consultation No.: WCR-2015-2764. 175p.

NMFS. 2017m. ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*). November 2017. NMFS, West Coast Region, Portland, Oregon. 366p.

NMFS. 2017n. ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*). November, 2017. NMFS, West Coast Region, Portland, Oregon. 284p.

NMFS. 2017o. Final Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Five Snake River Basin Spring/Summer Chinook Salmon Hatchery Programs. November 27, 2017. NMFS Consultation No.: WCR-2017-7319. 152p.

NMFS. 2017p. Final Endangered Species Act section 7 Consultation Biological Opinion. December 12, 2017. Five Clearwater River Basin Spring/Summer Chinook Salmon and Coho Salmon Hatchery Programs. NMFS Consultation No.: WCR-2017-7303. 145p.

NMFS. 2017q. Final Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. December 12, 2017. Nine Snake River Steelhead Hatchery Programs and one Kelt Reconditioning Program in Idaho. NMFS Consultation No.: WCR-2017-7286. 139p.

NMFS. 2017r. Letter to Herb Pollard (NMFS) from Barry Thom (NMFS) Summarizing NOAA's NMFS' Consultation Standards and Guidance Regarding the Potential Effects of the 2017 Season on ESA-Listed Salmonid Species. March 3, 2017. NMFS, Portland, Oregon. 14p.

NMFS. 2017s. National Marine Fisheries Service Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat (EFH) Consultation. March 17, 2017. Consultation on the implementation of the area 2A (U.S. West Coast) halibut catch sharing plan for 2017. NMFS Consultation No.: WCR-2017-6480. 218p.

NMFS. 2017t. Reinitiation of section 7 Consultation Regarding the Pacific Fisheries Management Council's Groundfish Fishery Management Plan. NMFS Consultation No.: WCR-2017-7552. 313p.

NMFS, and NOAA. 2009. Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 74: 52300-52351.

NMFS, and ODFW. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. Final. August 5, 2011. 462p.

NMFS, and USACE. 2017. Endangered Species Act (ESA) section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin. December 26, 2017. NMFS Consultation No.: WCR-2015-3607. 186p.

Noakes, D. J., R. J. Beamish, and M. L. Kent. 2000. On the decline of Pacific salmon and speculative links to salmon farming in British Columbia. Aquaculture. 183: 363-386.

NPCC. 1986. Compilation of Information on Salmon and Steelhead Total Run Size, Catch, and Hydropower Related Losses in the Upper Columbia. Fisheries Technical Report No. 2. December 1985. Upper Columbia United Tribes Fisheries Center, Cheney, Washington. 201p.

NPCC. 2004. Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan in Columbia River Basin Fish and Wildlife Program. Northwest Power and Conservation Council, Portland, Oregon.

NPPC. 1992. Information on Water Quality and Quantity Contained in the Salmon and Steelhead Subbasin Plans (above Bonneville Dam). September 17, 1992. Northwest Power Planning Council, Portland, Oregon. 25p.

NRC. 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press: Washington, D.C. 452p.

NWFSC. 2010. Lower Columbia River Tule Chinook Salmon Life-cycle Modeling. June 1, 2014. NWFSC, NMFS, Seattle, Washington. 251p.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. Northwest Fisheries Science Center. National Marine Fisheries Service, Seattle, Washington. 356p.

NWIFC, and WDFW. 2006. The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Revised July 2006. 38p.

ODEQ. 2008. Portland Harbor. Accessed July 29, 2016. Available at: http://www.deq.state.or.us/lq/cu/nwr/portlandharbor.

ODFW. 2001a. Upper Willamette River spring Chinook in Freshwater Fisheries of the Willamette Basin and Lower Columbia River Mainstem Fisheries Management and Evaluation Plan (FMEP). Final draft. February, 2001. 67p.

ODFW. 2001b. Upper Willamette River Winter Steelhead in Sport Fisheries of the Upper Willamette Basin Fisheries Management and Evaluation Plan (FMEP). June 8, 2001. ODFW, Portland, Oregon. 39p.

ODFW. 2003. Fish Health Management Policy, September 12, 2003. Oregon Department of Fish and Wildlife. 10p.

ODFW. 2005. Oregon Native Fish Status Report, Volume I, Species Management Unit Summaries. 164p.

ODFW. 2010a. Final Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. August 6, 2010. 437p.

ODFW. 2010b. Upper Willamette River Conservation and Recovery Plan for Chinook salmon and steelhead. Public review draft. July 2010. 499p.

ODFW. 2015. Fisheries Management and Evaluation for 2014 Willamette River Spring Chinook. January 2015.

ODFW. 2017. 1995-2015. ODFW Sturgeon Catch Data 1995 – 2015. Available online at: http://www.dfw.state.or.us/resources/fishing/sportcatch.asp. Accessed January 2017.

ODFW, and WDFW. 2008. 2008 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 31, 2008. 76p.

ODFW, and WDFW. 2009a. 2009 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 16, 2009. 57p.

ODFW, and WDFW. 2009b. 2009 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous

Regulations. January 26, 2009. 82p.

ODFW, and WDFW. 2010a. 2010 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 16, 2010. 59p.

ODFW, and WDFW. 2010b. 2010 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. February 2, 2010. 89p.

ODFW, and WDFW. 2011. 2011 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff. 86p. January 27, 2011. Available at: http://www.dfw.state.or.us/fish/OSCRP/CRM/reports/11_reports/2011spring%20jsr.pdf

ODFW, and WDFW. 2012. 2012 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 20, 2012. 88p.

ODFW, and WDFW. 2013. 2013 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 24, 2013. 88p.

ODFW, and WDFW. 2014. 2014 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 22, 2014. 88p.

ODFW, and WDFW. 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 21, 2015. 91p.

ODFW, and WDFW. 2016. 2016 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. January 20, 2016. 101p.

ODFW, and WDFW. 2017. 2017 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species, and Miscellaneous Regulations. November 9, 2017. 95p.

Olla, B. L., M. W. Davis, and C. H. Ryer. 1998. Understanding how the hatchery environment represses or promotes the development of behavioral survival skills. Bulletin of Marine Science. 62(2): 531-550.

Olsen, E., P. Pierce, M. McLean, and K. Hatch. 1992. Stock Summary Reports for Columbia River Anadromous Salmonids Volume I: Oregon Subbasins below Bonneville Dam.

Project No. 88-108. BPA, Portland, Oregon. 991p.

Olsen, E. A. 2003. Hood River and Pelton Ladder Evaluation Studies, 2003-2004 Annual Report, Project No. 198805304, (BPA Report DOE/BP-00004001-3). 279p.

Olson, D. 2017. Email to Charlene Hurst (NMFS) from Doug Olson (USFWS). October 3, 2017. Juvenile fish data requested. 1p.

OWRD. 1993. Memorandum to David Moskowitz, Oregon Trout from Tom Kline and Bill Fuji, Water Resources Department. September 17, 1993. Weak stocks and water supply conditions. 20p.

Pastor, S. M. 2004. An evaluation of fresh water recoveries of fish released from national fish hatcheries in the Columbia River basin, and observations of straying. AFS Symposium 44: 87-98.

Pearcy, W. G. 2002. Marine nekton off Oregon and the 1997–98 El Niño. Progress in Oceanography. 54(1): 399-403.

Pearcy, W. G., and S. M. McKinnell. 2007. The ocean ecology of salmon in the Northeast Pacific Ocean - An abridged history. American Fisheries Society Symposium. 57: 7-30.

Pearsons, T. N., and C. A. Busack. 2012. PCD Risk 1: A tool for assessing and reducing ecological risks of hatchery operations in freshwater. Environmental Biology of Fishes. 94: 45-65.

Pearsons, T. N., and A. L. Fritts. 1999. Maximum size of Chinook salmon consumed by juvenile coho salmon. North American Journal of Fisheries Management. 19(1): 165-170.

Pearsons, T. N., G. A. McMichael, S. W. Martin, E. L. Bartrand, M. Fischer, S. A. Leider, G. R. Strom, A. R. Murdoch, K. Wieland, and J. A. Long. 1994. Yakima River Species Interaction Studies. Annual report 1993. December 1994. Division of Fish and Wildlife, Project No. 1989-105, Bonneville Power Administration, Portland, Oregon. 264p.

Peery, C. A., and T. C. Bjornn. 2002. Water Temperatures and Passage of Adult Salmon and Steelhead in the Lower Snake River. Technical Report 02-1. U.S. Geological Survey. Technical Report 02-1. U.S. Geological Survey. 83p.

Peltz, L., and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium. 7: 244-252.

Perkins, W. A., and M. C. Richmond. 2001. Long-term, One-dimensional Simulation of Lower Snake River Temperature for Current and Unimpounded Conditions. February 2001. Prepared for the U.S. Department of Energy, Richland, Washington. 119p.

Peterson, W. T., J. L. Fisher, C. A. Morgan, B. J. Burke, S. M. Zeman, and K. C. Jacobson.

2017. Ocean ecosystem indicators of salmon marine survival in the Northern California Current. December 2017. Northwest Fisheries Science Center, National Marine Fisheries Service, and Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Oregon State University, Newport, Oregon. Prepared for Bonneville Power Administration, Portland, Oregon. 94p.

Peterson, W. T., J. L. Fisher, J. O. Peterson, C. A. Morgan, B. J. Burke, and K. L. Fresh. 2014. Applied fisheries oceanography: Ecosystem indicators of ocean conditions inform fisheries management in the California current. Oceanography. 27(4): 80-89.

Peven, C. M. 1990. The Life History of Naturally Produced Steelhead Trout from the mid-Columbia River Basin.

PFMC. 2003a. Pacific Coast Management Plan. Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the coasts of Washington, Oregon and California as revised through Amendment 14. (Adopted March 1999). September 2003. PFMC, Portland, Oregon. 78p.

PFMC. 2003b. Review of 2002 Ocean Salmon Fisheries. Stock Assessment and Fishery Evaluation Document for the Pacific Coast Fishery Management Plan. February 27, 2003. PFMC, Portland, Oregon. 297p.

PFMC. 2013. Review of 2012 Ocean Salmon Fisheries. Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. February 2013. PFMC, Portland, Oregon. 375p.

PFMC. 2016a. Coastal Pelagic Species Fishery Management Plan as amended through Amendment 15. February 2016. Pacific Fishery Management Council, Portland, Oregon. 49p.

PFMC. 2016b. Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species as amended through Amendment 3. March 2016. Pacific Fishery Management Council, Portland, Oregon. 120p.

PFMC. 2016c. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. August 2016. Pacific Fishery Management Council, Portland, Oregon. 160p.

PFMC. 2016d. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as Amended through Amendment 19. March 2016. PFMC, Portland, Oregion. 90p.

PFMC. 2016e. Review of 2015 Ocean Salmon Fisheries. Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. February 2016. PFMC, Portland, Oregon. 351p.

Piorkowski, R. J. 1995. Ecological effects of spawning salmon on several south central Alaskan streams. Ph.D. dissertation, University of Alaska, Fairbanks, Alaska. 191p.

PNERC. 2002. Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change. Version 2.0. Institute for a Sustainable Environment, University of Oregon, Eugene, Oregon. 2004. Map available at http://www.fsl.orst.edu/pnwerc/wrb/access.html or http://www.fsl.orst.edu/pnwerc/wrb/Atlas_web_compressed/PDFtoc.html.

Poesch, M. S., L. Chavarie, C. Chu, S. N. Pandit, and W. Tonn. 2016. Climate change impacts on freshwater fishes: a Canadian perspective. Fisheries. 41(1): 385-391.

Poytress, W. R., J. J. Gruber, C. Praetorius, and J. V. Eenennaam. 2013. 2012 Upper Sacramento River Green Sturgeon Spawning Habitat and Young-Of-The-Year Migration Surveys. Final Annual Report. September 2013. USFWS, Red Bluff, California. 41p.

Prentice, E. F., T. A. Flagg, and S. McCutcheon. 1987. A Study to Determine the Biological Feasibility of a New Fish Tagging System, 1986-1987. December 1987. Contract DE-AI79-84BP11982, Project 83-319. NMFS, Seattle, Washington. 120p.

Prentice, E. F., and D. L. Park. 1984. A Study to Determine the Biological Feasibility of a New Fish Tagging System, 1983-1984. May 1984. Contract DEA179-83BP11982, Project 83-19. BPA, Portland, Oregon. 44p.

Pycha, R. L. 1956. Progress report on white sturgeon studies. California Fish and Game. 42(1): 23-35.

Quamme, D. L., and P. A. Slaney. 2003. The relationship between nutrient concentration and stream insect abundance. American Fisheries Society Symposium 34. 163-175.

Quinn, T. P. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fisheries Research. 18: 29-44.

Quinn, T. P. 1997. Homing, Straying, and Colonization. Genetic Effects of Straying of Non-Native Fish Hatchery Fish into Natural Populations. NOAA Tech. Memo., NMFS-NWFSC-30. 13p.

Quinn, T. P., and N. P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (*Oncorhynchus kisutch*) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences. 53: 1555-1564.

Rehage, J. S., and J. R. Blanchard. 2016. What can we expect from climate change for species invasions? Fisheries. 41(7): 405-407.

Reimchen, T. E., and N. F. Temple. 2003. Hydrodynamic and phylogenetic aspects of the adipose fin in fishes. Canadian Journal of Zoology. 82: 910-916.

Reisenbichler, R. R., and J. D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada. 34: 123-128.

Rensel, J., K. L. Fresh, J. J. Ames, R. L. Emmett, J. H. Meyer, T. Scribner, S. Schroder, and C. Willis. 1984. Evaluation of Potential Interaction Effects in the Planning and Selection of Salmonid Enhancement Projects. J. Rensel, and K. Fresh editors. Report prepared by the Species Interaction Work Group for the Enhancement Planning Team for implementation of the Salmon and Steelhead Conservation and Enhancement Act of 1980. WDFW, Olympia, Washington. 90p.

Robichaud, D., K. K. English, R. C. Bocking, and T. C. Nelson. 2006. Direct and delayed mortality of white sturgeon in three gear types in the lower Fraser River. March 2006. Report prepared for Tsawwassen First Nation Fisheries, Delta, British Columbia. 50p.

Roby, D. D., K. Collis, D. E. Lyons, Y. Suzuki, P. J. Loschl, T. J. Lawes, K. S. Bixler, A. Piggott, A. Evans, B. Cramer, A. Turecek, Q. Payton, and M. Hawbecker. 2017. Avian Predation on Juvenile Salmonids: Evaluation of the Caspian Tern Management Plan in the Columbia River Estuary. 2015 Final Annual Report. Project No. 1997-024-00, 2/1/2015 – 1/31/2016. 46p.

Roegner, G. C., R. McNatt, D. J. Teel, and D. L. Bottom. 2012. Distribution, size, and origin of juvenile Chinook salmon in shallow-water habitats of the Lower Columbia River and estuary, 2002–2007. Marine and Coastal Fisheries. 4(1): 450-472.

Roegner, G. C., and D. J. Teel. 2014. Density and condition of subyearling Chinook salmon in the lower Columbia River and Estuary in relation to water temperature and genetic stock of origin. Transactions of the American Fisheries Society. 143: 1161–1176.

Rondorf, D. W., and W. H. Miller. 1994. Identification of the Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. Annual report 1994. Project 9l-029, (Report DOE/BP-21708-4). Bonneville Power Administration, Portland, Oregon. Available at: http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi.

Rykaczewski, R. R., J. P. Dunne, W. J. Sydeman, M. García-Reyes, B. A. Black, and S. J. Bograd. 2015. Poleward displacement of coastal upwelling-favorable winds in the ocean’s eastern boundary currents through the 21st century. Geophysical Research Letters. 42(15): 6424–6431.

Ryman, N. 1991. Conservation genetics considerations in fishery management. Journal of Fish Biology. 39 (Supplement A): 211-224.

Ryman, N., P. E. Jorde, and L. Laikre. 1995. Supportive breeding and variance effective population size. Conservation Biology. 9(6): 1619-1628.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology. 5(3): 325-329.

Sagar, J. P., A. B. Borde, L. L. Johnson, T. D. Peterson, J. A. Needoba, K. H. Macneale, M. Schwartz, A. Silva, C. A. Corbett, A. C. Hanson, V. I. Cullinan, S. A. Zimmerman, R. M. Thom, P. M. Chittaro, O. P. Olson, S. Y. Sol, D. J. Teel, G. M. Ylitalo, M. A. Maier, and C. E. Tausz5. 2015. Juvenile Salmon Ecology in Tidal Freshwater Wetlands of the Lower Columbia River and Estuary: Synthesis of the Ecosystem Monitoring Program, Trends (2005–2013) and Food Web Dynamics (2011-2013). March 2015. Project Number 2003-007-00. Prepared by the Lower Columbia Estuary Partnership, Portland, Oregon. 232p.

Saisa, M., M.-L. Koljonen, and J. Tahtinen. 2003. Genetic changes in Atlantic salmon stocks since historical times and the effective population size of a long-term captive breeding programme. Conservation Genetics. 4: 613–627.

Sandercock, F. K. 1991. The Life History of Coho Salmon (*Oncorhynchus kisutch*) *in* C. Groot and L. Margolis (eds.), Life history of Pacific Salmon. Univ. of British Columbia Press, Vancouver, B.C.

Schalk, R. F. 1986. Estimating salmon and steelhead usage in the Columbia Basin before 1850: The anthropological perspective. Northwest Environmental Journal. 2(2): 1-29.

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(6): 448-457.

Schreier, A., O. P. Langness, J. A. Israel, and E. V. Dyke. 2016. Further investigation of green sturgeon (*Acipenser medirostris*) distinct population segment composition in non-natal estuaries and preliminary evidence of Columbia River spawning. Environmental Biology of Fishes. 99(12): 1021-1032.

Seesholtz, A. M., M. J. Manuel, and J. P. V. Eenennaam. 2015. First documented spawning and associated habitat conditions for green sturgeon in the Feather River, California. Environmental Biology of Fishes. 98: 905-912.

Shapovalov, L., and A. C. Taft. 1954. The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and Recommendations Regarding Their Management. California Department of Fish and Game Fish Bulletin 98.

Sharpe, C. S., D. A. Thompson, H. L. Blankenship, and C. B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. The Progressive Fish-Culturist. 60(2): 81-87.

Sharpe, C. S., P. C. Topping, T. N. Pearsons, J. F. Dixon, and H. J. Fuss. 2008. Predation of

Naturally-produced Subyearling Chinook by Hatchery Steelhead Juveniles in Western Washington Rivers. June 2008. FPT 07-09. WDFW Fish Program, Science Division. 68p.

Simpson, P. C. 2017. Email to Rich Turner (NMFS) from Philip Simpson (ODFW). August 8, 2017. Length data for Hood River smolts. 9p.

Smith, S. G. 2014. Graphical image from a presentation made to the Northwest Power and Conservation Council in 2014.

Snow, C. 2017. Methow basin spring Chinook Travel Time and Survival_WDFW excel report. August 7, 2017.

Sosiak, A. J., R. G. Randall, and J. A. McKenzie. 1979. Feeding by hatchery-reared and wild Atlantic salmon (*Salmo salar*) parr in streams. Journal of the Fisheries Research Board of Canada. 36: 1408-1412.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. December 1996. TR-4501-96-6057. Corvallis, Oregon. 206p.

SRSRB. 2011. Snake River salmon recovery plan for SE Washington.

Stahl, T. 2011. Memorandum to Bob Turner (NMFS) from Tom Stahl (ODFW). January 7, 2011. Oregon's Report on Task E from the 2010 Lower Columbia Chinook Harvest Biological Opinion. 6p.

Steward, C. R., and T. C. Bjornn. 1990. Supplementation of Salmon and Steelhead Stocks with Hatchery Fish: A Synthesis of Published Literature. Technical Report 90-1. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho. 132p.

Swagerty, W. R. 2012. The Indianization of Lewis and Clark. October 29, 2012. University of Oklahoma Press, Norman, Oklahoma. 820p.

Sykes, G. E., C. J. Johnson, and J. M. Shrimpton. 2009. Temperature and flow effects on migration timing of Chinook salmon smolts. Transactions of the American Fisheries Society. 138(6): 1252–1265.

Sytsma, M. D., J. R. Cordell, J. W. Chapman, and R. C. Draheim. 2004. Aquatic Nonindigenous Species Survey 2001-2004. October 2004. Final technical report submitted to the U.S. Coast Guard and the U.S. Fish and Wildlife Service. Portland State University, Portland, Oregon. 78p.

TAC. 2008. Biological Assessment of Incidental Impacts on Salmon Species Listed under the Endangered Species Act in the 2008-2017 Non-Indian and Treaty Indian Fisheries in the Columbia River Basin. April 21, 2008. 181p.

TAC. 2015. 2014 TAC Annual Summary Report. Abundance, Stock Status and ESA Impacts, May 13-14, 2015. May 08, 2015. 28p.

TAC. 2017. 2018-2027 *U.S. v. Oregon* Biological Assessment of Incidental Impacts on Species Listed Under the Endangered Species Act Affected by the 2018-2027 *U.S. v. Oregon* Management Agreement. June 21, 2017. 624p.

Tatara, C. P., and B. A. Berejikian. 2012. Mechanisms influencing competition between hatchery and wild juvenile anadromous Pacific salmonids in fresh water and their relative competitive abilities. Environmental Biology of Fishes. 94(1): 7-19.

Taylor III, J. E. 1999. Making Salmon: An Environmental History of the Northwest Fisheries Crisis. November 23, 2009. University of Washington Press. ISBN: 0-295-97840-6

Teel, D. J., B. J. Burke, D. R. Kuligowski, C. A. Morgan, and D. M. V. Dornik. 2015. Genetic identification of Chinook salmon: stock-specific distributions of juveniles along the Washington and Oregon coasts. August 7, 2015. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7:274-300. doi: 10.1080/19425120.2015.1045961. 28p.

Tetra Tech. 1996. The Health of the River: 1990-1996: Integrated Technical Report. Final Report. May 20, 1996. TC 0253-01. Tetra Tech, Redmond, Washington. 132p.

Theriault, V., G. R. Moyer, L. S. Jackson, M. S. Blouin, and M. A. Banks. 2011. Reduced reproductive success of hatchery coho salmon in the wild: Insights into most likely mechanisms. Molecular Ecology. 20: 1860-1869.

Thorpe, J. E. 1994. An Alternative View of Smolting in Salmonds. Aquaculture 121: 105-113.

Thurow, R. 1987. Evaluation of South Fork Salmon River steelhead trout fishery restoration program. Idaho Fish and Game Department and U.S. Fish and Wildlife Service, completion report. Boise, Idaho.

Tolimieri, N., and P. Levin. 2004. Differences in responses of Chinook salmon to climate shifts: Implications for conservation. Environmental Biology of Fishes. 70: 155-167. http://dx.doi.org/10.1023/B:EBFI.0000029344.33698.34.

Turner, R. 2009. Letter to Dave Fast (YN) from Rich Turner (NMFS) regarding Cle Elum Sockeye Reintroduction. July 1, 2009. NMFS, Portland, Oregon. 4p.

UCSRB. 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352p. Available at: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Upper-Columbia/upload/UC_Plan.pdf.

UCSRB. 2014. Upper Columbia Salmon Recovery Board Integrated Recovery Program Habitat Report. June 2014. Wenatchee, Washington. 73p.

USACE. 2016. 2015 Field Report: Evaluation of Pinniped Predation on Adult Salmonids and other fish in the Bonneville Dam Tailrace, 2015. March 2016. USACE, Cascade Locks, Oregon. 39p.

USACE. 2017. 2016 Field Report: Evaluation of Pinniped Predation on Adult Salmonids and other fish in the Bonneville Dam Tailrace, 2016. February 9, 2017. USACE, Cascade Locks, Oregon. 51p.

USFWS. 1994. Biological Assessments for Operation of USFWS Operated or funded hatcheries in the Columbia River Basin in 1995-1998. Submitted with cover letter dated August 2, 1994, from W.F. Shake, USFWS, to B. Brown, NMFS, Portland, Oregon.

USFWS. 2004. U.S. Fish & Wildlife Service handbook of aquatic animal health procedures and protocols. (http://www.fws.gov/policy/AquaticHB.html).

USFWS. 2017. U.S. Fish and Wildlife Service-Lower Snake River Compensation Plan Office, editor. 2017. Proceedings of the Snake River fall Chinook Symposium May 16th and 17th, 2017, Clarkston, Washington. https://www.fws.gov/lsnakecomplan/Meetings/2017FallChinookSymposium.html (Accessed 11/14/2017). 103p.

Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society. 135(1): 151-163.

Vander Haegen, G. E., H. L. Blankenship, A. Hoffman, and O. A. Thompson. 2005. The effects of adipose fin clipping and coded wire tagging on the survival and growth of spring Chinook salmon. North American Journal of Fisheries Management. 25: 1160-1170.

Vasemagi, A., R. Gross, T. Paaver, M. L. Koljonen, and J. Nilsson. 2005. Extensive immigration from compensatory hatchery releases into wild Atlantic salmon population in the Baltic sea: Spatio-temporal analysis over 18 years. Heredity. 95(1): 76-83.

Verdonck, D. 2006. Contemporary vertical crustal deformation in Cascadia. Tectonophysics. 417(3): 221-230.

Vincent-Lang, D. 1993. Relative Survival of Unmarked and Fin-Clipped Coho Salmon from Bear Lake, Alaska. The Progressive Fish-Culturist. 55(3): 141-148.

Vu, N. V., M. W. Ackerman, K. K. Wright, J. McCane, M. R. Campbell, J. E. Hess, and S. R. Narum. 2015. Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam. January 2015. Idaho Department of Fish and Game Report 15-02. Annual Report, BPA Project 2010-026-00. 69p.

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.

Walker Jr., D. E. 1967. Mutual Cross Utilization of Economic Resources in the Plateau: An Example of Aboriginal Nez Perce Fishing Practices. Washington State University, Laboratory of Anthropology. Report of Investigation No. 41. Pullman, Washington.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries. 24(2): 12-21.

Waples, R. S., T. Beechie, and G. R. Pess. 2009. Evolutionary history, habitat disturbance regimes, and anthropogenic changes: What do these mean for resilience of Pacific Salmon populations? Ecology and Society. 14(1).

Waples, R. S., and C. Do. 1994. Genetic risk associated with supplementation of Pacific salmonids: Captive broodstock programs. Canadian Journal of Fisheries and Aquatic Sciences. 51 (Supplement 1): 310-329.

Waples, R. S., O. W. Johnson, and R. P. Jones, Jr. 1991. Status Review for Snake River Sockeye Salmon. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-F/NWC 195. 130p.

Waples, R. S., D. Teel, J. M. Myers, and A. Marshall. 2004. Life-history divergence in Chinook salmon: historic contingency and parallel evolution. Evolution. 58(2): 386-403.

Ward, B. R., and P. A. Slaney. 1988. Life history and smolt-to-adult survival of Keogh River steelhead trout (*Salmo gairdneri*) and the relationship to smolt size. Canadian Journal of Fisheries and Aquatic Sciences. 45: 1110-1122.

Ward, E. J., J. H. Anderson, T. J. Beechie, G. R. Pess, and M. J. Ford. 2015. Increasing hydrologic variability threatens depleted anadromous fish populations. Global Change Biology.

Ward, E. J., M. J. Ford, R. G. Kope, J. K. B. Ford, L. A. Velez-Espino, C. K. Parken, L. W. LaVoy, M. B. Hanson, and K. C. Balcomb. 2013. Estimating the Impacts of Chinook Salmon Abundance and Prey Removal by Ocean Fishing on Southern Resident Killer Whale Population Dynamics. July 2013. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-123. 85p.

Wasser, S. K., J. I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons, and R. Booth. 2017. Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). PLoS ONE. 12(6): 1-22.

WDFW. 2011. Draft Fishery Management and Evaluation Plan for state-managed commercial and recreational salmon and white sturgeon fisheries that encounter green sturgeon.

WDFW. 2014a. Deep River Net Pen Fall Chinook Program (Segregated) Washougal Hatchery HGMP. March 12, 2014. WDFW, Toledo, Washington. 43p.

WDFW. 2014b. Drano Lake Hatchery Summer Steelhead Program (Segregated) HGMP. March 12, 2014. WDFW, Toledo, Washington. 58p.

WDFW. 2014c. Kalama River Winter (Early) Steelhead (Segregated) HGMP. March 12, 2014. WDFW, Toledo, Washington. 80p.

WDFW, and LCFRB. 2015. Lower Columbia Conservation and Sustainable Fisheries Plan. 365p.

WDFW, and ODFW. 2011. 2011 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 13, 2011. 63p.

WDFW, and ODFW. 2012. 2012 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 12, 2012. 64p.

WDFW, and ODFW. 2013. 2013 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 11, 2013. 65p.

WDFW, and ODFW. 2014. 2014 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 14, 2014. 68p.

WDFW, and ODFW. 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 14, 2015. 77p.

WDFW, and ODFW. 2016. 2016 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. July 12, 2016. 73p.

WDFW, and ODFW. 2017. 2017 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. September 7, 2017. 75p.

Weitkamp, L., and K. Neely. 2002. Coho salmon (*Oncorhynchus kisutch*) ocean migration patterns: insight from marine coded-wire tag recoveries. Canadian Bulletin of Fisheries and Aquatic Sciences. 59(7): 1100–1115.

Weitkamp, L. A. 2010. Marine distributions of Chinook salmon from the west coast of North America determined by coded wire tag recoveries. American Fisheries Society. 139(1): 147-170.

Weitkamp, L. A., P. J. Bentley, and M. N. C. Litz. 2012. Seasonal and interannual variation in juvenile salmonids and associated fish assemblage in open waters of the lower Columbia River estuary. Fisheries Bulletin. 110: 426–450.

Weitkamp, L. A., G. Goulette, J. Hawkes, M. O'Malley, and C. Lipsky. 2014. Juvenile salmon in estuaries: comparisons between North American Atlantic and Pacific salmon populations. Reviews in Fish Biology and Fisheries. 24: 713–736.

Wentz, D. A., B. A. Bonn, K. D. Carpenter, S. R. Hinkle, M. L. Janet, F. A. Rinella, M. A. Uhrich, I. R. Waite, A. Laenen, and K. E. Bencala. 1998. Water quality in the Willamette Basin, Oregon, 1991-95 (No. 1161). U.S. Geological Survey.

Westley, P. A. H., T. P. Quinn, and A. H. Dittman. 2013. Rates of straying by hatchery-produced Pacific salmon (*Oncorhynchus* spp.) and steelhead (*Oncorhynchus mykiss*) differ among species, life history types, and populations. Canadian Journal of Fisheries and Aquatic Sciences. 70: 735-746.

Whiteman, K. J., J. J. Vaccaro, J. B. Gonthier, and H. H. Bauer. 1994. The Hydrogeologic Framework and Geochemistry of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho. U.S. Geological Survey Professional Paper 1413-B. 84p.

Whitlock, M. C. 2000. Fixation of new alleles and the extinction of small populations: Drift, load, beneficial alleles, and sexual selection. Evolution. 54(6): 1855-1861.

Whitney, J. E., R. Al-Chokhachy, D. B. Bunnell, C. A. Caldwell, S. J. Cooke, E. J. Eliason, M. Rogers, A. J. Lynch, and C. P. Paukert. 2016. Physiological basis of climate change impacts on North American inland fishes. Fisheries. 41(7): 332-345.

Wiles, G. J. 2004. Washington State Status Report for the Killer Whale. March 2004. WDFW, Olympia, Washington. 120p.

Wilkes, C. 1845. Narrative of the United States Exploring Expedition: During the Years 1838, 1839, 1840, 1841, 1842, Volume IV. Philadelphia, Pennsylvania.

Willard, C. 2017a. Chelan Falls summer Wenatchee summer Wenatchee spring survival to MCN_Chelan PUD excel report. August 31, 2017.

Willard, C. 2017b. Chelan Falls summer Wenatchee summer Wenatchee spring travel time to MCN_Chelan PUD excel report. August 31, 2017.

Willard, C. 2017c. Wenatchee Steelhead Survival_Chelan_PUD report. September 8, 2017. 3p.

Willard, C. 2017d. Wenatchee Steelhead Travel Time_Chelan_PUD excel report. October 23, 2017.

Willi, Y., J. V. Buskirk, and A. A. Hoffmann. 2006. Limits to the adaptive potential of small populations. Annual Review of Ecology, Evolution, and Systematics. 37: 433-458.

Williams, J. G., S. G. Smith, R. W. Zabel, W. D. Muir, M. D. Scheuerell, B. P. Sandford, D. M. Marsh, R. A. McNatt, and S. Achord. 2005. Effects of the Federal Columbia River Power System on Salmonid Populations. February 2005. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-63. NWFSC, Seattle, Washington. 169p

Williamson, K. S., A. R. Murdoch, T. N. Pearsons, E. J. Ward, and M. J. Ford. 2010. Factors influencing the relative fitness of hatchery and wild spring Chinook (*Oncorhynchus tshawytscha*) in the Wenatchee River, Washington. Canadian Journal of Fisheries and Aquatic Sciences. 67: 1840-1851.

Wipfli, M. S., J. P. Hudson, J. P. Caouette, and D. T. Chaloner. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase growth rates of stream-resident salmonids. Transactions of the American Fisheries Society. 132: 371-381.

Withler, R. E. 1988. Genetic consequences of fertilizing chinook salmon (*Oncorhynchus tshawytscha*) eggs with pooled milt. Aquaculture. 68: 15-25.

Wulff, R. J. 2017. Letter to Stuart Ellis, TAC Chair from Ryan J. Wulff, Assistant Regional Administrator. December 21, 2017. Extension of the 2008-2017 *U.S. v. Oregon* Management Agreement Interim. NMFS Sustainable Fisheries Division, West Coast Region, Sacramento, California. 5p

Yamada, S. B., W. T. Peterson, and P. M. Kosro. 2015. Biological and physical ocean indicators predict the success of an invasive crab, *Carcinus maenas*, in the northern California Current. Marine Ecology Progress Series. 537: 175-189.

YKFP. 2008. Klickitat River Anadromous Fisheries Master Plan. Yakima/Klickitat Fisheries Project 1988-115-35. 188p.

Young, B. 2017a. Coho surv and travel time for Eagle Creek and Cascad_NPTH excel report. November 2, 2017.

Young, B. 2017b. Coho Survival and travel to ICE from Eagle Creek and Cascade_SK-Copy of Coho surv TT NAT size NOAA data request (003) excel report. November 2, 2017.

Young, B. 2017c. Juvenille SR fall_Chinook_survival and travel time to Lower Granite Dam 2011 - 2015. August 16, 2017. 2p.

Young, B. 2017d. NPTH HAT surv & TT & NAT size NOAA data request_Bill Young (NPT)_May 23_2017 excel report.

Young, B., S. Rosenberger, D. Milks, B. Sandford, and S. Ellis. 2012. 2011 Snake River Fall Chinook salmon Run Reconstruction at Lower Granite Dam. March 27, 2012.

Zabel, R. W. 2013. Memo to James Lecky (NMFS) from Richard Zabel (NMFS). January 23, 2013. 2012 Estimation Memo. NWFSC, Seattle, Washington. 75p

Zabel, R. W. 2014a. Memorandum to Donna Wieting (NMFS) from Richard Zabel (NMFS). March 13, 2014. 2013 Estimation Memo. NWFSC, Seattle, Washington. 67p.

Zabel, R. W. 2014b. Memorandum to Donna Wieting (NMFS) from Richard Zabel (NMFS). November 4, 2014. 2014 Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2014. NWFSC, Seattle, Washington. 73p.

Zabel, R. W. 2015. Memorandum to Donna Wieting (NMFS) from Richard Zabel (NMFS). Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2015. October 5, 2015. NWFSC, Seattle, Washington. 72p.

Zabel, R. W. 2017. Memorandum to Christopher Yates (NMFS) from Richard Zabel (NMFS). Updated, Corrected Estimation of Percentages for listed Pacific Salmon and Steelhead Smolts Arriving at various locations in the Columbia River Basin in 2016. January 25, 2017. NWFSC, Seattle, Washington. 75p.

Zabel, R. W., M. D. Scheuerell, M. M. McClure, and J. G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology. 20(1): 190-200.

Zamon, J. E., T. J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter observations of Southern Resident Killer Whales *(Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. Northwestern Naturalist. 88(3): 193-198.

Zendt, J. 2017a. Email to Emily Reynolds (NMFS) from Joe Zendt (YKFP). September 7, 2017. Klickitat Hatchery survival to Bonneville. Yakama Nation, Klickitat, Washington. 1p.

Zendt, J. 2017b. Hatchery sthd spchk fchk BON juv detections_YKFP_to_Emily Reynolds (NMFS)_Klickitat excel report. October 24, 2017.

Zimmerman, C. E., and G. H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Canadian Bulletin of Fisheries and Aquatic Sciences. 57(10): 2152-2162.

Appendix A. 2018-2027 *US v Oregon* Management Agreement

2018-2027

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Management Agreement

2018-2027 *United States v. Oregon*

MANAGEMENT AGREEMENT

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PREAMBLE

The purpose of this Management Agreement is to provide a framework within which the Parties may exercise their sovereign powers in a coordinated and systematic manner to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-treaty fisheries.

The primary goals of the Parties are to rebuild weak runs to full productivity and fairly share the harvest of upper river runs between treaty Indian and non-treaty fisheries in the ocean and Columbia River Basin.

As a means to accomplish this purpose, the Parties intend to use (as herein specified) habitat protection authorities, enhancement efforts, and artificial production techniques, as well as harvest management, to ensure that Columbia River fish runs continue to provide a broad range of benefits in perpetuity.

By this Agreement, the Parties have established procedures to facilitate communication and to resolve disputes fairly. It is the intent of the Parties that these procedures will permit the Parties to resolve disputes outside of court, and that litigation will be used only after good faith efforts to settle disagreements through negotiation are unsuccessful.

1. INTRODUCTION

A. PARTICIPANTS

In their status as Parties to *United States v. Oregon*, Civil No. 68-513-MO (D. Or.)**,** the State of Washington, the State of Oregon, the State of Idaho, the United States, the Shoshone-Bannock Tribes, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation, the latter four, hereinafter referred to as "the Columbia River Treaty Tribes," (collectively, the Parties) enter into this Agreement, the 2018-2027 *United States v. Oregon* Management Agreement. The Shoshone-Bannock Tribes join only in Part I of this Agreement**.** The Shoshone-Bannock Tribes have filed a complaint in intervention in *United States v. Oregon* but have not taken any action on this complaint. The Parties agree that the Shoshone-Bannock Tribes' participation in any of the forums set forth in this Agreement in no way represents an admission, determination, settlement, or adjudication of any legal or factual issues related to the nature and scope of the Shoshone-Bannock Tribes' off-reservation fishing rights under the Fort Bridger Treaty of July 3, 1868 (15 Stat. 673). In the event the Shoshone-Bannock Tribes pursue litigation on their complaint in intervention or any other claims they may have concerning the Shoshone-Bannock Tribes' Fort Bridger Treaty of July 3, 1868, the Parties reserve the right to assert any and all defenses they may have to the claims of the Shoshone-Bannock Tribes in Civil No. 68-513, and the Shoshone-Bannock Tribes' participation in any of the forums set forth in this Agreement shall not be construed as a waiver or abandonment of any Party's claims or defenses.

B. SCOPE OF AGREEMENT

1. <u>Nature of Agreement</u>

This Agreement will be submitted as a stipulated order in *United States v. Oregon*, Civil No. 68-513-MO (D. Or.). If approved by the Court, this Agreement shall be binding on the Parties as a decree of the Court. The fishing regimes and production actions described in this Agreement neither set precedent nor prejudice any future allocation arrangements or production actions. Nothing in this Agreement limits the positions the Parties may take in any forum regarding harvest actions or production actions other than those expressly agreed to herein.

2. <u>ESA Section 7 and NEPA Processes</u>

The Parties recognize that the federal agencies (National Marine Fisheries Service (NOAA Fisheries), United States Fish and Wildlife Service (USFWS), and Bureau of Indian Affairs (BIA)) have consultation responsibilities under the Endangered Species Act (ESA). NOAA Fisheries and USFWS expect to complete biological opinions on the joint fishery proposal contained in the Agreement and further described in biological assessments to be prepared by the Technical Advisory Committee and Production Advisory Committee. The Parties also recognize that the federal agencies have responsibilities to prepare certain analyses under the National Environmental Policy Act (NEPA).

In Part III and Tables B1-B7 of this Agreement, the Parties have identified certain production programs that will be used to support the joint fishery proposal and support the intent of the Parties to not impede, and in some cases contribute to, ESA recovery. NOAA Fisheries and USFWS will continue to review the production programs contained in this Agreement and undertake ESA consultations as appropriate.

The Parties recognize that NOAA Fisheries or USFWS may recommend modifications to the production actions in this Agreement based on the results of these consultations. In the event that any of the production programs set forth in this Agreement would be affected by acceptance of NOAA Fisheries' or USFWS' recommendations in a manner that would affect the joint fishery proposal, the Parties agree to meet and discuss the resulting impacts on the valuable exchange of consideration reflected in this Agreement. The Parties agree to make a good faith effort to work collaboratively on any necessary modification to this Agreement. In so doing, the concerns and needs of all Parties will be accounted for to the extent possible. Should the Parties agree to modify any of the production programs in this Agreement, the Parties will monitor and evaluate the effects of such modifications on adult returns and fishery opportunities.

Notwithstanding the good faith efforts discussed above, the Parties recognize that NOAA Fisheries or USFWS may issue a Biological Opinion or Opinions that necessitate changes to the production programs of this Agreement and that such Biological Opinions or changes are not subject to the provisions of Parts I.B.8 and I.C.6. The Tribes reserve their rights to seek judicial relief in *United States v. Oregon* with respect to any federal action concerning production programs that may affect the number of fish returning to tribal usual and accustomed fishing places, or that otherwise impact their Treaty-reserved fishing rights. All Parties reserve any and all rights and defenses that they may have.

The Parties will work, to the extent they deem appropriate, with the U.S. Army Corps of Engineers, the Bonneville Power Administration, the U.S. Bureau of Reclamation, USFWS and NOAA Fisheries as necessary to facilitate the implementation of the hatchery provisions set forth in this Agreement.

3. Party Positions

The Columbia River Treaty Tribes maintain that tribal fisheries are subject to limitations only under the conservation necessity standards in federal case law, including case law governing the *United States v. Oregon* litigation. Other Parties, including the States, disagree.

4. Court Technical Advisor

The Court has appointed court technical advisors to assist in technical matters related to this case (*e.g.*, Docket Nos. 1072, 1719). When the Parties ask the court technical advisor to attend a meeting, or when the Court uses the court technical advisor's services, USFWS, NOAA Fisheries, and the states of Idaho, Oregon and Washington will share the costs of such participation. USFWS and NOAA Fisheries will jointly be responsible for one half of the cost. The states of Idaho, Oregon, and Washington will jointly be responsible for one half of the cost.

The Parties recognize selection and use of a court technical advisor is solely within the Court's discretion. This section shall not prevent any Party from seeking to advise the Court as to the Court's selection or use of a court technical advisor.

5. Availability of Funds

This Agreement shall not be interpreted as binding federal agency or state parties to expend in any one fiscal year any sum in excess of appropriations made by Congress or a state party's legislature, and available for purposes of this Agreement for that fiscal year, or as involving the United States or a state party in any contract or other obligation for the further expenditure of money in excess of such appropriations.

6. Management Precision

Careful monitoring and a conservative in-season management philosophy will be employed to minimize the risk that harvest management objectives are not met due to inadvertent management error. The Parties recognize that, even using the best available data in-season, the actual harvest rates may differ due to management imprecision. Adult trapping will be conducted at Bonneville Dam, Priest Rapids Dam and Lower Granite Dam to facilitate in-season management, run reconstruction, and/or broodstock collection.

7. Duration of Agreement

This Agreement becomes effective upon the signature of all Parties. This Agreement covers the winter, spring, summer, and fall season Columbia River fisheries and includes agreed-to production measures. The harvest provisions in Part II of this Agreement shall terminate on December 31, 2027. The production provisions for spring, summer and fall Chinook, sockeye and coho in Part III of this Agreement shall terminate with the release of the 2027 brood year production identified herein and for steelhead with the release of the 2028 brood year production.

8. <u>Modification and Withdrawal</u>

a. Modification. Any Party may at any time seek a modification of any provision of this Agreement. Where consideration and approval of such modification is otherwise subject to a specific process under this Agreement, the process specified in the applicable provision shall be followed. In all other instances, the Party shall provide written notice to the other Parties of the modification being sought and any changed conditions necessitating such modification, and if an agreement on modification cannot be reached, the Party seeking modification may invoke dispute resolution as provided in Part I.C.6 as a means to seek consensus. This Agreement, if adopted by the Court, shall be modified only by written agreement of all Parties.

b. Withdrawal. Any Party may withdraw from this Agreement at any time by serving written notice to the Court and the other Parties. The notification shall include a description of any changed conditions necessitating withdrawal. At the request of any Party, the Parties shall meet to discuss the withdrawal. Upon withdrawal of any Party, any remaining Party may withdraw upon notice to the Court and other Parties. Withdrawal of one or more Parties shall not preclude the remaining Parties from continuing the Agreement.

9. <u>Communication</u>

The Parties agree to continue to communicate in good faith, consistent with the Court's Stipulated Order, dated April 16, 1998 (Docket No. 2153).

C. *United States v. Oregon* FRAMEWORK

For purposes of implementing this Agreement, the Parties will continue to utilize the Technical Advisory Committee (TAC), the Production Advisory Committee (PAC), the Policy Committee, and Dispute Resolution as described below. TAC and PAC will provide the technical information outlined in Schedule A: *Annual Schedules for Committee Activities*. In addition, the Parties establish two workgroups, the Strategic Work Group and the Regulatory Coordination Work Group as described below.

1. Technical Advisory Committee

A Technical Advisory Committee (TAC) is hereby established to develop, analyze, and review data pertinent to this Agreement and to make reports and technical recommendations regarding harvest management. Members shall be qualified fisheries scientists familiar with harvest management of Columbia River fish runs. TAC shall be composed of designated technical representatives of each of the following entities: Washington, Oregon, Idaho, USFWS, NOAA Fisheries, the BIA, the Warm Springs Tribe, the Umatilla Tribes, the Nez Perce Tribe, the Yakama Nation, and the Shoshone-Bannock Tribes. The Parties agree to seek funding sources to assist TAC and its representatives in the performance of their functions.

a. TAC shall select annually from among its members a Chair and Vice-Chair. Unless otherwise agreed, the entity represented by the Chair shall be responsible for providing administrative and logistical support to the TAC. In the Chair's absence, the Vice-Chair shall assume the Chair's duties and responsibilities. TAC shall meet and provide technical information in accordance with Schedule A, or any then-applicable replacement schedule, or as otherwise needed.

b. Prior to the earliest contemplated or requested opening of any fishery that is subject to the requirements of this Agreement, and continuously thereafter until the close of such fishery and the final compilation of catch and escapement data for runs affected by such fishery, each Party shall promptly and continuously make available to each other Party copies of data, information, forecasts, estimates, forecasting procedures, methods, models, and other information available to or used by such Party in determining management policies and the timing, location, scope or conditions of any contemplated or requested fishery that would be subject to the provisions of this Agreement. Included in the foregoing shall be any materials pertaining to Columbia River stocks of fish furnished by such Party to the United States Section of the Pacific Salmon Commission, the Pacific or North Pacific Fishery Management Councils or the Department of Commerce. The materials shall be exchanged through TAC or through such representative as a Party has specified in writing as its agent for this purpose when the circumstances do not allow for timely communication through TAC. Prior to any Party's distribution to any management entity of a report concerning potential fishing regulations on any fishery subject to this Agreement, TAC shall, to the extent that time permits, exchange all relevant data and review the management entities' respective recommendations for fisheries.

c. The TAC shall endeavor to reach consensus on its reports and technical recommendations. If TAC is unable to achieve consensus upon a technical issue, the TAC Chair shall invite the Court Technical Advisor to attend the next TAC meeting to review the various technical contentions. The TAC Chair shall advise the TAC of the Court Technical Advisor invitation.

(i) The role of the Court Technical Advisor shall be that of a facilitator, not an arbitrator. The Court Technical Advisor shall preside over the discussion and endeavor to facilitate resolution of the unresolved issue.

(ii) When the TAC is unable to achieve consensus on a report or recommendation, the TAC Chair shall identify a time certain for each Party (or group of parties) to provide an issue paper summarizing any position it wants the Policy

Committee to consider. The TAC Chair will then prepare a written report to the Policy Committee for consideration of the issue. The report shall include the factual background, a description of the Parties' respective positions along with the issue papers offered in support of the Parties' positions, the TAC minutes, if any, and any independent views or recommendations by the Court Technical Advisor not contained in TAC report.

d. Distribution of Reports. The reports required by Schedule A and this section shall be submitted by the TAC Chair to the Parties through their Policy Committee representatives. If there are issues where TAC did not reach a consensus, the report shall conform with Part I.C.1.c. (ii) above with respect to those non-consensus issues. TAC shall make good faith efforts to ensure timely compilation and distribution of reports to the Parties. Except in cases of emergencies that preclude such advance distribution, all reports and recommendations shall be distributed to all Policy Committee representatives at least ten days prior to the Policy Committee meeting at which a report or recommendations are to be considered.

2. Production Advisory Committee

Coordination of production and harvest management is essential to the successful implementation of this Agreement. Accordingly, a Production Advisory Committee (PAC) is hereby established to coordinate information, to review and analyze existing and future natural and artificial production programs pertinent to this Agreement, and to submit recommendations to the management entities. Members shall be qualified fisheries scientists familiar with Columbia River artificial and/or natural fish production. PAC shall be composed of designated technical representatives of each of the following entities: Washington, Oregon, Idaho, USFWS, NOAA Fisheries, the BIA, the Warm Springs Tribe, the Umatilla Tribes, the Nez Perce Tribe, the Yakama

Nation, and the Shoshone-Bannock Tribes. The Parties agree to seek funding sources to assist PAC and its members in the performance of its functions.

a. PAC shall select annually from among its members a Chair and Vice-Chair, however, neither position shall represent the same entity as the TAC Chair. Unless otherwise agreed, the entity represented by the Chair shall be responsible for providing administrative and logistical support to PAC. In the Chair’s absence, the Vice-Chair shall assume the Chair’s duties and responsibilities. PAC shall meet and provide technical information in accordance with Schedule A, or any then-applicable replacement schedule, or as otherwise needed.

b. The reports and recommendations of PAC shall be summarized in writing, and shall express the consensus views and recommendations of its members whenever possible.

c. If PAC is unable to achieve consensus upon a technical issue, the PAC Chair shall invite the Court Technical Advisor to attend the next PAC meeting to review the various technical contentions. The PAC Chair shall advise the PAC of the Court Technical Advisor invitation.

(i) The role of the Court Technical Advisor shall be that of a facilitator, not an arbitrator. The Court Technical Advisor shall preside over the discussion and endeavor to facilitate resolution of the unresolved issue.

(ii) When the PAC is unable to achieve consensus on a report or recommendation, the PAC Chair shall identify a time certain for each Party (or group of parties) to provide an issue paper summarizing any position it wants the Policy Committee to consider. The report shall include the factual background, a description of the Parties' respective positions along with the issue papers offered in support of the Parties' positions, the PAC minutes, if any, and any independent views or recommendations by the Court Technical Advisor not contained in PAC report.

d. Distribution of Reports. The reports required by Schedule A and this section shall be submitted by the PAC Chair to the Parties through their Policy Committee representatives. If there are issues where PAC did not reach a consensus, the report shall conform with Part I.C.2.c.(ii) above with respect to those non-consensus issues. PAC shall make good faith efforts to ensure timely compilation and distribution of reports to the Parties and relevant management entities. Except in cases of emergencies that preclude such advance distribution, all reports and recommendations shall be distributed to all Policy Committee representatives at least ten days prior to the meeting at which a report or recommendations are to be considered.

3. Strategic Work Groups

From time to time, the Policy Committee shall appoint a Strategic Work Group or Groups (SWG) to assist the Policy Committee by reviewing technical information, evaluating potential solutions to particular problems arising over the implementation of this Agreement from a biological and policy perspective, and proposing resolutions or courses of action to the Policy Committee. Each SWG shall be composed of persons designated to represent the Parties' varied interests in the particular issue assigned to the SWG, and may vary from issue to issue. Persons assigned to the SWG should possess either technical or policy expertise, or both, as necessary to evaluate potential solutions from different perspectives with the aim of finding a common approach to resolving the practical difficulties of implementing this Agreement.

4. Regulatory Coordination Committee

The Regulatory Coordination Committee (RCC) shall include one person designated by each Party who shall serve as its point of contact. Each Party shall provide its fisheries enforcement regulations to the other Parties. The RCC shall convene as necessary to review the Parties' regulations with the goal of identifying inconsistencies and/or inaccuracies, and shall notify the Parties of potentially conflicting regulations to assure consistency with the Agreement and each other, and shall make recommendations to the Policy Committee for resolving such conflicts and inconsistencies for potential adoption by all Parties. The RCC shall also provide a forum for resolving conflicts and coordinating among the Parties regarding fisheries enforcement, and for negotiating the prosecution referral agreements described below in Part I.E. Each Party shall designate law enforcement, attorney, and fishery manager representatives to participate in the RCC as necessary to achieve its responsibilities under this section.

5. Policy Committee

A Policy Committee, composed of a policy and a legal representative appointed by each Party signatory to this Agreement, is hereby established. The purpose of the Policy Committee is to facilitate cooperative action by the Parties with regard to fishing regulations, policy issues or disputes, and the coordination of the management of fisheries on Columbia River runs and production and harvest measures. The Policy Committee may make assignments to the technical committees described in this Agreement to assist it.

The Policy Committee shall designate a Chairman and meet in accordance with Schedule A or at such times as are appropriate to conduct the business described in this Agreement. The Chairman shall provide all Parties with notice of meetings. The Committee may adopt appropriate rules to govern its proceedings.

6. Dispute Resolution Procedure

a. A Party must raise a formal "point of disagreement" to initiate the dispute resolution processes of this Agreement. A Party raising a formal point of disagreement shall provide all other Parties written notice that it is raising a formal point of disagreement. That written notice shall include a summary of the disagreement, the Party's position on the appropriate resolution(s) of the disagreement, and any documents or supporting materials that assist in describing the disagreement and/or supporting the Party's position on an appropriate resolution. If the Party raising the point of disagreement believes that emergency circumstances make it impossible to employ the full dispute resolution process, a complete explanation of the emergency shall be included. All Parties shall strive to provide notice of a point of disagreement at the earliest possible time. Points of disagreement shall be referred for dispute resolution as herein prescribed unless the Parties agree on other means for resolving them.

b. Technical Disputes

(i) In the course of developing reports identified in Schedule A and in completing any other tasks assigned by the Policy Committee, the TAC and PAC shall employ the procedures prescribed in Part I.C.1. and Part I.C.2. above to attempt to resolve technical disputes prior to referring a non-consensus report or recommendation to the Policy Committee. If TAC or PAC is unable to achieve consensus, the TAC or PAC report conforming with the requirements of Part I.C.1. or C.2. will be provided to the Policy Committee for its review and consideration.

(ii) Non-consensus among TAC and PAC does not ripen into a formal point of disagreement unless and until a Policy Committee representative notifies all other Parties through their Policy Committee representatives that it is raising a formal point of disagreement as provided in Part I.C.6.a. above.

(iii) When a point of disagreement arising out of technical non-consensus is raised by a Party for Policy Committee consideration, the Policy Committee shall review the reports and materials submitted by TAC or PAC. In the course of considering a point of disagreement, the Policy Committee may identify additional technical issues and data needs related to the specific point of disagreement as to which further documentation is deemed necessary and ask the PAC or TAC to do additional analysis.

c. Policy Disputes

(i) Policy points of disagreement must be raised by a Party's Policy Committee representative. If a TAC or PAC representative believes that a policy dispute is preventing a consensus on a technical TAC or PAC report or recommendation, that person should review the matter with its Policy Committee representative to determine if that Policy Committee representative should raise a policy-based point of disagreement.

(ii) Upon notice of a point of disagreement, the Policy Committee Chairman shall establish a date and place for the Policy Committee to consider the dispute, taking into consideration any emergency circumstances. The Chairman's notice setting a date and place for consideration of the point of disagreement shall include an invitation for any Party to submit documents or supporting materials relevant to the point of disagreement that it believes should also be considered by the Policy Committee.

(iii) The Policy Committee shall discuss and attempt to resolve the point of disagreement. Unless the Committee unanimously agrees otherwise, its deliberations and discussions shall remain confidential except for the documents or other materials submitted to or considered by it. The Policy Committee Chairman shall compile a complete record of written materials considered by the Policy Committee in its deliberations on a point of disagreement. On points of disagreement over which the Policy Committee is unable to reach a consensus decision, any Party may provide to a non-Party management entity or other person a statement in support of its position on the disputed issue. The statement shall identify the data and other information that supports the Party's position but may be abbreviated as required to permit timely action by the entity or person. Any such statement shall be submitted to the Policy Committee for inclusion in its record related to the dispute.

d. The Parties recognize that the entities charged with making decisions and resolving disputes must be given the opportunity to examine competing positions of the Parties and the factual basis for their positions prior to rendering such decisions. They therefore will use their best efforts to share fully all relevant data and information and to present their positions and the factual basis therefor prior to seeking judicial review.

7. Emergency matters

Emergency matters may require immediate judicial action without compliance with this Section, and nothing in Part I.C.6 shall be construed as limiting a Party's right to seek such relief when those emergency matters arise. However, the Parties shall make every reasonable effort to use the foregoing dispute resolution procedures prior to initiating judicial action, and the Party seeking immediate judicial relief shall have the burden of establishing the existence of an emergency.

D. JUDICIAL REVIEW OF DISPUTES

1. In the event that a dispute arises concerning this Agreement and, after compliance with the foregoing Part I.C.6, to the extent required thereunder, a Party may petition the Court in Case No. 68-513 for a determination of the dispute. Unresolved disputes over matters that are not within the retained jurisdiction in Case No. 68-513 may be submitted to any court having subject matter and personal jurisdiction.

2. The Parties expect and intend that review by the Court in Case No. 68-513 of any

dispute that has been subject to a Policy Committee proceeding under the foregoing Part I.C.6. will be limited to documents or other written materials submitted to or considered by the Policy Committee. The Parties understand that the Court may consider other documents or materials where good cause is shown why such documents or materials were not submitted to the Policy Committee during its deliberations. A Party may present oral testimony, declarations or affidavits concerning any documents and materials before the Court.

E. PROSECUTION REFERRAL AGREEMENTS

1. The Columbia River Treaty Tribes, Oregon and Washington agree that the Tribes should bear primary responsibility for enforcing agreed-upon regulations applicable to mainstem Treaty Indian fisheries.

2. To carry out this responsibility, the Columbia River Treaty Tribes agree to commit, to the maximum extent possible, the police, prosecutorial, and judicial resources necessary to ensure compliance with Tribal regulations governing mainstem fisheries.

3. To assist the Columbia River Treaty Tribes in carrying out this responsibility, Oregon and Washington may negotiate with each tribe for an agreement to refer to such tribe, for prosecution under tribal law, those tribal fishermen cited by state enforcement officers for violating agreed upon mainstem fishing regulations, and to cooperate with tribal authorities in making evidence and testimony available in tribal court proceedings. As part of each referral agreement, the tribe shall report the disposition of the tribal prosecution to the state law enforcement agency making the referral.

4. Unless specified otherwise in the referral agreements entered into under this Part I.E., the states of Oregon and Washington shall retain authority to prosecute violations of applicable laws or regulations in state court.

5. If Oregon or Washington believes that a tribe or tribes is not carrying out its responsibilities under this section to enact and enforce agreed-upon mainstem fisheries regulations, it may refer the matter to the Policy Committee for dispute resolution as provided in Part I.C.6.c.

F. PERFORMANCE MEASURES, COMMITMENTS AND ASSURANCES

1. General

The Parties enter this Agreement based, in part, on their expectation that the measures in Parts II and III will help upriver stocks rebuild over time. The Parties also recognize that other laws and processes outside the scope of the Agreement, as well as the actions of public and private entities not signatory to this Agreement, may affect their ability to fulfill rebuilding and harvest sharing objectives. The Parties anticipate that their efforts will focus primarily on implementation of the specific measures in Parts II and III. This section establishes procedures to monitor progress toward rebuilding and to seek consensus on actions to address the circumstances where activities that are beyond the scope of the Agreement may affect the achievement of rebuilding and sharing goals.

2. Performance Evaluation

The Parties agree to establish performance measures that will be used to monitor progress toward rebuilding the upriver stocks of salmon and steelhead that presently constrain fisheries. Should rebuilding not progress as expected, the Parties further commit to a process to identify why stocks are not rebuilding and to take actions available within the scope of the Parties' joint and separate authorities to address the underlying problem and reestablish a positive rebuilding trend for those stocks.

a. Performance Measures. The Parties will monitor progress toward rebuilding by tracking trends in the status of the indicator stocks listed below. The Parties have selected these indicator stocks because of their geographic distribution, and because of the current availability of data sets that the Parties can use to establish a base against which to compare the future status of these stocks.

The Parties have identified two types of indicator stocks. Harvest indicator stocks are those used directly for managing the fisheries. Abundance indicator stocks provide more detailed information about natural-origin stocks or populations that currently limit fisheries. Neither the indicator stocks nor the performance measures listed below shall preclude the Parties from considering other indicators or performance measures that may be developed in the future, or that may be necessary to determine the status of a particular stock of concern.

The Parties will compare the status of indicator stocks to the 1988-2007 "base period," which represents the status of stocks before completion of this Agreement. The Parties will use the performance measures and base period data as reference points for gauging progress.

TAC will update the indicator stock summaries annually and provide a report to the Policy Committee annually.

Harvest Indicator Stocks	
Stock	**Performance Measure**
Upriver spring/summer Chinook	
Upriver spring and Snake River spring/summer Chinook	Number of returning adults at Columbia River mouth
Natural-origin Snake River spring/summer Chinook	Number of returning adults at Columbia River mouth
Natural-origin Upper Columbia spring Chinook	Number of returning adults at Columbia River mouth
Upper Columbia Summer Chinook	
Upper Columbia Summer Chinook	Number of returning adults at Columbia River mouth
Sockeye	
Combined Upper Columbia River and Snake River sockeye	Number of returning adults at Columbia River mouth
Summer Steelhead	

Harvest Indicator Stocks	
Stock	**Performance Measure**
Skamania natural-origin A-run steelhead	Number of returning adults at Bonneville Dam
Natural-origin A-run steelhead	Number of returning adults at Bonneville Dam
Natural and Hatchery-origin B-run steelhead	Number of returning adults at Bonneville Dam
Fall Chinook	
Upriver Bright fall Chinook	Number of returning adults at Columbia River mouth
Snake River natural-origin fall Chinook	Number of returning adults at Columbia River mouth

Abundance Indicator Stocks	
Stock	**Performance Measure**
Upriver spring/summer Chinook	
Snake River natural-origin spring/ summer Chinook	Number of returning adults at Lower Granite Dam
Upper Columbia River natural-origin spring Chinook	Number of returning adults at Priest Rapids Dam
Upriver Columbia River natural-origin spring Chinook stocks (Wenatchee, Entiat, Methow)	Sub-basin run size
Snake River spring/summer Chinook index stocks (Bear Valley, Marsh, Sulphur, Minam, Catherine Cr., Imnaha, Poverty Flats, Johnson)	Redd counts
John Day natural-origin spring Chinook	Redd counts
Warm Springs natural-origin spring Chinook	Number of returning adults at Warm Springs NFH weir
Upper Columbia Summer Chinook	
Upper Columbia River summer Chinook	Priest Rapids Dam counts
Sockeye	
Snake River	Number of returning adults at Lower Granite Dam
Lake Wenatchee natural-origin	Number of returning adults at Tumwater Dam
Okanogan natural-origin	Number of returning adults at Wells Dam
Snake River	Number of adults returning to Stanley Basin
Summer Steelhead	
Methow River natural-origin steelhead	Redd counts
Wenatchee River natural-origin steelhead	Redd counts
Select populations/groups of Snake River natural-origin A-run steelhead	Juvenile and adult abundance indices for groups that are monitored regularly
Select populations/groups of Snake River natural-origin B-run steelhead	Juvenile and adult abundance indices for groups that are monitored regularly

Abundance Indicator Stocks	
Stock	**Performance Measure**
Natural-origin Snake River A-run Steelhead	Adults returning to Lower Granite Dam
Natural-Origin Snake River B-run Steelhead	Adults returning to Lower Granite Dam
Joseph Cr A-run steelhead	Redd counts
John Day natural-origin steelhead	Redd counts
Umatilla natural-origin steelhead	Threemile Dam counts
Klickitat River natural-origin steelhead	Data developed in accordance with the recommendations in Rawding, D. 2007
Warm Springs natural-origin steelhead	Number of returning adults at Warm Springs NFH weir
Fall Chinook	
Hanford natural-origin adult fall Chinook	Population estimates
Snake River adult fall Chinook	Number of hatchery and natural adults at Lower Granite Dam
Snake River adult fall Chinook	Redd counts between Lower Granite Dam and Hells Canyon Dam and in Clearwater River
Deschutes River natural- origin adult fall Chinook	Population estimates
Additional Stocks and Performance Measures	
TAC will add additional abundance indicator stocks and performance measures to this table as directed by the Parties and as data become available. It is the intent of the Parties to update, add to, and revise the abundance indicator groups as needed to assess progress toward salmon and steelhead recovery.	

b. Analysis of Decline. If the performance measure of any indicator stock declines for three consecutive years relative to the base period, any Party to this Agreement may request the Policy Committee to direct TAC to complete an Analysis of Decline. TAC shall complete the Analysis of Decline within one year of receiving Policy Committee direction. The Parties will exercise their best efforts to provide the resources necessary for a timely and thorough analysis.

The Analysis of Decline shall identify factors leading to the decline in the stock's performance, and shall assess the overall significance of the decline with respect to the achievement of rebuilding for the stock. The Analysis of Decline shall identify which factors are within the Parties' control, such as the activities described in Parts II and III of this Agreement, and which are not, such as ocean conditions. As part of its analysis, TAC may rely on any Assessment or review conducted by the Salmon Technical Team or Habitat Committee of the Pacific Fishery Management Council under Section 3.2.3 of the Pacific Coast Salmon Plan (revised May 2000).

Based on its findings, TAC shall recommend any modifications to Parts II and III of this Agreement that in TAC's judgment are needed to promote achievement of rebuilding, or may recommend adjustments to the rebuilding or performance measures. The TAC recommendations may also include suggestions for habitat restoration or enhancement measures. TAC may identify whether special programs, research, or analyses by experts who are not TAC members are needed to promote the long-term rebuilding of the stock in question.

TAC shall submit the Analysis of Decline to the Policy Committee for consideration.

3. Policy Committee Consideration

After receiving the Analysis of Decline, the Policy Committee shall convene. After review of the Analysis of Decline Report, the Policy Committee may make recommendations for modification of the Agreement. The Parties may thereafter modify Parts II and III of this Agreement, or the performance measures, consistent with the Policy Committee's recommendations. Provided, however, that only the Agreement as modified by such amendments will create additional legal obligations on Parties to the Agreement.

If the Policy Committee determines that no modifications to Parts II and III of this Agreement, or to the performance measures, can reasonably be expected to provide benefits to the stock in question, the Policy Committee may identify actions of other entities that may be needed to promote rebuilding of the stock. Examples might include habitat restoration and enhancement measures, or adjustments in fisheries outside the Columbia River Basin. The

Policy Committee shall make and communicate recommendations to those other entities concerning such actions. Examples could be recommendations about fish habitat or access to habitat, fisheries regimes, data collection, or research.

4. Public Notice/Education about Terms of Agreement

The Parties will use their best efforts to make all members of their respective governments aware of the commitments in this Agreement.

G. DEFINITIONS

Terms defined in the Glossary shall have the meaning given therein wherever they are used in this Agreement.

II. HARVEST

The Parties, through this Agreement, in recognition of the Columbia River Treaty Tribes' federally secured rights, the conservation requirements, and the rights of other fishermen to fishery resources under applicable federal law, have proposed fisheries as set out below.

Tribal harvest in mainstem treaty fisheries with subsistence gear shall be consistent with any harvest guidelines identified herein. Mainstem treaty subsistence fisheries shall be open on a year round basis and shall not be restricted by the States or the United States, except for conservation purposes. The Columbia River Treaty Tribes shall manage mainstem treaty subsistence fisheries in good faith to remain within harvest guidelines, in coordination with other Parties.

This Agreement describes specific provisions for managing mainstem fisheries and certain tributary fisheries. Harvest plans for the Parties' other tributary fisheries will be developed cooperatively by the management entities with primary management responsibility in the respective sub-basin (as specified in Table 1: Lead Management Entities for each Sub-Basin).

Other Parties may be affected by, and therefore may have an interest in, tributary harvest plans, and therefore shall be provided an opportunity to review and comment on the development of such plans.

The Parties have previously directed TAC to establish a schedule for investigating all upriver escapement goals, management goals and rebuilding objectives. Some progress has been made on this effort. The Parties recognize the importance of this information. Accordingly, the Parties will work with TAC to identify and prioritize their work, including development of upriver escapement goals, management goals and rebuilding objectives.

A. UPRIVER SPRING AND SNAKE RIVER SUMMER CHINOOK

Mainstem Columbia River salmon fisheries occurring from January 1 through June 15 will be managed depending on the abundance of upriver spring Chinook and Snake River summer Chinook. Upriver spring Chinook include all natural and hatchery spring Chinook stocks originating from the Columbia River and its tributaries upstream of Bonneville Dam. Snake River summer Chinook include all natural and hatchery summer Chinook stocks originating from the Snake River watershed.

1. Catch Expectations of the Parties

The Parties recognize that Table A1 (Spring Management Period Chinook Harvest Rate Schedule) sets limits on the percentage of natural origin upriver spring Chinook and SR summer Chinook that can be taken in mainstem fisheries. The Parties recognize that non-treaty fisheries may use mark-selective fishing techniques that allow for a higher harvest rate on marked hatchery fish compared to unmarked fish. Mark rates for hatchery fish subject to those fisheries will be determined in accordance with Part III.A.3. The Parties agree that the fish to be allocated among treaty and non-treaty fisheries are all upriver spring Chinook and Snake River summer

Chinook. In agreeing to Table A1, the Parties expect that mainstem fisheries on upriver spring Chinook and Snake River summer Chinook will be managed to achieve catches roughly matching those shown in Table A1.

Non-treaty fisheries will be designed to meet the intent of catch balancing as represented by columns D and F in Table A1, and managed to stay within both the ESA impact rate and the mortality guideline, i.e., the allowable Treaty catch. The States of Oregon and Washington will do this by implementing the following actions: (1) conservative management of non-Treaty fishing prior to the first in-season TAC run size update consistent with the mortality guideline for a run size reduced from the pre-season forecast by a buffer of at least 30%; and (2) setting subsequent fishing periods that are scaled to the in-season TAC run size updates and associated mortality guidelines. If the non-Treaty fishery exceeds the mortality guideline (allowable Treaty catch) by 5% or 1,000 fish, whichever is greater, then, in the subsequent year the States of Oregon and Washington will increase the buffer above 30%. The buffer increase could be up to 40% if the Parties agree that that level of increase is necessary to address the cause of the divergence. In the event that in-season fishery management factors result in non-Treaty or Treaty catch exceeding levels in columns D and F in Table A1, or if the Parties agree that re-distribution of unused ESA impacts would better meet the mutual objectives of the Parties, unused ESA impacts may be, by agreement of the Parties, transferred between the non-Treaty and Treaty fisheries.

The Parties will monitor whether those expectations are being met, as follows:

a. Each year, the States of Oregon and Washington and the Columbia River Treaty Tribes will monitor mainstem fisheries from January 1 through June 15, and will compare how actual performance compares with management guidelines as shown in Table A1 as part of the annual run reconstruction process;

b. As part of the annual run reconstruction process, the States of Oregon and Washington will monitor and report to the Parties the mark rate in the fishery; the number of fish retained or landed; the number of unmarked fish released; the number of marked fish released; the stock composition of the mortalities; and other information as agreed upon.

c. If the annual run reconstruction reveals that the Parties' catch balance expectations are widely divergent from the results, the Parties agree to meet and discuss whether modifications to Table A1 or other provisions of Part II.A should be made.

2. <u>Minimum Columbia River Treaty Indian Ceremonial and Subsistence Entitlement</u>

There is a minimum mainstem treaty Indian ceremonial and subsistence entitlement to the Columbia River Treaty Tribes of 10,000 spring and summer Chinook. It is anticipated that the majority of this entitlement will be taken during the January 1 through June 15 management period. Tributary harvest of spring and summer Chinook is not included in this entitlement. It is understood that if the total mainstem Columbia River Treaty Indian harvest of spring and summer Chinook is greater than or equal to 10,000 spring and summer Chinook, then this entitlement has been met. If the total mainstem Columbia River Treaty Indian harvest of spring and summer Chinook is less than 10,000, then the difference will be distributed to the Tribes from spring Chinook hatcheries below Bonneville Dam as first priority. If spring Chinook are not available from hatcheries below Bonneville Dam, or by agreement of the Parties, the entitlement may be filled from other hatchery sources of equivalent quantity and quality.

3. <u>Ocean Fisheries</u>

The Parties assume, based on available information, that ocean harvest of upriver spring and Snake River summer Chinook in the Pacific Ocean south of the southwesterly projection of the United States-Canada boundary between British Columbia and Washington is, and will continue to be minimal. If new information becomes available related to this assumption, the Parties agree to further discussion and consideration of management adjustments. If non-treaty ocean fisheries are proposed that would increase fishery-related mortalities on upriver spring and Snake River summer Chinook above minimal levels assumed herein, the estimated ocean harvest of upriver spring and Snake River summer Chinook shall be reviewed by TAC and shall count toward the total allowable harvest for non-treaty fisheries (Table A1).

4. Non-Treaty Mainstem Columbia River Fisheries

Non-treaty commercial and recreational fisheries will be managed according to Table A1 of this Agreement.

5. Treaty Indian Mainstem Columbia River Fisheries

Fisheries conducted by the Columbia River Treaty Tribes will be managed according to Table A1 of this Agreement.

6. Review if Escapement Goals Established

If during the term of this Agreement TAC recommends specific escapement goals to the Policy Committee, and the Policy Committee adopts those escapement goals, and if it appears that either the treaty or the non-treaty fisheries governed by this Agreement are not being accorded an opportunity to attempt to take a fair and equitable share of upriver spring Chinook and Snake River summer Chinook, the Parties will review the Spring Management Period Chinook Harvest Rate Schedule (Table A1) and discuss whether to modify it so as to achieve fair sharing.

7. Review of Impacts

The Parties commit to good faith efforts to monitor and evaluate fishery impacts for the Snake River Spring/Summer ESU. The Parties direct TAC to make recommendations to the Policy Committee for monitoring and evaluation. In the fall of 2019, the Policy Committee will review and consider any appropriate adjustments to management measures, as they relate to this ESU and June 15 as the transition date from spring to summer harvest regimes for chinook in the mainstem Columbia River.

B. UPPER COLUMBIA RIVER SUMMER CHINOOK

Mainstem Columbia River Chinook fisheries occurring from June 16 through July 31 will be managed based on the abundance of upper Columbia River summer Chinook as provided in Table A2. The Parties agree to manage upper Columbia River summer Chinook based on an interim management goal of 29,000 hatchery and natural origin adults as measured at the Columbia River mouth. The management goal is based on an interim combined spawning escapement goal of 20,000 hatchery and natural adults. The following table lists the component of the interim escapement goal. Mainstem fisheries will not be managed for these individual components. The Parties agree to consider new information related to the escapement goals as it becomes available.

Upper Columbia Summer Chinook Interim Goals	
Stock Group	Spawning Objective Components
Wenatchee/Entiat/Chelan Natural	13,500
Methow/Okanogan Natural	3,500
Hatchery	3,000

The Parties instruct TAC, with PAC assistance, to calculate appropriate adjustments to the upper Columbia River summer Chinook interim escapement goals to address the aggregate broodstock and escapement needs of the upper Columbia summer Chinook programs. TAC will present its recommended adjustments to the Policy Committee.

Concerns have been identified by the federal Parties regarding the development of a better data set to monitor and evaluate natural origin and hatchery stock status of upper Columbia summer Chinook as part of the integrated management approach. The Parties direct TAC to review options regarding upper Columbia summer Chinook natural origin and hatchery stock status monitoring and to make recommendations for future consideration by the Parties.

1. Upper Columbia Summer Chinook Fishery Framework

The following table describes the framework for managing fisheries targeting upper Columbia summer Chinook. Table A2 provides the harvest rate schedule for these fisheries.

Upper Columbia Chinook Fishery Framework		
Run Size at River Mouth	Allowed Treaty Harvest	Allowed Non-Treaty Harvest
<5,000	5%	<100 Chinook
5,000-<16,000	5%	<200 Chinook
16,000-<29,000	10%	5%
29,000-<32,000	10%	5-6%
32,000- <36,250 (125% of 29,000 goal)	10%	7%
36,250-50,000	50% of total harvestable[1]	50% of total harvestable[1]
>50,000	50% of 75% of margin above 50,000 plus 10,500[2]	50% of 75% of margin above 50,000 plus 10,500[2]

[1]The total number of harvestable fish is defined as the run size minus 29,000 for run sizes of 36,250 to 50,000.
[2]For the purposes of this Agreement, the total number of harvestable fish at run sizes greater than 50,000 is to be determined by the following formula: (0.75 * (runsize-50,000)) + 21,000.

2. Ocean Fisheries

Adult equivalent harvest of non-treaty fisheries in the Pacific Ocean south of the southwesterly projection of the United States-Canada boundary between British Columbia and Washington will be counted as part of the total run size for allocation purposes. Pre-season modeled impacts of ocean fisheries will be used for the purposes of in-season management of in-river fisheries. Post-season modeled impacts will be used to assess actual fishery compliance with the Agreement. If treaty and non-treaty fisheries fail to meet the specified catch sharing objectives on a consistent basis, additional management measures will be applied so that the catch sharing objectives will be met. The Parties agree to develop such measures if they become necessary.

3. Non-Treaty Fisheries

Non-treaty commercial and recreational impacts in the summer management period will be managed according to the framework and harvest rate schedule in Table A2 of this Agreement. These fisheries include commercial and recreational fisheries in the ocean south of the U.S.-Canada border at run sizes greater than 29,000, commercial and recreational fisheries in the mainstem and tributaries, and ceremonial and subsistence fisheries conducted by the Wanapum Band and the Colville Tribes.

4. Treaty Indian Fisheries

Fisheries conducted by the Columbia River Treaty Tribes will be managed according to the framework and harvest rate schedule in Table A2 of this Agreement. These fisheries include mainstem and tributary fisheries.

C. SOCKEYE

1. Bonneville Dam Management Goal

The management goal for upper Columbia River sockeye is 65,000 adult sockeye as measured at Priest Rapids Dam which, under average migration conditions, requires a 75,000 run over Bonneville Dam.

2. Non-treaty Columbia River Fisheries

Non-treaty commercial and recreational impacts on listed sockeye will be minimized to the degree possible, but the total impact shall not exceed 1% of the river mouth run of listed Snake River sockeye.

3. Treaty Indian Columbia River Fisheries

Fisheries conducted by the Columbia River Treaty Tribes will be managed according to the following schedule; all fishery impacts on sockeye will be included in the specified harvest rates:

Upriver Sockeye Run Size	Harvest Rate on Upriver Sockeye
<50,000	5%
50-75,000	7%
>75,000	7% with further discussion

4. Fisheries on Sockeye Returns Greater than 75,000 Adults

If the upriver sockeye run size is projected to exceed 75,000 adults over Bonneville Dam, any Party may propose harvest rates exceeding those specified in Part II.C.2. or Part II.C.3. of this Agreement. The Parties shall then prepare a revised biological assessment of proposed Columbia River fishery impacts on listed sockeye and shall submit it to NOAA Fisheries for consultation under section 7 of the ESA.

D. FALL CHINOOK

1. Snake River Fall Chinook Harvest

Fall season fisheries in the Columbia River Basin below the confluence of the Snake River will be managed according to the abundance based harvest rate schedule shown in Table A3. Upriver bright stock Chinook harvest rates will be used as a surrogate for Snake River fall Chinook harvest rates unless TAC develops and the Policy Committee approves a new methodology that makes it possible to manage fisheries based on stock-specific Snake River fall Chinook harvest rates.

2. Harvest Management Objectives for Fall Chinook

The Parties have agreed that the following fishery regimes and management measures will be implemented for fall Chinook fisheries:

a. TAC will annually produce a fall season fishery model output that provides the information for the annual model known as Attachment A. The Parties shall implement fisheries in approximate accordance with this modeled fishery output. The model will include expected river mouth run sizes and Bonneville Dam passage along with overall harvest rates based on river mouth run sizes of fall Chinook, summer steelhead, coho and chum. For fisheries management, the Parties agree to use Attachment A as a template for fishery models.

b. This Agreement contemplates that in the implementation of the non-treaty fisheries, Oregon and Washington agree to manage their fisheries in a manner that will not exceed an URB harvest rate shown in Table A3. If mark-selective fisheries are implemented that impact upriver fall Chinook, the non-treaty ocean and in-river fisheries may not harvest more than 50% of the harvestable surplus of upriver fall Chinook, consistent with the applicable federal allocation case law.

c. This Agreement contemplates that in the implementation of the tribal fisheries, the Columbia River Treaty Tribes agree to manage their fisheries in a manner that will not exceed an URB harvest rate shown in Table A3.

d. The Treaty Tribes and the States of Oregon and Washington may agree to a fishery for the Treaty Tribes below Bonneville Dam not to exceed the harvest rates provided for in this Agreement.

3. Escapement and Management Objectives

a. McNary Dam: The Parties agree that the minimum combined Columbia River and Snake River upriver bright management goal at McNary Dam is 60,000 adult fall Chinook, which includes both hatchery and natural production for all areas above

McNary Dam. The 60,000 McNary Dam goal will be used as part of the annual calculation of harvestable surplus and allocation shares. The Parties also agree that the minimum upriver bright adult escapement to meet the combined Hanford Reach, lower Yakima River, and mainstem Columbia River above Priest Rapids Dam natural spawning goal, as well as the current Priest Rapids Hatchery production goal is 43,500 adult fall Chinook (this historically included a minimal run to the Snake River). In the event of anticipated low returns of upriver bright fall Chinook to the Hanford Reach, notwithstanding the provisions of Table A3, ocean and in-river fisheries will be managed at the discretion of the Parties to help achieve the escapement goal. If future hatchery production is modified as a result of mitigation agreements or new production programs, then the Parties will instruct TAC to calculate appropriate adjustments to the McNary Dam management goal to address program adjustments and natural production needs for this area. TAC will present its recommended adjustments to the Policy Committee.

b. Spring Creek National Fish Hatchery (NFH): The Spring Creek NFH escapement necessary to meet the full hatchery program requirements is 6,000 adult fall Chinook (3,500 females) which is expected to produce a 10.5 million smolt release. Ocean and in-river fisheries will be managed to help achieve this escapement in accordance with the fishing regimes described herein.

c. Klickitat Hatchery: The Klickitat Hatchery program production needs of 2,400 adult bright fall Chinook shall not be a management constraint. Until the Klickitat Hatchery implements a broodstock collection program, the broodstock need for Klickitat Hatchery fall Chinook shall be made up from bright fall Chinook returning to Little White Salmon NFH or other appropriate hatchery that is above base program needs. In the event base program needs cannot be met, the Parties agree to develop a program, which will address the shortfall.

d. Little White Salmon/Willard NFH: The number of bright fall Chinook adults necessary to meet the full production program, including the on-station release program of 6.5 million smolts, the 1.7 million transfer to the Yakima River (Prosser), and the 4.0 million Klickitat Hatchery program need, is 8,000 fish (3,800 females). To meet Bonneville and Umatilla hatchery program needs, an additional 1,300 fish may be needed. The Little White Salmon NFH escapement goal shall not be a management constraint.

e. Mid-Columbia Fall Chinook: The Parties have used the interim escapement goals recommended by TAC for Mid-Columbia tributaries for the purposes of developing the annual fishery model known as Attachment A. Mid-Columbia bright fall Chinook escapement is not a management constraint for fisheries.

f. Deschutes River: The Deschutes River fall Chinook stock is of special management concern. If a Deschutes River mouth sanctuary closure to fall Chinook fishing is determined to be necessary, then the Parties commit to conducting on the water monitoring and enforcement of any steelhead subsistence or sport fishing occurring in the closed area for the purpose of determining the incidental mortality of Chinook in those fisheries.

4. Ocean Fisheries

The Parties recognize that the Secretary of Commerce adopts regulations recommended by the Pacific Fishery Management Council (PFMC) that annually establish a Chinook catch quota for all fisheries south of the U.S.-Canada border. The ESA ocean fishery management criteria currently require a 30 percent reduction of the total harvest impact on Snake River fall Chinook from the 1988-93 base period for all ocean fisheries combined (including Canadian and S.E. Alaskan fisheries). The Parties acknowledge that all U.S. ocean fisheries will be managed consistent with the ESA ocean fishery management criteria and applicable case law under *United States v. Oregon*. If NOAA Fisheries modifies the ESA ocean fishery management criteria, the Parties will discuss whether it is appropriate to reconsider criteria for in-river fisheries.

5. Non-treaty Columbia River Fisheries

Non-treaty fall season fisheries will be managed in approximate accordance with modeling summary results annually described in Attachment A and Part II.D.2 of this Agreement. Non-treaty fisheries shall be managed to not exceed the over-all URB Chinook harvest impacts listed in modeling summary results annually described in Attachment A. It is the intent of the Parties that conduct of the Hanford sport fishery will not in any manner constrain the treaty Indian fishery unless the tribes have already achieved the treaty tribal fisheries' share as described in modeling summary results provided in Attachment A.

6. Treaty Indian Fisheries

The fall season treaty Indian fishery shall be managed in approximate accordance with modeling summary results annually described in Attachment A and Part II.D.2 of this Agreement. Commercial fishing in Zone 6 of the Columbia River shall remain an exclusive treaty Indian fishery. The actual fishing dates, gear restrictions, and other shaping measures with respect to this fishery shall be defined by the tribes in-season as the fishery progresses.

7. In-Season Review

The Parties shall meet in-season to review run size updates and the fisheries that have occurred up to that point. If that review suggests that the States of Oregon and Washington or the Columbia River Treaty Tribes will be unable to achieve the fisheries or harvest sharing objectives described in Part II of this Agreement by continuing to adhere to the harvest rates set forth in Part II.D.2.b. and c. or Part II.E.3 and 4, the Parties may, by agreement, adjust those harvest rates. The total URB harvest rate resulting from such an adjustment shall not exceed those shown in Table A3. The total Group B index steelhead fall season harvest rate resulting from such an adjustment shall not exceed the rates shown in the abundance based harvest rate schedule shown in Table A4.

E. STEELHEAD

1. Management Principles

The Parties have discussed the concerns identified by the Tribes regarding the appropriateness of Group A and B steelhead stock separation as applied to fisheries management relative to non-harvest activities. Information and harvest management criteria will be established to address steelhead management issues. The Parties direct TAC to make recommendations to the Policy Committee for further studies as needed to address steelhead management issues. For the purposes of this Agreement, Group B index steelhead are defined as any steelhead measuring at least 78cm fork length and passing Bonneville Dam between July 1 and October 31. The Parties direct TAC to review non-retention impacts to the Snake River Steelhead DPS from all fisheries, and to make recommendations in 2019 to the Policy Committee regarding any appropriate adjustments to the determination of total fishery impacts.

2. Steelhead Escapement Goals

TAC has completed a review of Snake River steelhead escapement information. The Parties will consider the information in monitoring management activities.

3. Non-treaty Columbia River Harvest

Non-treaty fisheries in the mainstem Columbia River will be managed in approximate accordance with modeling summary results annually described in Attachment A. These fisheries will result in a harvest rate that is no greater than that shown in Table A4. Non-treaty fisheries for steelhead in the mainstem Columbia River and its tributaries will be managed consistent with *United States v. Oregon* and *United States v. Washington* case law principles regarding harvest sharing. All Non-treaty fisheries outside the Snake River basin will be managed not to exceed 2% harvest impact for natural origin Group B index steelhead. Oregon and Washington will provide catch estimates annually. The harvest impacts will be estimated for Group A and Group B index steelhead.

4. Treaty Indian Zone 6 Harvest

Zone 6 Treaty Indian fall season fisheries will be managed in approximate accordance with modeling summary results annually described in Attachment A. These fisheries will result in a harvest rate that is no greater than that shown in Table A4. The tribes will employ standard management tools, at their discretion, to stay within the steelhead guideline while achieving the fall Chinook allocation.

F. COHO

1. Management Principles

An important aspect of this Agreement is to define an understanding among the Parties regarding procedures and schedules for mass marking of Columbia River hatchery coho originating from state and federal facilities, for clarifying releases above Bonneville Dam, and for subsequent fishery management. The Parties recognize that the actions defined in this Agreement reflect the Parties' best efforts at reaching a negotiated agreement to protect, rebuild, and enhance upriver Columbia River coho while providing harvests for both treaty Indian and non-treaty fisheries.

2. *United States v. Oregon* Harvest Sharing Principle

The Parties agree to implement fisheries in the Pacific Fishery Management Council (PFMC) and Columbia River Compact fora that provide treaty Indian and non-treaty fisheries the opportunity to each harvest 50 percent of the upriver adult coho available for harvest south of the U.S.-Canada border. The provision for 50 percent of the defined upriver adult coho run size to non-treaty fisheries shall include any catches in sport fisheries above Bonneville Dam as well as sport and commercial fisheries below Bonneville Dam and in the ocean. The upriver coho run is comprised of both early and late stocks.

3. Responsibilities for Costs

This Agreement does not commit the tribes to additional costs directly related to mass marking and a selective fisheries plan. These envisioned costs specifically include providing for equipment use and maintenance, costs for marking and tagging operations, and increases in staff for coded-wire tag sampling, if any are required. The Party sponsoring and conducting mass marking will carry out this responsibility by providing equipment and technical assistance when needed.

4. Escapement Objectives

Non-treaty fisheries will be managed to achieve at least the collective broodstock escapement necessary to fulfill Columbia River hatchery production goals, including hatchery programs both above and below Bonneville Dam. TAC shall provide a recommended spawning escapement goal analysis to the Policy Committee. The Parties intend to gather information for developing a coho spawning escapement goal and/or a management goal (in Bonneville Dam equivalents). In the event of agreement on a natural spawning escapement goal for upriver coho, the 50 percent sharing agreement shall apply to that portion of the run size in excess of the agreed natural spawning escapement goal.

5. Fisheries Management

The Parties agree that all fisheries, including selective and non-selective types, affecting upper Columbia River coho, will be implemented as a result of the co-management process that includes the North of Cape Falcon Forum, the PFMC, the Columbia River Compact, and *United States v. Oregon* Columbia River tributary jurisdictions. The Parties recognize that the Secretary of Commerce will adopt regulations recommended by the PFMC that establish ocean salmon fisheries for all areas south of the U.S.-Canada border. Upriver coho impacts in ocean and Columbia River Basin fisheries shall be described annually. Catch-and-release mortalities associated with non-treaty selective fisheries will be included in calculations of the total upriver run size and the harvest sharing provisions of Part II.F.2 of this Agreement. The Parties agree that selective and non-selective fishery options will be evaluated on their merits consistent with the management objectives and fishery sharing provisions stated in this Agreement and there is no assurance that selective fisheries will occur simply because marking has occurred. The Parties acknowledge that coho fisheries will be managed consistent with the harvest sharing principles. Fisheries adjustments in-season will also be made accordingly.

G. WHITE STURGEON

1. Management Goals

The intent of the Parties is to manage sturgeon populations in the Zone 6 fishing area to provide long term sustainable harvest opportunities for Indian and non-treaty fisheries. The current status of the sturgeon population is the key factor in determining appropriate harvest levels. The Parties commit to continue ongoing studies to estimate present and optimum population levels, life history characteristics, recruitment, spawning potential and appropriate sturgeon fishing sanctuaries.

2. Management Measures

Oregon, Washington and the Columbia River Treaty Tribes have established a joint Sturgeon Management Task Force. They will continue to meet regularly in that forum to review sturgeon management issues and set harvest guidelines for the upcoming year. Information to be reviewed includes recreational, commercial and subsistence landings for each reservoir between Bonneville and McNary Dam. Estimates of encounters in non-retention recreational activities will also be provided. The Sturgeon Management Task Force shall determine the harvest guidelines for each reservoir annually. The effectiveness of harvest management shall be measured relative to a three-year rolling average of the guidelines. Annual harvest guidelines may be adjusted to account for cumulative overages/underages. The treaty catch may be taken in gillnet, setline, platform or hook-and-line fisheries.

Oregon, Washington, and the Columbia River Treaty Tribes agree to undertake a review of sturgeon management regulations. The effect of size limits, sanctuaries and other regulations on the harvest guidelines will be estimated.

The Parties commit to pursuing enhancement activities, along with the necessary funding, for sturgeon populations in the Zone 6 fishing area. Activities considered will include, but not be limited to, artificial propagation, transplantation from other areas and flow augmentation. The Parties agree that funding for ongoing studies to estimate present and optimum population levels, life history characteristics, recruitment, spawning potential and appropriate sturgeon fishing sanctuaries is essential to successfully managing these populations.

H. SHAD

Shad runs have been sufficiently large to allow for major expansion of harvest. However, markets are limited and need to be developed for this species. Development of catch methods shall be pursued to promote a sufficient catch of shad while minimizing the catch of other species. The Parties shall seek to minimize the harvest of salmon incidental to treaty Indian and non-treaty shad fisheries as set forth in Part II, Sections A.4 and 5, B.3 and 4, and C.2 and 3. The incidental shad catch during treaty Indian fisheries for anadromous fish may be sold or otherwise utilized. The tribes may also implement directed shad fisheries using traps or other appropriate gear. All incidental impacts to salmon and steelhead will be accounted for as part of applicable harvest guidelines.

I. WALLEYE AND OTHER NON-NATIVE SPECIES

The incidental catch of walleye and other fish species not native to the Columbia River during treaty Indian fisheries for anadromous fish may be sold or otherwise utilized. Non-treaty fisheries on walleye shall continue under state regulation, which prohibits the sale of walleye.

J. LAMPREY

The Parties recognize the depressed status of lamprey populations originating from upstream of Bonneville Dam. The Parties acknowledge that factors other than harvest have been the major cause of population decline. The Parties commit to jointly support efforts to identify and implement projects to restore lamprey populations above Bonneville Dam.

There shall be no commercial harvest of lamprey in the Columbia River and its tributaries. This does not prevent trade or barter among Indian Tribes, or harvest for personal use by non-Indians, if otherwise permitted. The Parties recognize that opportunities for harvest of lamprey are extremely limited. In recent years, the primary opportunity for harvest of lamprey has been at Willamette Falls. Annual take levels will be determined through a process that includes discussions between the State of Oregon and the tribes.

K. RESEARCH AND MONITORING

The *United States v. Oregon* Parties have agreed to a series of species-specific harvest management regimes described in Part II. Implementing those management regimes requires continuation of essential monitoring activities. Additional research and monitoring is needed to improve the accuracy and precision of management. Important components of a comprehensive research and monitoring program include, but are not limited to, those described below. The Parties agree that maintaining a vigorous research and monitoring program is essential to continued implementation of the harvest regimes as envisioned in this Agreement. The Parties therefore agree to work together to maintain funding for current programs, and seek additional funding that are considered essential to increase certainty in the conservation effectiveness of the harvest strategies contained within this Agreement.

1. Current Needs

a. Fisheries sampling for stock composition including impacts to natural origin fish.

b. Fishery effort accounting.

c. Natural spawning escapement enumeration.

d. Run reconstruction and forecasting.

e. Observer programs and test fisheries.

f. Dam passage sampling.

2. Additional Needs

a. Snake River fall Chinook run reconstruction and forecasts.

b. Enhanced natural spawning escapement enumeration.

c. PIT tag sampling.

d. Increase sampling effort to maintain necessary fishery sampling rates.

e. Evaluate genetic stock identification methods to further improve stock identification.

III. PRODUCTION ACTIONS

A. MANAGEMENT PRINCIPLES

1. General Statement

The Parties have responsibilities with regard to the conservation, rebuilding, and/or enhancement of the anadromous salmonids of the upper Columbia River Basin. The Parties also recognize the existing Northwest Power and Conservation Council's interim rebuilding goal to increase total adult salmon and steelhead runs above Bonneville Dam by 2025 to an average of 5 million annually in a manner that supports tribal and non-tribal harvest (Council Document 2014-12, III.). The Parties intend to use artificial production techniques where appropriate, among other strategies, to assist in rebuilding weak runs and mitigating for lost production. The Parties' stated intent to implement the production actions described in this Agreement is an important consideration to the Tribes. These production actions, in conjunction with other enhancement efforts, habitat protection, hydrosystem management, and harvest management, are intended to ensure that Columbia River fish runs continue to provide a broad range of benefits in perpetuity.

2. Research, Monitoring, and Evaluation

The Parties will work in cooperation to continue developing monitoring and evaluation programs for the production actions contained in this Agreement and for any production program modifications implemented under Part I.B.2 and III.A.1. Monitoring and evaluation programs for production shall be consistent with the research and monitoring activities for harvest described in Part II.K, and may use some of the same tools. Therefore, the Parties commit to retain flexibility as they develop monitoring and evaluation programs, to use their best efforts to maintain current funding for monitoring and evaluation programs, and to secure additional funding to address information needs. The Parties will integrate information gained from monitoring and evaluation with the production strategies in this Agreement so as to increase certainty in their conservation effectiveness.

3. Marking

The Parties recognize and have discussed the concerns identified by the Parties regarding marking protocols for various production programs identified in this Agreement. Marking scenarios identified in this Agreement are expected to occur during the period of this Agreement. It should not be interpreted that each marking program has the full support of all Parties or that any Party waives any rights it may have with regard to any marking protocol. Nothing in this Agreement shall be interpreted as setting precedent for future marking programs or as preventing Parties from reaching other agreements on individual marking programs which may be implemented during or after termination of this Agreement; provided, however, that notice of such agreements shall be given to the other Parties. All Parties commit to make a good faith effort to continue discussions and negotiations on individual marking issues during the period of this Agreement.

The Parties agree to engage in a "basin by basin" approach to develop marking protocols. The Parties will evaluate releases in all tributaries within a sub-basin. The Parties will take into account the purpose of the releases and the interests of the appropriate Parties, and accommodate all Party interests to the extent possible. The Parties will place particular emphasis on evaluating the marking protocols and allowable harvest rates that affect the harvest sharing principles embodied in this Agreement.

Nothing in this Agreement shall be interpreted to prevent the federal Parties and/or states from mass marking fish required to be marked under Congressional acts directing the mass marking of Chinook, coho, and steelhead intended for harvest which are released from federally operated or financed hatcheries. In the event USFWS and/or states mark fish inconsistent with Tables B1-B7, nothing in this Agreement prevents any Party from challenging these acts. In the event of insufficient funding to carry out such marking, the federal Parties will consult with the other Parties to review and revise the priorities in any marking plan provided for under this Agreement. The federal Parties will, to the extent required by law, consider the other Parties' recommendations and the United States' trust and treaty responsibility to the Tribes before deciding marking priorities.

4. Broodstock, Facility and Funding Needs for Production Programs

The Parties hereby commit to a good faith effort to meet the juvenile release programs identified in Tables B1, B2, B3, B4, B5, B6, and B7. However, juvenile release levels will be dependent on obtaining adequate returns of broodstock, maintaining adequate facility rearing space, and funding to accomplish the agreed-to production programs. The Parties recognize that much of the funding for the production programs central to this Agreement is the responsibility of entities that are not Parties to this Agreement (e.g., BPA, BOR, COE, PUDs and private entities) as mitigation for Columbia River Basin water development projects. All the Parties agree to work cooperatively to provide the necessary facility rearing space and to make a good faith effort to secure the necessary funding for these production programs. In the event that production program goals are not achievable, the Parties will negotiate contingencies on a case-by-case basis through the *United States v. Oregon* Policy Committee and Dispute Resolution process.

For production programs that are not included in Tables B1-B7, the Parties commit annually to provide their individual production plans for review and discussion by the PAC. As a result of this review, the PAC will determine if there are issues that should be forwarded to the Policy Committee. Any such issues will be discussed annually at the Mid-Spring Meeting or otherwise designated negotiation session.

5. Mitchell Act Funding

The Parties agree to request, and to use their best efforts to secure, sufficient funding to carry out production management measures set forth in Tables B1-B7. If appropriations through the duration of this Agreement contain sufficient funding to carry out current Mitchell Act programs, the Parties agree to implement the Mitchell Act production actions as set forth in this Agreement subject to compliance with all applicable laws. If there is insufficient funding to maintain current Mitchell Act programs, then, consistent with the Anti-Deficiency Act, the United States cannot commit to fund any particular Mitchell Act program. In the event of such insufficiency in Mitchell Act appropriations to meet all of the Parties' desires, the United States will consult with the Tribes and the States to review and revise the Mitchell Act program in light of the actual Fiscal Year appropriations, and, the United States will give good faith consideration to all Parties' recommendations, the United States' trust responsibility to the Tribes, and Mitchell Act history before deciding which Mitchell Act program actions will be funded. It is not the Parties' intent to eliminate or substantially reduce any Mitchell Act programs, however, the upriver releases identified in this Agreement have priority over lower river releases. The Parties understand that options for any program changes will be considered pursuant to Part I.C.

6. <u>Non-Mitchell Act Funding</u>

Implementation of other non-Mitchell Act funded production measures in this Agreement may involve new costs that are funded by government and non-government entities. For programs funded by the federal agency signatories, non-Mitchell Act production measures are subject to obtaining funding sufficient to implement the measures and are subject to compliance with all applicable laws. The Parties agree to request, and to use their best efforts to secure, sufficient funding to carry out production management measures set forth in Tables B1-B7. If there is insufficient funding to implement non-Mitchell Act programs funded by a federal agency signatory, the Parties will consult to review and revise the program measures in light of the funding for that year. The United States will give good faith consideration to all Parties' recommendations, the United States' trust responsibility, and the purpose and history of the program before deciding which programs will be funded.

B. SPRING CHINOOK PRODUCTION

The Parties agree to implement spring Chinook production programs described in Table B1: Spring Chinook Production for Brood Years 2018-2027. In developing marking protocols, the Parties agree to take a "basin by basin" approach as described in Part III.A.3.

C. SUMMER CHINOOK PRODUCTION

The Parties agree to implement summer Chinook production programs described in Table B2: Summer Chinook Production for Brood Years 2018-2027.

C. SOCKEYE PRODUCTION

The Parties agree to implement sockeye production programs described in Table B3: Sockeye Production for Brood Years 2018-2027.

E. FALL CHINOOK PRODUCTION

1. Snake River Fall Chinook Supplementation Program

a. The Parties all have an interest in the current Snake River (SR) fall Chinook production program, its effects on SR fall Chinook abundance and productivity, and the magnitude or relative impact of the current production program compared to other actions and conditions that influence SR fall Chinook abundance and productivity. With the implementation of the SR fall Chinook supplementation program, the abundance of natural origin SR fall Chinook has significantly increased, thereby effectively reducing the near-term risk to the population's persistence.

The Parties agree that the effect of the current supplementation strategy on SR fall Chinook abundance, productivity, spatial structure, and diversity, and the magnitude or relative impact of the current production program to other actions that influence SR fall Chinook will continue to be evaluated over the course of this Agreement. If, during the course of this Agreement, additional data or changed circumstances arise associated with the SR fall Chinook, then the Parties agree to consider options to address the issue identified, including whether to modify the current supplementation program or consider other management responses.

In the event that NOAA seeks to revise the SR fall Chinook supplementation program utilizing its ESA authorities, or another event triggers ESA-based re-consideration of the SR fall Chinook supplementation program during the term of this Agreement, NOAA shall meet with all the Parties to analyze the SR fall Chinook supplementation program compared to other actions and conditions that influence SR fall Chinook abundance, productivity, spatial structure and diversity, as well as legal principles, including but not limited to the Tribes' treaty rights, the States' interests, the

Secretarial Order on ESA and Tribal Treaty rights, the conservation necessity principles and the ESA.

b. The Parties agree to implement SR fall Chinook production programs described in Table B4: Snake River Fall Chinook Production for Brood Years 2018-2027 pursuant to action defined above.

c. The Parties will meet annually prior to September 15 of each year to develop broodstock collection protocols needed to implement Table B4. In the case of broodstock shortages, priorities outlined in Table B4 will be followed. Annual plans for the respective fall Chinook brood year will be provided to PAC by October 1 of each year.

d. Trapping of adult fall Chinook at Lower Granite Dam will occur at a fixed percentage rate agreed upon by the fishery managers prior to initiation of trapping at the dam. Trapping is to provide for broodstock collection (hatchery and natural origin), accurate run reconstruction, and for removal of non-Snake origin fish.

e. The Parties will work cooperatively to seek and maintain adequate funding to operate the Lower Granite Dam trap to further the goals of the Snake River production programs.

f. A monitoring and evaluation implementation plan remains in development as part of the long term production plan for SR fall Chinook to support conservation and harvest programs. In the interim, an appropriate number of fish will be coded-wire tagged for evaluation purposes as identified in Table B4. The tagging/marking technique shall allow for the adult returns of the off-site released juvenile Lyons Ferry Hatchery fall Chinook to pass the Lower Granite Dam trap because it is the Parties' intent that current trapping protocols at Lower Granite Dam will ensure that the majority of supplementation fish will pass upstream of Lower Granite Dam to spawn naturally. Unless the Parties agree otherwise, the adult returns from juvenile SR fall Chinook releases that are surplus to broodstock needs shall be allowed to pass Lower Granite Dam to spawn naturally.

g. The Parties shall coordinate the use of Lyons Ferry subyearling production for supplementation and research. To facilitate research review, the Parties shall consider research proposals through existing research review forums. In order to protect the integrity of the Parties' production commitments with regard to SR fall Chinook contained in this Agreement, research proposals are subject to review and agreement of the Parties. Such agreement shall not be unreasonably withheld.

h. The PAC shall provide an annual update report of SR fall Chinook adult returns and expected egg-take by November 1. The PAC shall also provide an actual egg-take and juvenile production estimate report by January 15 of each year.

2. Other Fall Chinook Production

The Parties agree to implement other fall Chinook production programs described in Table B5: Fall Chinook Production for Brood Years 2018-2027. With respect to John Day and The Dalles Dam mitigation, in 2012 the Parties and the US Army Corps of Engineers (USACOE) agreed upon a compromise interim reprogramming mitigation level of 107,000 Total Adult Production with a stock split of approximately 75% upriver bright fall Chinook and 25% tule Chinook. The Parties will continue to work with the USACOE to implement that compromise level of mitigation.

F. STEELHEAD PRODUCTION

1. Steelhead Production for Brood Years 2019-2028

Hatchery steelhead from the 2019-2028 brood (fish that return to the Columbia River in 2018-2027 and will spawn in 2019-2028) shall be implemented as described in Table B6: Steelhead Production for Brood Years 2019-2027. The Parties agree to continue a monitoring and evaluation program for the mass marking and selective fisheries program in the Columbia River Basin. A purpose of the program is to evaluate catch and release mortalities to unmarked steelhead.

2. Monitoring Adult Composition

The Parties commit to seek funding for a program to monitor the composition of adult steelhead returning above Bonneville, Lower Granite, and Priest Rapids dams. The Parties commit to working with US Army Corps of Engineers to improve sampling at Bonneville Dam. This program is expected to include but is not limited to the collection of scales from adult steelhead at Bonneville, Lower Granite, and Priest Rapids dams to assist in monitoring hatchery and natural origin adult escapement to the Snake River and upper Columbia River areas.

G. COHO

1. Purpose of Program Modifications

The coho program modifications described below are a result of a negotiated agreement between the Parties to address mass marking, the selective fisheries program, and the Parties' desire to restore upriver coho runs.

2. Upriver Coho Production for 2018-2027 Brood Coho

The Parties agree to implement upriver coho production and reintroduction programs described in Table B7: Coho Production for Brood Years 2018-2027.

3. Grande Ronde Program

The Parties have agreed to implement a pilot program and will evaluate its effectiveness over the course of this Agreement. If the Parties determine this program is not meeting the objectives identified, the balance of the production will revert back to release in the Umatilla River.

4. Priority for Upriver Programs

Except as described in Table B7, for each respective brood year, the upriver releases identified in this Agreement have priority over lower river releases. The States of Oregon and Washington and the United States shall manage lower river hatchery programs such that upriver release levels will meet the coho release goals described in Table B7. In the event of a juvenile rearing catastrophe, the Parties agree to consider alternative release strategies, which may include but are not limited to making up the shortfall in subsequent broodyears.

5. Contingency

The Parties recognize that disease, weather disasters, or other unforeseen events might impact non-mass marked upriver coho programs and result in a situation where already mass-marked lower river coho are the only fish available to be reprogrammed for an upriver release to meet the release goals identified in this Agreement. Therefore, if a shortfall in non-mass marked coho for upriver programs occurs after mass marking is completed, the Parties will meet and agree on how best to address the shortfall.

H. PRODUCTION ISSUES REQUIRING FURTHER DEVELOPMENT

The Parties acknowledge that on-going hatchery reviews, production planning, evaluation of hatchery programs to meet mitigation responsibilities, development of new programs and other factors may require the Parties to modify some of the production programs described in tables B1-B7. The Parties commit to good faith efforts to continue the development of production plans, including descriptions of issues requiring policy guidance, analyses of technical issues, and identification of funding mechanisms in order to reach consensus on outstanding issues that prevent the finalization of Tables B1-B7.

The following list of production issues is recognized as being of high priority for resolution by the Parties but is not intended to exclude other production issues that may arise during the term of this Agreement. The Parties commit to good faith efforts to better define and/or resolve issues and engage in cooperative planning for the implementation of the following programs:

1. <u>Table B1, Spring Chinook Salmon</u>

   a. Leavenworth NFH complex facility modification, spring Chinook program levels, release locations, development of locally adapted broodstocks and marking protocols.

   b. Yankee Fork spring Chinook development of locally adapted broodstock for supplementation and production planning that also considers the Sawtooth FH program and Crystal Springs Hatchery design and build out.

2. <u>Table B2, Summer Chinook Salmon</u>

   a. Panther Creek summer Chinook development of locally adapted broodstock for supplementation and production planning.

3. <u>Table B3, Sockeye Salmon</u>

   a. Wallowa Lake sockeye program.

4. <u>Table B5, Fall Chinook Salmon</u>

   a. John Day and The Dalles Dams mitigation program.

   b. Priest Rapids Hatchery fall Chinook marking protocols (Grant County

PUD mitigation program).

5. Table B6, Steelhead

a. Wenatchee, Methow, Okanogan steelhead development of new acclimation facilities and marking protocols.

b. Methow River/Winthrop NFH and Okanogan River steelhead management plans developed within 18 months of completing ESA consultations.

c. Yankee Fork of the Salmon River steelhead local broodstock transition and production planning.

I. PROCESSES FOR ONGOING OR FUTURE REVIEWS AFFECTING PRODUCTION PROGRAMS, AND FOR HIGH PRIORITY PRODUCTION ITEMS THAT WILL REQUIRE FURTHER DEVELOPMENT, COOPERATIVE PLANNING, AND RESOLUTION

1. Process for Ongoing or Future Reviews Affecting Production Programs

The Parties recognize that ongoing or future reviews of hatchery management programs and policies may affect the production programs described in this Agreement. Program modifications recommended by NOAA and USFWS as a result of the ESA section 7 process are addressed in Section I.B.2 of this Agreement. Program modifications proposed by any other Party, will be considered by the *U.S. v. Oregon* Parties on a case-by-case basis, and the following specifics shall apply consistent with the general modification provision in Section I.B.8 of this Agreement. The Parties will consider the relationship of the proposed modification to the overall Agreement and the valuable exchange of consideration the Agreement represents. After considering any modification, the Parties may agree to modify the Agreement, renegotiate the Agreement, or pursue any and all options they may have, including but not limited to dispute resolution pursuant to this Agreement, withdrawal from this Agreement, or initiating legal action. The Parties commit to monitor and evaluate the effects of program modifications on adult returns and fishery opportunity as a condition of agreement to a modification.

2. <u>Process for High Priority Production Items That Will Require Further Development, Cooperative Planning, and Resolution</u>

The Parties have identified a list of high priority production items set forth in Part III.H. that will require further development, cooperative planning, and resolution during the course of this Agreement and could result in modification of tables B1-B7.

The Parties agree that additions, deletions, or modifications to tables B1-B7, aside from those subject to Part I.B.2, may be made by agreement of the Parties at any time during the term of this Agreement. The following specific process shall apply to the extent feasible consistent with the general modification provision of Section I.B.8.

a. The Party proposing any such modification is responsible for supplying to other Parties all relevant information and rationales supporting a proposal. All proposals must be submitted to PAC by the relevant co-managers or Parties for technical analysis and eventual recommendation to the Policy Committee.

b. Planning efforts in connection with the proposal will occur at a sub-basin level, and appropriate Parties (as identified in Table 1) for each production program proposal will make a good faith effort to participate in and contribute to the planning effort.

c. Each Party shall advise and update its PAC representative regarding progress on production program planning efforts. An annual progress report will be provided by the PAC to the Policy Committee on each production item after coming under active consideration by the Parties.

d. In the event PAC cannot reach a consensus recommendation, an issue paper will be prepared for Policy Review which describes the issue preventing consensus and contains relevant facts of the dispute. If the Policy Committee cannot reach consensus, any Party may elect to invoke the Dispute Resolution procedure in Part I.C.6.

e. If the Parties reach consensus on a proposed modification, they shall incorporate the modification into this Agreement.

SCHEDULE A: *Annual Schedules for Committee Activities*

Annual TAC Schedule

Report/Activity	Information	Dates/Deadlines
Spring/summer season management (spring, summer, sockeye)	Post-season run reconstruction Pre-season run forecasts	November – December Mid-December
Steelhead	Post-season run reconstruction and Pre-season Forecasts	January
Fall season management (TAC works with Joint State Staff to accomplish these tasks)	Post-season run reconstruction (all managed fall Chinook stock groups including Snake River Fall Chinook) Pre-season forecasts	November- February February
Winter Season Joint Staff Report Sturgeon/Smelt (TAC works with Joint State Staff)	Stock status/management guidelines Fishery review/recommendations TAC review of document	Final document available mid- December Early December
Winter/Spring Season Joint Staff Report and Spring Chinook / Steelhead (TAC works with Joint State Staff)	Stock status/Run forecasts, Management guidelines, Fishery review/recommendations TAC review of document	Final document available January Early January
Fall Season Joint Staff report Fall Chinook, coho, steelhead (TAC works with Joint State Staff)	Stock status/run forecasts, Management guidelines, Fishery review/recommendations TAC review of document	Final document available Mid-July Early July
Annual Summary Report (for Policy Committee)	Final Post-season impacts from all fisheries compared to targets in Management Agreement for previous year. Includes Spring Catch Balance report, Fall summary report, Indicator Stock summary Report, and ESA Impact report.	April/May
In-season spring management	Assist Joint State staff with Compact Fact Sheet development Run size updates Fishery updates	Weekly February – Early June
Pre-season fall management	Run forecasts Fall fishery planning/PFMC/NOF	Mid-February March – April
In-season summer management	Assist Joint State staff with Compact Fact Sheet development Run size updates Fishery updates	Weekly June-July
Post-season spring/summer season summary report for Policy Committee	Fishery Impact Summary for spring and summer season fisheries	August-October
In-season fall management	Compact Fact Sheet development Run size updates/fishery updates	Weekly August – October
Post-season fall season summary report for Policy Committee	Fishery Impact Summary for fall season fisheries	November-December

Annual PAC Schedule

Report/Activity	Information	Dates/Deadlines
Consider production changes to Tables B.1 – B.7	Spring/summer Chinook Fall Chinook/coho/ Steelhead	Monthly PAC meetings
Production plan modifications based on preseason forecast	Spring/summer Chinook Fall Chinook/coho/ Steelhead	Early April Early August
Update on production programs not included in Tables B.1 – B.7	Spring/summer Chinook Fall Chinook/coho/ Steelhead	Update at mid-Spring Policy Committee meeting
Preliminary tributary escapements	Spring/summer/fall Chinook Coho Steelhead	Early November Early December Mid-June
Determine Lower Granite trapping and broodstock collection protocols	Fall Chinook	August
Summarize annual release numbers for production review report	Spring/summer Chinook Fall Chinook/coho/ Steelhead	September – November PAC meetings
Post-season escapement and identification of production changes	Spring/summer/fall Chinook Coho Steelhead	Early December Early December Early May
Finalize annual production review report	Spring/summer Chinook Fall Chinook/coho/ Steelhead	Update at mid-Winter Policy Committee meeting
Summarize PAC/Policy Committee approved changes to Tables B.1 – B.7	Spring/summer Chinook Fall Chinook/coho/ Steelhead	Update at mid-Winter Policy Committee meeting

Note: Columbia Basin production activities involve a wide number of agencies and staff. Different agencies, including parties to this Agreement, delegate aspects of the above responsibilities to staff who may not be members of PAC. PAC will involve itself as needed to ensure these tasks are accomplished, and PAC will work with state, federal, and tribal agency staff as needed to collect appropriate information regarding the above activities and report it to the Policy Committee. PAC will share information regarding current production programs not included in Tables B1-B7. PAC is directed by the Policy Committee to assist in resolution of any disputes regarding production programs included in this Agreement and report any issues requiring policy resolution. TAC and PAC will provide additional data and analysis as requested in order to implement this Agreement.

Annual Policy Committee Schedule

Report/Activity	**Information**	**Dates/Deadlines**
Mid-Winter Meeting - Specified negotiation topics - Fall fisheries post-season review - Spring and summer management period fishery preview - Sturgeon Management Task Force meeting - Production review and annual decision point for (non-steelhead) production program issues	 Briefing papers TAC post-season fall season fishery report TAC pre-season fishery report (Summary of Forecasts and Joint Staff Report) Staff/TAC sturgeon technical reports/abundance data Proposed production modifications	January-February
Mid-Spring Meeting - Specified discussion topics - Potential Non-Party Interaction - Fall management period fishery preview - Mid-spring season fishery update - Review Annual Indicator Summary Report -RCC Regulation Consistency Review Report	 Briefing papers Issue Papers TAC pre-season fishery report (Summary of PFMC/NOF and in-river fishery modeling) TAC spring season update TAC Annual Indicator Summary Report RCC Report	April-May
Mid/Late Summer Meeting - Specified discussion topics - Spring/summer fisheries post-season review - Fall Season Management Issues	 Briefing papers TAC post-season spring/summer season fishery report TAC report	August-September

Report/Activity	Information	Dates/Deadlines
- Production review and annual decision point for steelhead production program issues	PAC report	
<u>Fall Meeting</u> - Specified discussion topics - Fall Season update - Coho broodstock collection update	 Briefing papers TAC report PAC report	October-November

Table 1. Lead Management Entities for Each Sub-basin.*

Sub-Basin	Fishery Management Entities	Sub-Basin	Fishery Management Entities
Wind River	WDFW, YIN	Little White Salmon River	WDFW, YIN
Big White Salmon River	WDFW, YIN	Klickitat River	WDFW, YIN
Yakima River	WDFW, YIN	Wenatchee River	WDFW, YIN
Entiat River	WDFW, YIN	Methow River	WDFW, YIN
Hood River	ODFW, CTWSOR	Deschutes River	ODFW, CTWSRO
John Day River	ODFW, CTWSRO, CTUIR	Umatilla River	ODFW, CTUIR
Walla Walla River	ODFW, CTUIR, WDFW	Tucannon River	WDFW, CTUIR, NPT
Grande Ronde	ODFW, WDFW, NPT, CTUIR	Imnaha River	ODFW, NPT, CTUIR
Clearwater River	IDFG, NPT	Salmon River	IDFG, NPT, SBT**
Snake River Mainstem	WDFW, ODFW, IDFG, CTUIR, NPT	Columbia River, Upper Mainstem (Confluence of Snake R. to Chief Joseph Dam)	WDFW, YIN, CTUIR

* The lead management entities will consult with USFWS and NOAA Fisheries as necessary when fish listed under the ESA inhabit a sub-basin and/or when USFWS funds or has a production facility in the sub-basin.

** The Shoshone-Bannock Tribes shall be deemed a management entity for purposes of those portions of the Salmon River sub-basin that concern those lands and streams outside the Nez Perce Reservation originally established by the Nez Perce Treaty of 1855 where the Shoshone-Bannock Tribes exercise treaty-secured fishing rights, and such other sub-basin areas as may subsequently be agreed upon by the affected parties hereto.

GLOSSARY

For the purposes of this Agreement:

Ad-Clip or **Ad** means: A means of marking fish by removing the adipose fin.

AEQ means: Adult equivalent.

anadromous fish means: Fish that ascend freshwater rivers and streams to reproduce after maturing in the ocean.

AOP means: Annual Operations Plan developed for an artificial production program.

artificial production or **artificial propagation** means: Spawning, incubating, hatching or rearing fish in a facility constructed for fish production.

BA means: A biological assessment prepared under 16 U.S.C. § 1536(c).

BIA means: Bureau of Indian Affairs, an agency of the United States Department of the Interior.

BOR or **BR** means: United States Bureau of Reclamation, an agency of the United States Department of the Interior.

BPA means: Bonneville Power Administration.

BPH means: Bonneville Pool Hatchery; tule fall Chinook salmon produced in artificial production facilities between Bonneville and The Dalles Dams.

BUB means: Bonneville Upriver Bright; bright fall Chinook salmon produced in Bonneville Hatchery.

BY means: Brood year.

C&S means: Ceremonial and subsistence.

ceremonial fish means: Those fish caught and used pursuant to tribal authorization for religious or other traditional Indian cultural purposes of the tribes and which may not be sold, bartered or offered for sale.

COE means: United States Army Corps of Engineers.

Columbia River Compact or **Compact** means: The Oregon-Washington Columbia River Compact, enacted in Oregon as 1915 Or. Laws ch. 188, § 20 (codified at ORS 507.010), in Washington as 1915 Wash. Laws ch. 31, § 116 (codified as amended at RCW 77.75.010 (2006)), and ratified by Congress in the Act of April 8, 1918, ch. 47, 40 Stat. 515.

Columbia River Treaty Tribes means: The Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation.

commercial fish means: Those fish that are sold or bartered or are caught for that purpose (except subsistence fish).

conversion rate means: The estimated survival of adult fish during upstream migration. Conversion rates are calculated by dividing the count of a particular group of adult fish at the uppermost dam by the count of that group at the lowest dam.

CTUIR means: Confederated Tribes of the Umatilla Indian Reservation.

CTWSRO means: Confederated Tribes of the Warm Spring Indian Reservation of Oregon.

CWT means: Coded Wire Tag, a means of marking fish by inserting numeric-coded wires into their snouts.

DPS means: Distinct Population Segment under 16 U.S.C. § 1532(16), as defined in 61 Fed. Reg. 4722 (Feb. 7, 1996).

emergency means: Unanticipated change in fish resource status, abundance, timing or harvest level for which the relevant data was not available during preseason planning and which requires immediate management response to achieve the objectives of this Agreement.

enhancement means: The use of artificial propagation to increase the abundance of fish for harvest and spawning purposes.

ER means: Exploitation rate.

ESA means: Endangered Species Act, 16 U.S.C. §§ 1531-1544.

escapement means: The total number of adult fish that are passed through fisheries for purposes of artificial or natural production.

ESU means: Evolutionarily Significant Unit, as defined in 56 Fed. Reg. 58,612 (Nov. 20, 1991) for the purpose of identifying salmon "species" under 16 U.S.C. § 1532(16).

FCRPS means: Federal Columbia River Power System.

FH means: Fish Hatchery.

fishery impact or **harvest impact** means: Incidental fishery-related mortalities, measured as a percentage of run size at some geographical point.

FWS means: United States Fish and Wildlife Service, an agency of the United States Department of the Interior.

harvestable fish means: Those fish determined pursuant to this Agreement to be available for harvest.

hatchery fish means: Fish spawned, incubated, hatched or reared in an artificial production facility.

HCP means: A habitat conservation plan prepared under 16 U.S.C. § 1539.

HGMP means: A Hatchery and Genetics Management Plan prepared under 50 C.F.R. § 223.203(b)(5).

HR means: Harvest rate.

IDFG means: Idaho Department of Fish and Game.

IPC means: Idaho Power Company.

ISS means: Idaho Supplementation Study.

Joint State Staff or **Joint Staff** means: Joint Columbia River Management Staff of the Oregon and Washington Departments of Fish and Wildlife.

LCR means: Lower Columbia River, that portion of the Columbia River downstream from Bonneville Dam.

listed means: Determined to be a threatened or endangered species under 16 U.S.C. § 1533.

LM means: A means of marking fish by clipping the left maxillary.

lower river means: That portion of the Columbia River downstream from Bonneville Dam.

LRB means: Lower River Bright; bright fall Chinook salmon that spawn naturally in the Columbia River approximately three miles downstream of Bonneville Dam.

LRH means: Lower River Hatchery; tule fall Chinook salmon produced in artificial production facilities in the Columbia River basin downstream of Bonneville Dam.

LRW means: Lower River Wild; naturally-produced bright fall Chinook salmon from Columbia River tributaries downstream of Bonneville Dam.

LSRCP means: The Lower Snake River Fish and Wildlife Compensation Plan, initially authorized by Pub. L. No. 94-587, § 102, 90 Stat. 2917, 2921 (1976).

LV means: A means of marking fish by clipping the left ventral fin.

MA means: Mitchell Act, Act of May 11, 1938, ch. 193, 52 Stat. 345 (codified as amended at 16 U.S.C. §§ 755-757).

mainstem means: The Columbia River between its mouth and McNary Dam, except where expressly indicated otherwise.

management entity means: The agency (tribal, state, or federal) having fisheries management or production authority over the specific area and subject matter involved. The Parties designate the following as their management entities for purposes of this Agreement:

Idaho−Idaho Department of Fish and Game

Nez Perce Tribe−Nez Perce Department of Fisheries

Oregon−Oregon Department of Fish and Wildlife

Shoshone-Bannock Tribes−Shoshone-Bannock Fish and Wildlife

United States−

National Marine Fisheries Service (ocean fisheries)

United States Fish and Wildlife Service (National Fish Hatcheries)

Umatilla Tribe−Umatilla Department of Natural Resources, Fisheries Program

Warm Springs Tribe−Warm Springs Natural Resources Branch, Fish, Wildlife, and Parks Department

Washington−Washington Department of Fish and Wildlife

Yakama Nation−Yakama Nation Fisheries Resource Management

A party may change the designation by notifying the Chair of the Policy Committee in writing.

management goal means: A desired adult fish run size, usually composed of an aggregate of individual stocks, as measured at a given geographic point.

marked fish means: Fish to which humans have applied some external/internal means of identification.

M&E means: Monitoring and evaluation.

Mid Columbia fall Chinook or **MCB** means: Bright fall Chinook salmon originating from the Columbia River and its tributaries from about three miles downstream of Bonneville Dam upstream to McNary Dam.

Mid Columbia coho means: Coho salmon originating from the Wenatchee, Entiat, and Methow watersheds.

Mid Columbia HCP means: The Habitat Conservation Plans prepared under 16 U.S.C. § 1539 for the operation of Rock Island Dam, Rocky Reach Dam, and the Wells Hydroelectric Project.

natural origin fish, **natural spawning fish**, or **naturally produced fish** means: Fish produced by spawning and rearing in natural habitat, regardless of the parentage of the spawners.

NEOH means: Northeast Oregon Hatchery.

NFH means: National Fish Hatchery.

NI means: Non-Indian.

NMFS means: The National Marine Fisheries Service, a subdivision of NOAA.

NOAA means: The National Oceanic and Atmospheric Administration, a subdivision of the United States Department of Commerce.

NOAA Fisheries means: The National Marine Fisheries Service, a subdivision of NOAA.

non-treaty fisheries means: All fisheries within the United States' portion of the Columbia River Basin except those open only to members of the Columbia River Treaty Tribes or the Shoshone-Bannock Tribes, and all ocean fisheries in the United States' Exclusive Economic Zone and shoreward off the coasts of Washington and Oregon except those open only to members of the Makah, Quileute, Hoh, or Quinault Tribes.

North of Falcon Forum or **NOF** means: A series of public meetings associated with the annual planning of salmon fisheries in Washington and Oregon north of Cape Falcon.

NPCC means: The Northwest Power and Conservation Council established by 16 U.S.C. § 839b.

NPT means: Nez Perce Tribe.

NPTH means: Nez Perce Tribal Hatchery.

ODFW means: Oregon Department of Fish and Wildlife.

outplant means: A form of supplementation releasing adults in streams to increase or establish natural spawning fish populations.

PBT tagging means: Parentage-based tagging, a means of genetic identification of fish through annual tissue sampling and genotyping of broodstock so that tissue samples from offspring may be genotyped to identify parentage or hatchery-of-origin.

PCSRF means: Pacific Coastal Salmon Recovery Fund, initially authorized by Pub. L. No. 106-113, Appendix A, § 623, 113 Stat. 1501, 1501A-56 (1999).

PFMC means: The Pacific Fishery Management Council established by 16 U.S.C. § 1852.

PIT tag means: A means of marking fish with passive integrated transponders.

point of disagreement means: A disagreement over the interpretation or application of this Agreement.

PUB means: Pool Upriver Bright; artificially-produced bright fall Chinook salmon released in areas between Bonneville and McNary Dams.

PUD means: Public Utility District.

rebuilding means: Progress toward achieving an abundance of fish that meets the long-term natural production and harvest goals of the Parties.

RM means: A means of marking fish by clipping the right maxillary.

run means: An aggregate of one or more stocks of the same species migrating at a discrete time.

RV means: A means of marking fish by clipping the right ventral fish.

SAB means: Select Area Bright; artificially-produced bright fall Chinook salmon derived from a Rogue River stock.

sanctuary means: A specific location closed to fishing for the protection of certain fish populations that may be present.

SBT means: Shoshone-Bannock Tribes.

spawning escapement means: The number of fish arriving at a natal stream, river, or artificial production facility to spawn.

spawning escapement goal or **spawning objective** means: The numerical target for a given population, stock, or run of adult fish for artificial or natural production.

SR means: Snake River.

SRW means: Snake River Wild; natural-origin Snake River fall Chinook salmon, a component of upriver bright fall Chinook salmon.

stock means: An aggregation of fish spawning in a particular stream or lake during a particular season which to a substantial degree do not interbreed with any group spawning at a different time.

subbasin or **sub-basin** means: A geographic area upstream from Bonneville Dam containing-tributaries to the Columbia River mainstem or to the Snake River that produce anadromous fish.

subsistence fish means: Those fish caught by enrolled members of a federally-recognized Indian Tribe or the Wanapum Band for the personal consumption of tribal members, or their immediate family, or for trade, sale or barter to other Indians for their consumption, or for consumption at a tribally approved function for which no admission or other fee is charged.

subsistence gear, as applied to treaty Indians, means: Dipnet or bagnet, spear, gaff, club, fouling hook, hook and line or other methods as determined by the management entities.

supplementation means: The release of artificially propagated fish or fertilized eggs in streams to increase or establish natural spawning fish populations.

tributary means: Any portion of the Columbia River system other than the mainstem of the Columbia River.

unclipped fish means: Fish with all fins intact.

upper river or upriver means: The portion of the Columbia River and its tributaries upstream from Bonneville Dam.

URB means: Upriver bright fall Chinook salmon.

USACOE means: United States Army Corps of Engineers.

USFWS means: United States Fish and Wildlife Service, an agency of the United States Department of the Interior.

VIE means: Visible Implant Elastomer or Visual Implant Elastomer, a means of marking fish by injecting a small amount of colored or fluorescent material under the skin.

WDFW means: Washington Department of Fish and Wildlife.

YIN means: Yakama Nation.

YKFP means: the Yakima/Klickitat Fisheries Project that is the subject of a Memorandum of Understanding Between the Confederated Tribes and Bands of the Yakama Indian Nation and the State of Washington, dated May 19, 1994.

Zones 1-5 means: The statistical zones of the Columbia River commercial fishing area downstream from Bonneville Dam, as defined in Section 635-042-0001 of the Oregon Administrative Rules. Zones 1 through 5 encompass the Columbia River mainstem easterly of a line projected from the knuckle of the south jetty on the Oregon bank to the inshore end of the north jetty on the Washington bank, and westerly of a line projected from a deadline marker on the Oregon bank (approximately four miles downstream from Bonneville Dam Powerhouse 1) in a straight line through the western tip of Pierce Island, to a deadline marker on the Washington bank at Beacon Rock.

Zone 6 means: The statistical zone of the Columbia River treaty Indian commercial fishing area upstream from Bonneville Dam running from Bonneville to McNary Dams.

Appendix B. Competition and Predation from Juvenile Release Site to Columbia River Mouth

In our hatchery consultations and reviews, NMFS has long struggled with how to gauge the impacts of hatchery-origin juvenile salmonids in the Columbia River migration corridor and estuary as they interact with natural-origin salmon and steelhead. It stands to reason that there would be effects on natural-origin fish from predation and competitive interactions with hatchery juveniles, at least at the broad scale of assessing effects caused by all hatchery operations collectively, but detecting and measuring these effects is not possible without any reliable method to observe and monitor them. However, NMFS was not satisfied with discounting these effects and over the last six years we have been working to establish a model which would further our understanding in this regard. This is the PCD Risk model, described in more detail below. The model is still undergoing significant refinement, but even in its initial form NMFS believes that it contributes to the best available science.

We used the PCD Risk model (Pearsons and Busack 2012) to simulate predation and competition on natural-origin salmon and steelhead juveniles from all of the hatchery-origin juveniles included in the 2018 Management Agreement, from their release sites to the mouth of the Columbia River. Although these simulations should not be considered estimates of the actual predation and competition impact on natural-origin salmon and steelhead from hatchery-origin juveniles, they are useful in that they give an example of the magnitude of interactions that could occur under a certain set of assumptions. Many of these assumptions will need to be refined, but NMFS used the best data that it could obtain at the time the model was run.

It is important at the outset of this discussion to emphasize that the PCD Risk model is not by any means a total simulation of ecological interactions between hatchery and wild fish. Competition is dealt with in the model as a direct interaction between hatchery-origin and natural-origin fish; the model does not include the effects of density dependence on food availability, for example. The model also does not include predation or competition from other fish species such as bass or non-fish species such as piscivorous birds. It also does not account for the possible beneficial effects of juvenile hatchery-origin fish releases, mainly in the form of prey for natural-origin salmon and steelhead. Another limitation is that neither species grows during the simulation; in reality, of course, fish growth could greatly change competition dynamics and susceptibility to predation. Finally, and perhaps most relevant, PCD Risk runs are limited to evaluating interactions between one hatchery-origin species and one natural-origin species under specified conditions in a limited area over a limited time. The model was originally intended for evaluating effects in tributaries or independent streams with direct access to the ocean. Using it to model passage from upper Columbia tributaries required combining program-specific tributary runs over species and then doing additional runs for commingled groups (e.g., Snake spring/summer and upper Columbia spring Chinook salmon downstream of the Snake-Columbia confluence). This approach almost certainly biases modeled effects upward. Refinements to PCD are planned based on experiences with the model to improve simulation of effects in the migration corridor.

Simulated predation and competition interactions in PCD Risk must be interpreted very differently. Within the parameter values chosen and the mechanisms for interactions coded into the model, a predation event is an actual loss of a fish: the fish is removed from the simulated population. Competition events in the PCD model have quite different consequences than predation events. Whereas a predation event denotes a mortality, a competition event means that a fish does not eat for a day, and suffers some weight loss as a result. The same fish could suffer another competition event the next day, and possibly one each day of the interaction period. Thus at the end of a ten-day interaction period (set as the residence time parameter), a particular natural-origin fish could have sustained anywhere between 0 and 10 competitive interactions that will have resulted in weight loss. Ten interactions are expected to result in a weight loss of approximately 10- 15%. In reality, a weight loss of this magnitude is unlikely to directly result in death, but could result in increased susceptibility to disease (Pearsons and Busack 2012), or perhaps to further interactions, neither of which mechanism is included in the model. The model reports instead, "competition equivalent" deaths, which are computed as how many fish would die if the cumulative weight loss of all the natural-origin fish due to competitive interactions were concentrated into individual fish to reach lethal levels (typically programmed at 50% weight loss). In other words, if an individual fish suffering 20 competitive interactions dies from weight loss, than if 5,000 total competitive interactions occurred in a run of the model, this would result in 250 competition equivalent deaths, even if no fish in the simulation truly suffered 20 interactions. Detailed analysis of model runs done for this consultation have revealed that even with substantial time periods over which for interactions to occur, a substantial proportion of fish may not suffer any competitive "hits," and maximally affected fish suffer only a few. However, because we believe that the model underestimates the effects of competition, we aggregated the competitive interactions so that they all happened on the same natural-origin fish until that fish died (i.e., competition equivalent deaths). Although this is not a realistic scenario in the natural environment, it allowed us to put an upper bounds on potential mortalities.

The current version of this program (version 2.3) is a 2017 modification by Busack of the original described in (Pearsons and Busack 2012). The modification was done to increase ease of use, reliability, supportability, and expandability. The current version lacks two operational prominent operational features of the original: disease effects and probabilistic output. The calculation of disease effects in the original version was deleted for the time being upon the advice of fish-disease experts who felt that the disease effects modeling was uninformative. We expect to restore the disease function in the near future. We also expect to restore the probabilistic feature in the near future[26].

Parameter values used across multiple model runs are shown in Table B - 1 and Table B - 2. Hatchery program specific parameter values are detailed in Table B - 5 and (NMFS 2017a). For our model runs, we assumed a 100% population overlap between hatchery-origin fish and all natural-origin listed species present. However, because our analysis is focused on assessing effects on ESA listed species, we wanted to limit overlap for each species to areas where listed species are present. Therefore, we modified residence/travel times for hatchery juveniles if they did not overlap completely with certain natural-origin species (Table B - 3). For example, the Snake River fall-run Chinook salmon ESU do not inhabit the Upper Columbia River (UCR) above the Snake River confluence. Thus, effects on the Snake River fall-run Chinook salmon ESU from hatchery releases in the Upper Columbia River would not occur until they commingled in the mainstem Columbia River below the Snake River confluence. We believed it was better to address overlap by adjusting residence time than by adjusting population overlap because the population overlap parameter represents microhabitat overlap, not basinwide-scale

[26] In the meantime, probabilistic output can be obtained with the current version by multiple runs of the model in which the parameters of interest are varied.

overlap. We acknowledge that a 100% population overlap in microhabitats likely overestimates effects.

Model runs were divided into various segments, depending on available data and release location. Thus, we conducted model runs for individual programs from release location to McNary Dam for those programs above McNary Dam and to Bonneville Dam for those programs releasing fish below McNary Dam. We retained three separate groupings (Upper Columbia River, Snake River, and Mid-Columbia River) for aggregate model runs for each species, run, and lifestage for analyzing effects down to the mouth of the Columbia River (Figure B - 1). For example, the effects of all fish from the Snake River that survived to McNary Dam were then assessed down to Bonneville Dam, and then from Bonneville Dam to the mouth of the Columbia River. These breaks in the model runs were important for two reasons. First, for the Snake River aggregates, we needed to add in fish that were barged from the Snake River and released below Bonneville Dam (for steelhead, spring/summer Chinook salmon, and some coho only). Second, there are no PIT tag data that would allow us to estimate survival of hatchery fish below Bonneville Dam; therefore, we assumed survival for all hatchery-origin fish in the reach to be 100%. This, again, overestimates effects when the model is run.

Table B - 1. Parameters from the PCD Risk model that are the same across all programs.

Parameter	Value
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation[1]	0.3 for intraspecific pairings; 0.6 for interspecific pairings
Dominance mode	3
Piscivory rate[1]	0.002 for yearling Chinook salmon on Chinook salmon, sockeye, coho, chum 0.0023 for steelhead on Chinook salmon, sockeye, coho, chum 0.0189 for coho on Chinook salmon, sockeye, coho, chum
Maximum encounters per day	3
Predator:prey length ratio for predation[2]	0.25

[1] Values from HETT (2014).
[2] Daly et al. (2014).

Table B - 2. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery-origin fish after release; cv = coefficient of variation.

Species	**Age Class**	**Mean length in mm (cv)**		
		Upper Columbia	**Snake River**	**Mid-Columbia**
Chinook salmon	0	38 (0.18)	55 (0.18)	62 (0.15)
	1	98 (0.13)	91 (0.13)	89 (0.15)
Steelhead	1	112 (0.14)	71 (0.14)	96 (0.22)
	2	164 (0.23)	128 (0.23)	178 (0.1)
Sockeye salmon	1	86 (0.08)	86 (0.08)	86 (0.08)
	2	128 (0.06)	128 (0.06)	128 (0.06)
Coho salmon	2	90 (0.22)	90 (0.22)	90 (0.22)
Chum salmon	0	40 (0.08)	40 (0.08)	40 (0.08)

Sources: HETT (2014) for sockeye and upper Columbia values; Hillson et al. (2017) for chum salmon; Simpson (2017) for mid-Columbia values and coho salmon; Young (2017d) for Snake River values.

Table B - 3. Model run adjustments to account for presence/absence of listed species in specific areas within the action area.

Species	**Run Caveats**
Chinook salmon	No listed Chinook salmon are present in mid-Columbia watersheds
	No listed age-0 Chinook salmon are expected in mainstem upper Columbia
Steelhead	No age-1 steelhead are anticipated to be present in mainstem Columbia or Snake Rivers; steelhead predominantly migrate out as age-2 smolts (Busby et al. 1996).
Sockeye salmon	No listed sockeye in upper Columbia watersheds
	No listed sockeye in mid-Columbia watersheds
Coho salmon	No listed coho above Hood River confluence with Columbia River
Chum salmon	No listed chum above Hood River confluence with Columbia River
	Chum fry have largely left freshwater by early June

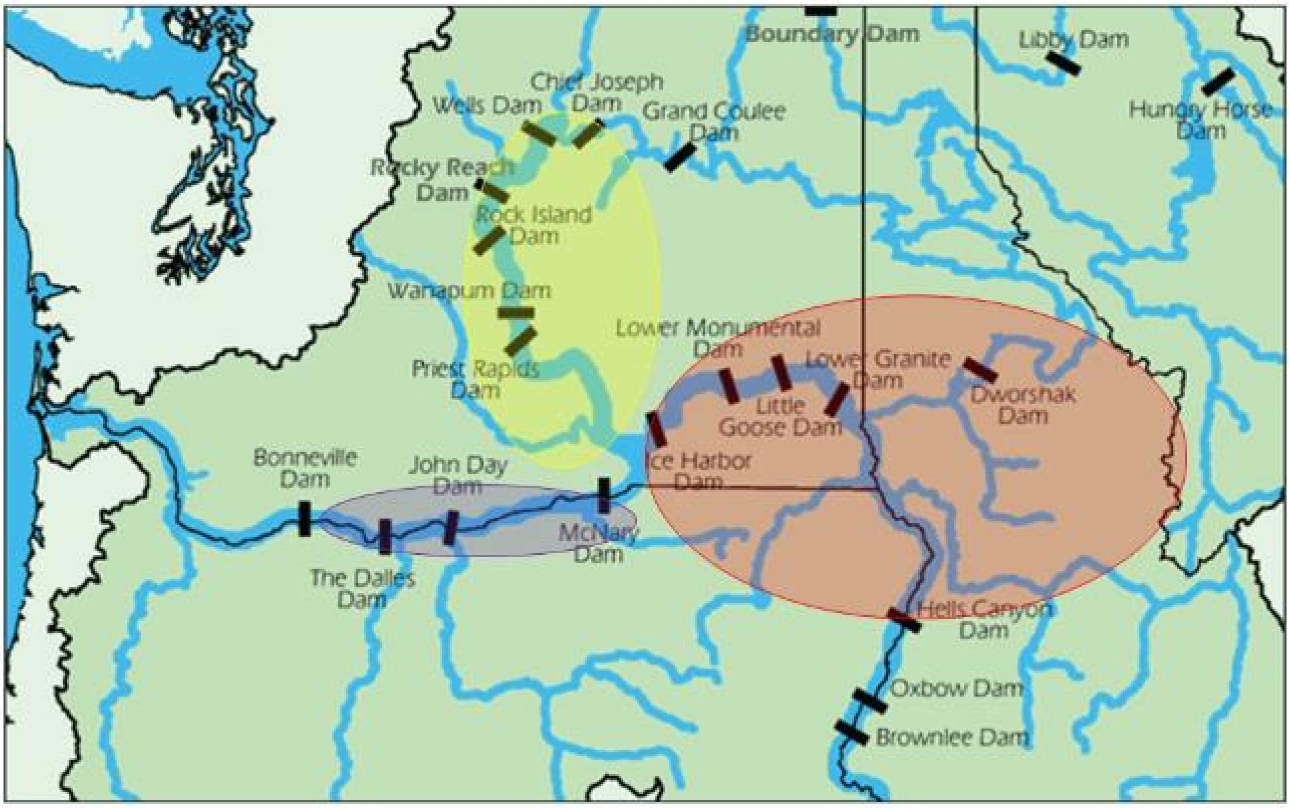

Figure B - 1. Hydropower project in the Columbia River Basin. The orange circle defines approximate area of programs included in the Snake River aggregate runs, yellow circle represents Upper Columbia River, and purple circle represents mid-Columbia River aggregate runs.

In the absence of data on natural-origin fish abundance, we model that number at a level where all possible hatchery-origin fish interactions are exhausted at the end of each day. This allows us to estimate worst-case impacts on listed natural-origin fish. However, it is likely that in doing this, we ran the models with natural-origin juvenile abundances that exceed actual numbers available. The exception to this is for sockeye salmon because we have data for natural-origin abundance for the one population that composes the entire ESU that demonstrates that, from 2006-2016, the maximum number of natural-origin sockeye salmon produced was ~61,000. Thus, we used this value in the model along with the actual proportions of each age-class (87% age-1, and 13% age-2) available (Kozfkay 2017).

Because listed Chinook salmon outmigrants occur as both subyearlings and yearlings, we first need to separate the adult equivalents into these two categories before applying the ESU proportions. For our runs, it is likely that the UCR programs would mostly interact with UCR ESUs and programs originating in the Snake River Basin would mostly interact with listed fish in Snake River Basin ESUs. Thus, we summed the effects of every program in each region and assumed that effects down to McNary Dam were only on their respective ESUs. Furthermore, we divided the number of natural-origin fish lost from Snake River programs down to McNary Dam by the percentages of listed, wild, subyearlings and yearlings estimated at McNary Dam to allocate "hits" between Snake River spring/summer-run and fall-run Chinook salmon ESUs

(Table 7a in Zabel 2013; Zabel 2014a; 2014b; 2015; 2017).

To allocate potential "hits" on natural-origin Chinook salmon between McNary and the mouth of the Columbia, we first needed to determine the proportions of subyearlings versus yearlings. At Tongue Point, 27% of listed Chinook salmon juveniles are likely to be yearlings, while 73% of listed Chinook salmon juveniles are likely to be subyearlings (Table 7a in Zabel 2013; Zabel 2014a; 2014b; 2015; 2017). This equates to an upper bounds of about 1,053 adult equivalents from ESUs with listed yearlings and an upper bounds 3,343 adult equivalents from ESUs with listed subyearlings. We then used estimates of the proportion of each listed ESU present in juvenile outmigrants captured at Tongue Point, and applied these values to the adult equivalents we calculated based on SAR.

To allocate potential "hits" for each listed steelhead DPS, we took a similar approach as we did for Chinook salmon. For impacts down to McNary, we assumed that the UCR programs and Snake River program effects were limited to the DPSs in their respective areas. From McNary Dam to the mouth of the Columbia River, we used the proportions of each DPS estimated from 2012-2016 at Tongue Point to determine loss attributable to each DPS (taking the average of values from 2012 through 2016; Table 9 of: Zabel 2013; 2014a; 2014b; 2015; 2017).

The sockeye salmon impacts based in our simulations are all likely to be listed Snake River sockeye salmon. This is because we calibrated the natural-origin juvenile numbers to the actual number of listed Snake River sockeye salmon measured from this ESU. This is easier to do when considering the ESU consists of a single population that spawns and rears in an area that is geographically separated from other non-listed sockeye ESUs.

For both chum and coho salmon, there is only a single ESU in the Columbia River Basin (i.e., Columbia River Chum Salmon ESU and Lower Columbia River Coho Salmon ESU), so we did not need to allocate potential impacts among listed ESUs of the same species.

The results of our model simulations are found in Table B - 4. Again, these results should not be considered estimates of the actual predation and competition impact on natural-origin salmon and steelhead from hatchery-origin juveniles because, as described earlier, the PCD Risk model is not a total simulation of ecological interactions between hatchery and wild fish. Nonetheless, they are useful in that they give an example of the magnitude of interactions that could occur under a certain set of assumptions. Based on these simulations, it appears that ecological impacts from the release of hatchery-origin fish included in the Management Agreement may be greatest on the Snake River spring/summer-run Chinook Salmon ESU, Lower Columbia River Chinook Salmon ESU, Lower Columbia River Coho Salmon ESU, and Snake River Steelhead DPS. Most of the ecological effects on natural-origin ESA-listed salmon and steelhead occurred via competition. Our model runs did not result in any predation on Snake River, Upper Columbia, Middle Columbia or Lower Columbia Steelhead DPSs or the Snake River Sockeye ESU.

NMFS used the best data that it could obtain at the time the model was run, but we will continue to refine these parameters. In addition, we will continue to monitor median travel times from Lower Granite Dam to McNary Dam, and Rocky Reach Dam to McNary Dam on an annual basis (using a five-year rolling median) compared to the values used in our analyses to ensure the effects of competition and predation are consistent with our model simulations.

Table B - 4. Simulated natural-origin adult equivalents (AE's) mortalities when PCD Risk model was run under the assumptions outlined in this appendix. For Chinook, coho, and chum salmon minima were calculated as total simulated AEs lost expected to be predation losses.

Species (ESU/DPS)		Modeled Lost AEs to McNary Dam	Modeled Lost AEs from McNary Dam to Tongue Point	Total Lost AEs
Chinook Salmon	Snake River spring/summer-run	379-3,004	6-274	385-3,278
	Snake River fall-run	16-125	3-134	19-259
	Upper Columbia River spring-run	65-513[1]	0-13[2]	65-526
	Lower Columbia River	0	71-3,556	71-3,556
	Upper Willamette River	0	8-379	8-379
Steelhead	Snake River Basin	0-2,612	0-577	0-3,189
	Upper Columbia River	0-700	0-74	0-774
	Mid-Columbia River	0	0-233	0-233
	Lower Columbia River	0	0-233	0-233
	Upper Willamette River	0	0-111	0-111
Snake River Sockeye Salmon		0-118	0-38	0-156
Columbia River Chum Salmon		0	135-902	135-902
Lower Columbia River Coho Salmon		0	104-3,467	104-3,467

[1] We accounted for effects to the ESA-listed UCR spring-run Chinook Salmon ESU from our model by applying the total Chinook salmon adult equivalents reaching to McNary Dam from the UCR by the ratio of UCR spring Chinook salmon to UCR River summer Chinook salmon. This was calculated by summing the average total return (hatchery and natural) of UCR spring Chinook salmon (Table 8 of ODFW and WDFW 2016) and the total return of UCR summer Chinook salmon (Table 10 of ODFW and WDFW 2016) from 2011-2015, and then dividing the total UCR spring Chinook salmon return into this sum. We then applied this average proportion (0.24) of UCR spring Chinook salmon to the total number of UCR Chinook salmon adult equivalents estimated to be lost from our modeled analysis (2,137).

[2] We also applied the ratio of ESA-listed UCR spring Chinook salmon to UCR summer Chinook salmon (0.24) here to the total number of UCR Chinook salmon adult equivalents estimated to be lost from our model analysis (53).

Table B - 5. Data caveats and sources for the PCD Risk ecological analysis.

Biological Opinion	Program/Program Component	Species	Data Provided	Data Caveats	Reference to data sources
Wenatchee	Chiwawa	Spring Chinook Salmon	Survival and travel to MCN	2010-2014 data; median of median for travel; mean of mean for survival	Willard (2017a; 2017b)
	Nason Creek				
	Nason Creek	Steelhead		Size Data Source: HETT 2014; Temp from HETT	Willard (2017d; 2017c)
Entiat	Entiat	Summer Chinook Salmon	Survival and travel to MCN	Data for 2011-2016; median of median for travel; mean of mean for survival	Fraser (2017a; 2017b)
Leavenworth	Leavenworth	Spring Chinook Salmon	Survival and travel to MCN	To MCN - FPC report: travel time median of median; survival mean of mean. Travel to mouth of Wenatchee is from HETT; size data are from HETT (2014) for Wenatchee	Chockley (2017)
Methow[1]	Winthrop National Fish Hatchery (WNFW)	Spring Chinook Salmon	Travel and survival from release to Columbia River juvenile detection sites and for juveniles through Columbia River Reaches (multiple ones), respectively	Release year 2012-2016; median of median for travel; mean of mean for survival	Humling (2017)
	Methow		Survival and travel to MCN and Bonneville	BY 2010-2014; median of median for travel; mean of mean for survival	Snow (2017)
Snake River Fall Chinook Salmon[2]	Nez Perce Tribal Hatchery (NPTH) / Idaho Power Company (IPC)	Fall Chinook Salmon	Survival and travel time to LGD	No age 1 steelhead at release site RM 247 (and no age 1 steelhead in mainstem Snake River model runs); Some data was reported in	Bumgarner (2017b); Young (2017c)

	Fall Chinook Salmon acclimation			means where medians were n/a (i.e., Clearwater River subyearling releases (RM 11.8-N. Lapwai Valley) for travel and survival to LGD))	
	Lyons Ferry			Some of these data have noted that the closest dam is Lower Monumental (LOMO) so data is to there and the fish were aggregated below Lower Granite Dam (LGD)	
Snake River Sockeye	Snake Sockeye (Redfish Lake Creek release)	Sockeye	Survival and travel time to LGD	Travel time is reported in means (as a 5 year average) because medians were n/a; assume age 0-sockeye are largely present only in Lake- above smolt release site; FPC report is data source for LGD-MCN reach; Temp data for model is based on furthest gauge upstream in Salmon : 13296000 Yankee Fork; using different temp (10.5) for MCN run; size data are from: Snake River data sources, HETT (2014) for sockeye	Johnson (2017)
Mitchell Act	Washougal	Coho	Survival and travel to Bonneville	Umatilla coho used as surrogate for travel/survival- but data was for survival and travel time to John Day Dam (JDD)	Clarke (2017)
	Klickitat	Spring Chinook Salmon		Data years: 2007-2017; median of raw data	Zendt (2017a; 2017b)
		Fall Chinook Salmon		Umatilla subyearling fall Chinook salmon used as surrogate for Travel/Survival	

		Steelhead (Skamania)		Data years: 2010-2017; median of raw data	
		Coho		Umatilla coho used as surrogate for travel/survival- but data was for survival and travel time to JDD	Clarke (2017)
	Ringold	Steelhead	Survival and travel to MCN	Wells Hatchery steelhead as surrogate for travel time/ survival- data is for priest rapids to MCN	NMFS (2017k)
	Eagle Creek	Coho	Survival and travel to Ice Harbor Dam (ICE) and LGD	Clear Creek: only 1 year of data (2016 migratory year) so travel time is that single median, and survival is that single mean (for both ICE and LGD data); Lapwai: travel time for ICE and LGD is median of median for 2013, 2014, 2015, 2016 migratory years, and survival is mean of means for same years.	Young (2017b; 2017a)
	Cascade			Only 1 year (Migratory year 2017 data) of data so the data point is just a single median for both survival and travel time to ICE and LGD	
Wenatchee Methow	Wenatchee Methow	Coho	Travel and survival to MCN	median of median for travel, mean of mean for survival	Kamphaus (2017)
Yakima	Yakima	Coho (smolts and parr)	Survival to MCN	Dave Lind spreadsheet in e-mail from Rich, used travel time from Easton, but average survivals (for smolts); Travel time to McNary for integrated parr: from Prosser to MCN once Parr start migrating based on raw PIT tag data from	Lind (2017b)

				Todd Newsome to Rich for 2014-2016	
		Spring Chinook Salmon		Survival for spring Chinook, fall Chinook, and summer Chinook salmon is from David Lind email/pdf, travel time for spring Chinook salmon is from David Lind email/pdf	Lind (2017a)
		Fall Chinook Salmon (subyearlings and yearlings)	Travel rate from Umatilla Chinook salmon	Travel for fall and summer Chinook salmon were Umatilla surrogates	
		Summer Chinook Salmon			
USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River	Carson NFH Spring Chinook Salmon	Spring Chinook Salmon	Survival estimates of PIT tagged yearling spring Chinook salmon released from Carson National Fish Hatchery to Bonneville Dam	Survival is Haeseker and Brignon USFWS preliminary unpublished data for PTES study; mean size of hatchery fish from Dammerman report (Mitchell Act report)	Dammerman et al. (2017); Olson (2017)
	Willard NFH	Upriver Bright Fall Chinook Salmon	Survival and travel to Bonneville	Mean size of hatchery fish from Dammerman report (Mitchell Act report)	Dammerman (2016); Dammerman et al. (2017)
	Spring Creek	Tule Fall Chinook Salmon		Travel time expressed as a mean of a mean	Dammerman et al. (2016)
	Warm Springs Hatchery	Spring Chinook Salmon (juvenile)		N/A	Davis et al. (2016)
	Little White Salmon NFH	Spring Chinook Salmon	Summaries of the 2014 outmigration for USFWS hatcheries of	Mean size of hatchery fish from Dammerman report (Mitchell Act report)	Chockley (2015);

			the Columbia Gorge Complex: (1) juvenile timing to Bonneville Dam (BON), (2) juvenile fish travel time to BON, and (3) estimates of smolt-to-adult return rates (SARs) from release to BON.		Dammerman et al. (2017)
Umatilla River	Umatilla River	Coho	Travel time from Three Mile Falls Dam to John Day Dam for PIT tagged juvenile hatchery coho salmon, 2001–2017; Estimated survival probability from Three Mile Falls Dam to John Day Dam for PIT tagged juvenile hatchery coho salmon, 2001–2017.	Mean of mean for travel to John Day; for Travel from JDD to Bonneville (median): from Faulkner estimates. Used same values for all species/runs because only steelhead and yearling Chinook salmon were available. Run with temp at JDD	Hanson (2017)
		Chinook salmon (spring and fall)	Travel time to JDD (Days) (RY 2012-2016)		Clarke (2017)
NEOR/SEWA[3]	Lookingglass, Tucannon, Lostine, Grande Ronde, Catherine Creek, Imnaha	Spring Chinook Salmon	Mean %age survival to LGD; Survival and travel to LOMO and MCN	Mean of mean survival to LGD (for Tucannon); Assume survival is same to ICH as it is for LOMO, which was the value provided by Joseph Feldhaus (WDFW);	Bumgarner (2017a); Feldhaus (2017)
US *vs* OR 2018 Opinion: aggregated runs: McNary to	various programs	Snake River spring/summer Chinook salmon, fall-run	Travel and survival throughout Columbia River Basin	Source provided information on reaches that we then used at times when we didn't already	DeHart (2017)

Bonneville and Bonneville to estuary[4]		Chinook salmon, steelhead, sockeye, coho, and Upper Columbia River spring-run Chinook salmon, summer Chinook salmon, steelhead, and coho salmon (2012-2016) from LGD to MCN (for Snake River) and from UCR to MCN		have individual information for those areas	
		Spring Chinook salmon and steelhead	Survival estimates for spring Chinook salmon and steelhead through Snake and Columbia River Dams, 2011, 2012, 2013, 2014, 2015		Faulkner et al. (2012); Faulkner et al. (2013a); Faulkner et al. (2013b; 2015); Faulkner et al. (2016b)
Okanogan	WNFH	Spring Chinook Salmon	see data column	See completed Biological Opinion; data from DeHart memo used for model run from Rocky Reach to McNary, further aggregated to estuary.	NMFS (2014c); DeHart (2017)
	Wells	Steelhead			
	Chief Joseph	Summer Chinook Salmon			

		(yearlings and subyearlings)			
Methow	Winthrop Wells Complex	Steelhead	see data column	See completed Biological Opinion; data from Methow Steelhead Opinion used for run from Priest Rapid to McNary, then further aggregated to estuary.	NMFS (2016e)
Middle Columbia River	Touchet Umatilla	Steelhead	see data column	See completed Biological Opinion; model runs were from release to Bonneville; aggregate runs from below Bonneville to estuary	NMFS (2017f)
	Walla Walla Round Butte	Spring Chinook Salmon			
Clearwater River Basin	Kooskia NFH	Spring Chinook Salmon	see data column	See completed Biological Opinion; runs using extrapolated data from Ice Harbor to MCN, aggregate run from MCN to estuary	NMFS (2017p)
	Clearwater Fish Hatchery (CFH)	Spring/Summer Chinook Salmon			
	NPTH	Spring/Summer Chinook Salmon			
	Dworshak NFH	Spring Chinook Salmon			
	Clearwater River coho (at DNFH and KNFH)	Coho			
Snake River Steelhead Hatchery Programs[5]	Steelhead Streamside Incubator (SSI) Project DNFH B-Index Steelhead East Fork Salmon Natural A-Index Steelhead	Steelhead	see data column	See completed Biological Opinion; runs using extrapolated data from Ice Harbor to MCN, aggregate run from MCN to estuary	NMFS (2017q)

	Hells Canyon Snake River A-Index Summer Steelhead				
	Little Salmon River A-Index Summer Steelhead				
	South Fork Clearwater (Clearwater Hatchery) B-Index Steelhead				
	Salmon River B-Index				
Snake River Basin	Rapid River	Spring Chinook Salmon	see data column	See completed Biological Opinion; runs using extrapolated data from Ice Harbor to MCN, aggregate run from MCN to estuary	NMFS (2017o)
	Hells Canyon				
	South Fork Salmon River (SFSR)	Summer Chinook Salmon			
	Johnson Creek Artificial Propagation and Enhancement Project				
	South Fork Chinook Eggbox Project				
Upper Columbia River Basin	Chelan Falls	Summer/Fall Chinook Salmon	see data column	See completed Biological Opinion	NMFS and USACE (2017)
	Wenatchee				
	Methow				
	Wells				
	Priest Rapids	Fall Chinook			
	Ringold Springs				
Upper Salmon River Basin	Yankee Fork	Spring Chinook Salmon	see data column	See completed Biological Opinion; runs using extrapolated data from	NMFS (2017d)

	Panther Creek	Summer Chinook Salmon		Ice Harbor to MCN, aggregate run from MCN to estuary	
	Upper Salmon River (Sawtooth)	Spring Chinook Salmon			
	Pahsimeroi	Summer Chinook Salmon			
Hood River	Hood River	Spring Chinook Salmon	see data column	See completed Biological Opinion; runs using extrapolated data from Bonneville to estuary	NMFS (2017e)
		Winter Steelhead			
Little White Salmon National Fish Hatchery	Little White Salmon NFH	Upriver Bright Fall Chinook Salmon	see data column	See completed Biological Opinion	NMFS (2017l)

Appendix C. Factors Considered When Analyzing Hatchery Effects

NMFS' analyses the potential effects of an action on ESA-listed species and designated critical habitat based on the best scientific information available. The effects, positive and negative, for two categories of hatchery programs are summarized in Table C - 1. Generally speaking, effects range from beneficial to negative when programs use local fish[27] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[28]. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Analysis of a Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. These factors are:

(1) the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,
(4) RM&E that exists because of the hatchery program,
(5) operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(6) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The analysis assigns an effect for each factor from the following categories:

(1) positive or beneficial effect on population viability,
(2) negligible effect on population viability, and
(3) negative effect on population viability.

The effects of hatchery fish on ESU/DPS status will depend on which of the four VSP criteria are currently limiting the ESU/DPS and how the hatchery program affects each of the criteria (NMFS 2005d). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population's current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

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[27] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[28] Exceptions include restoring extirpated populations and gene banks.

Table C - 1. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004b).	**Negligible to negative effect** Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects.	**Negligible to negative effect** Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	**Negligible to negative effect** Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).

Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

This factor considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The level of effect for this factor ranges from neutral or negligible to negative.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population tapped to provide hatchery broodstock. “Mining” a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program “backfills” with fish from outside the local or immediate area. The physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species is considered under Factor 2.

Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning gournds and encounters with natural-origin and hatchery fish at adult collection facilities

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. The level of effect for this factor ranges from positive to negative.

There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations based on the weight of available scientific information at this time. Hatchery fish can thus pose a risk to diversity and to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that beneficial effects exist as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011).

NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d).

2.1 **Genetic effects**

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risks.

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). Two is when N_e is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman and Laikre 1991; Ryman et al. 1995), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Fiumera et al. 2004; Busack and Knudsen 2007).

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects, the second major area of genetic effects of hatchery programs, are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Grant 1997; Quinn 1997; Jonsson et al. 2003; Goodman 2005), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g.(Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish (pHOS)[29] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Saisa et al. 2003; Blankenship et al. 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These

[29] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.

differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-influenced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). For an individual, the amount of time a fish spend in the hatchery mostly equates to fish culture. For a population, exposure is determined by the proportion of natural-origin fish in the hatchery broodstock, the proportion of natural spawners consisting of hatchery-origin fish (Lynch and O'Hely 2001; Ford 2002), and the number of years the exposure takes place. In assessing risk or determining impact, all three factors must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., Berntson et al. 2011; Theriault et al. 2011; Ford et al. 2012; Hess et al. 2012). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[30]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure C - 1).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by(Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[31]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5% for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004)offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

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[30] Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish. In other words, all will contribute to the natural-origin gene pool.

[31] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence, but operationally the distinction is unimportant.

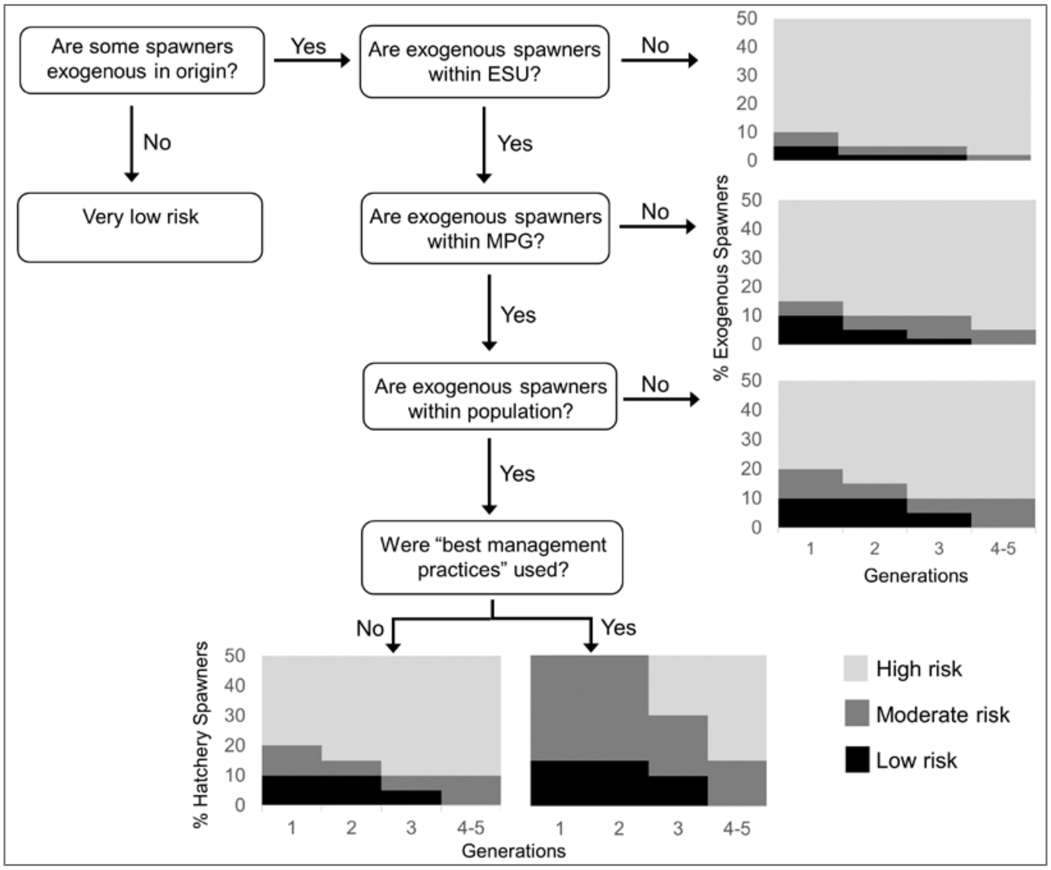

Figure C - 1. ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish hatchery-origin, and non-normative strays of natural-origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5%. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity." They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose demographic risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with "the proportion of the natural spawning population that is made up of hatchery fish" in the Conclusion, Principles and Recommendations section (HSRG 2009), but with "the proportion of *effective* hatchery-origin spawners" in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (Appendix C in HSRG 2009) they introduce a new term, *effective pHOS* ($pHOS_{eff}$) defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference the HSRG defined *effective* pHOS as:

$$pHOS_{eff} = RRS * pHOS_{census}$$

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014). In the 2014 report, the HSRG explicitly addressed the differences between *census* pHOS and *effective* pHOS, by defining PNI as:

$$PNI = \frac{pNOB}{(pNOB + pHOS_{eff})}$$

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the "effective" pNOB might be much lower than the census pNOB.

It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure C - 2 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[32]. For example, at a census pHOS level of 10%, 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases; with no overlap, the proportion of NxN matings is 1 minus pHOS and the proportion of HxH matings equals pHOS. RRS does not affect the mating type proportions directly but changes their effective proportions. Overlap and RRS can be related. For example, in the Wenatchee River, hatchery spring Chinook salmon tend to spawn lower in the system than natural-origin fish, and this accounts for a considerable amount of their lowered reproductive success (Williamson et al. 2010). In that particular situation the hatchery-origin fish were spawning in inferior habitat.

[32] These computations are purely theoretical, based on a simple mathematical binomial expansion ($(a+b)^2=a^2 + 2ab + b^2$).

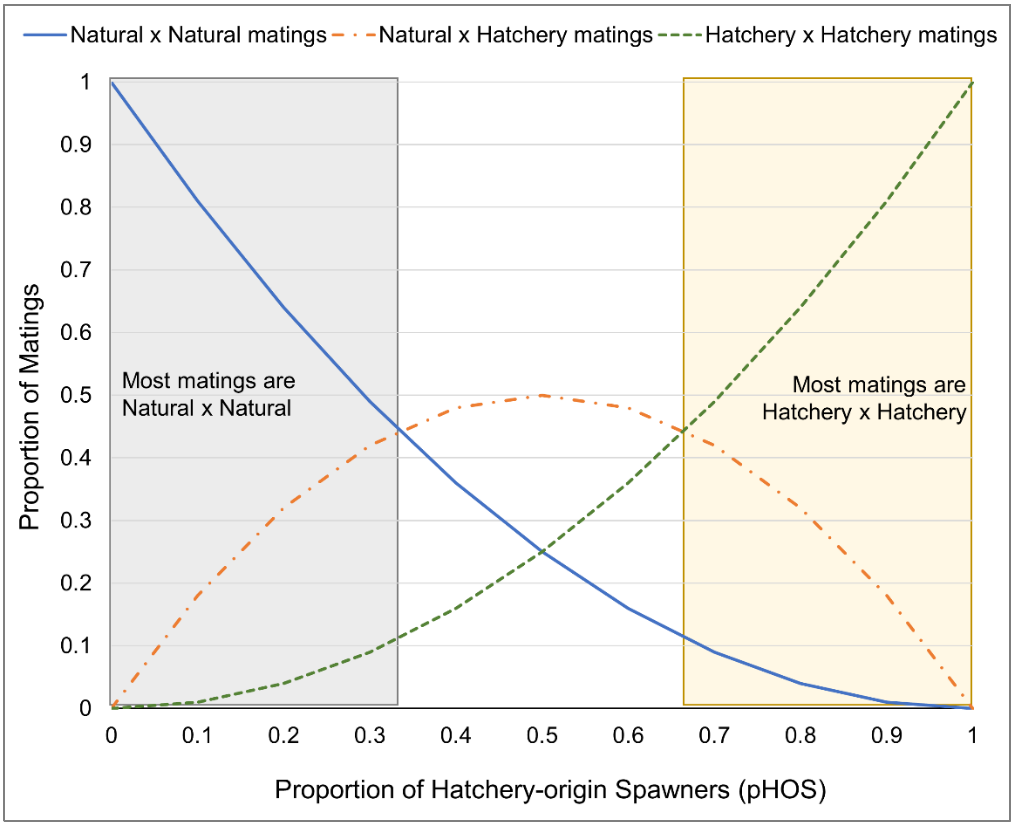

Figure C - 2. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

2.2 **Ecological effects**

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Gresh et al. 2000; Murota 2003; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976; Bilton et al. 1982; Holtby 1988; Ward and Slaney 1988; Hartman and Scrivener 1990; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., (Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences at times. In particular, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species when there is spatial overlap between hatchery and natural spawners. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

2.3 **Adult Collection Facilities**

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally, on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary, and ocean

NMFS also analyzes the potential for competition and predation when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. The level of effect for this factor ranges from neutral or negligible to negative.

3.1 **Competition**

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors. However, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature outmigration by natural-origin juvenile salmonids. Pearsons et al. (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas in the vicinity of hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012)
- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by naturally produced juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[33] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

3.2 **Predation**

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish

[33] "Action area" means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

(Rensel et al. 1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas at the time. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (Rensel et al. 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (Pearsons and Fritts 1999; HSRG 2004), but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted,

limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

3.3 **Disease**

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou virus* (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990; Naish et al. 2008). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

Adherence to a number of state, Federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; NWIFC and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, Federal and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

3.4 **Acclimation**

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Quinn 1997; Dunnigan 1999; YKFP 2008).

(Dittman and Quinn 2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Hoar 1976; Beckman et al. 2000). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Fulton and Pearson 1981; Quinn 1997; Hard and Heard 1999; Bentzen et al. 2001; Kostow 2009; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Kenaston et al. 2001; Clarke et al. 2011).

Having hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. By having the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of homing include:

- The timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.

Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

- Observation during surveying
- Collecting and handling (purposeful or inadvertent)
- Holding the fish in captivity, sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

4.1 **Observing/Harassing**

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish, which are more sensitive to disturbance. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors. Redds may be visually inspected, but would not be walked on.

4.2 **Capturing/handling**

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels because stress can be immediately debilitating, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly.

4.3 **Fin clipping and tagging**

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied, but fin clips do not generally alter fish growth (Brynildson and Brynildson 1967; Gjerde and Refstie 1988). Mortality among fin-clipped fish is variable, but can be as high as 80% (Nicola and Cordone 1973). In some cases, though, no significant difference in mortality was found between clipped and un-clipped fish (Gjerde and Refstie 1988; Vincent-Lang 1993). The mortality rate typically depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that have clipped pectoral, dorsal, or anal fins (Nicola and Cordone 1973), probably because the adipose and pelvic fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). However, some work has shown that fish without an adipose fin may have a more difficult time swimming through turbulent water (Reimchen and Temple 2003; Buckland-Nicks et al. 2011).

In addition to fin clipping, PIT tags and CWTs are included in the proposed action. PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled, so it is critical that researchers ensure that the operations take place in the safest possible manner. Tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery holding tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice and Park 1984; Prentice et al. 1987; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3% and was at times as high as 33.3%.

Coded-wire tags are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

Mortality from tagging is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release—it can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000c; 2008a) that have been incorporated as terms and conditions into section 7 opinions and Section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by the (Galbreath et al. 2008).

The effects of these actions should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties concerning effects on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agency(s) NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the proposed action mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses RM&E and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

Factor 5. Construction, operation, and maintenance of facilities that exist because of the hatchery program

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. The level of effect for this factor ranges from neutral or negligible to negative.

Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of the proposed action in a section 7 consultation. One is where there are fisheries that exist because of the HGMP that describes the proposed action (i.e., the fishery is an interrelated and interdependent action), and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally. The level of effect for this factor ranges from neutral or negligible to negative.

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty

> obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under Section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005d).

In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.