Final

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

Ringold Springs Upriver Bright Fall Chinook Salmon Hatchery Program

NMFS Consultation Number: WCRO-2019-04027

Federal Action Agency: U.S. Army Corps of Engineers (Corps)

Affected Species and Determinations:

ESA-Listed Species	Status	Is the Action Likely to Adversely Affect Species or Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Chinook salmon *(Oncorhynchus tshawytscha)*				
Upper Columbia River Spring	Endangered	Yes	No	No
Snake River Spring/Summer	Threatened	Yes	No	No
Snake River Fall	Threatened	Yes	No	No
Lower Columbia River	Threatened	Yes	No	No
Upper Willamette River Spring	Threatened	Yes	No	No
Steelhead *(O. mykiss)*				
Upper Columbia River	Threatened	Yes	No	No
Snake River	Threatened	Yes	No	No
Middle Columbia River	Threatened	Yes	No	No
Lower Columbia River	Threatened	Yes	No	No
Upper Willamette River	Threatened	Yes	No	No
Sockeye salmon *(O. nerka)*				
Snake River	Endangered	Yes	No	No
Chum salmon *(O. keta)*				
Columbia River	Threatened	No	No	No
Coho salmon *(O. kisutch)*				
Lower Columbia River	Threatened	No	No	No
Killer whales *(Orcinus orca)*				
Southern Resident	Endangered	No	No	No
Green sturgeon *(Acipenser medirostris)*				
Southern Distinct Population Segment	Threatened	No	No	No

ESA-Listed Species	Status	Is the Action Likely to Adversely Affect Species or Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Pacific eulachon *(Thaleichthys pacificus)*				
Southern Distinct Population Segment	Threatened	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does the Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	No

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

Issued By: PURCELL.ALLYSON.O.1365850964 Digitally signed by PURCELL.ALLYSON.O.1365850964 Date: 2020.06.26 14:35:46 -07'00'

For Ryan J. Wulff
Assistant Regional Administrator
Sustainable Fisheries Division

Date: 6/26/2020

Table of Contents

Table of Tables

Table of Figures

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.

The Proposed Federal Action in this opinion consists of the U.S. Army Corps of Engineers (Corps) funding of the operation the Ringold Springs Upriver Bright (URB) Fall Chinook Salmon Program and the expansion of the Ringold Springs Hatchery (RSH) of as part of the John Day Mitigation (JDM) program (see Section 1.3 for details). The RSH facility is operated by the Washington Department of Fish and Wildlife (WDFW) and rears and releases URB fall Chinook salmon into the Columbia River within the Hanford Reach area of Washington State. The details of the URB fall Chinook hatchery program are summarized in Section 1.3 of this biological opinion based on a Hatchery and Genetic Management Plan (HGMP) (USACE and WDFW 2019), along with the Biological Assessment (BA) (USACE 2019) – which also describes construction activities related to the expansion of the hatchery; both documents were submitted to NMFS for review as part of this evaluation.

The HGMP was updated to include post-construction and expansion operations at the RSH, which is intended to increase production of sub-yearling fall Chinook for the JDM program from 3.5M to 8.15M fish. A portion of this increase, from 3.5M to 4.5M, is proposed to take place in 2020. All of the 8.15M subyearling releases will occur on-site, as will broodstock collection, rearing, and acclimation. Until the full expansion occurs, increases in production will occur both on-site and from excess brood collected and spawned at Priest Rapids Hatchery (NMFS 2017b).

The purpose of the Corps funding the program operation and expansion is to, in part, meet its JDM program objectives associated with the Corps' construction and operation of The Dalles and John Day projects, which inundated URB fall Chinook salmon spawning habitat. The Corps' pursuit of "in place" and "in kind" mitigation better meets its mitigation goals under the Flood Control Act of 1950, House Document 531, and to support the "*United States v. Oregon* (*U.S. v. Oregon*) Federal District Court case that applied the 1979 Supreme Court decision addressing tribal treaty rights.

Fall Chinook salmon in the Upper Columbia and RSH fall Chinook salmon stocks are not listed under Endangered Species Act (ESA).

NMFS defines integrated hatchery programs as those that are reproductively connected or "integrated" with a natural population, promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species, and are included in an ESA-listed salmon ESU or steelhead DPS.

Table 1. Program included in the Proposed Action.

Program	Date	Program Type	Program Purpose	Funding Entity	ESA Pathway
Ringold Springs Hatchery Fall Chinook Salmon	November 14, 2019	Integrated Harvest	Create terminal fishery in Columbia River.	Corps	Section 7

1.1. Background

NMFS prepared the Biological Opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the actions proposed by NMFS, the USFWS, and BOR.

NMFS 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 (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991 (56 FR 58619), Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as a threatened species on April 22, 1992 (57 FR 14653), and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994). The 1994 opinion was superseded by “Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383” completed on April 5, 1995 (NMFS 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after UCR steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5% of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia steelhead were added to the list of endangered and threatened species (Smith 1999).

Between 1991 and the summer of 1999, the number of distinct groups of Columbia Basin salmon and steelhead listed under the ESA increased from 3 to 12, and this prompted NMFS to reassess its approach to hatchery consultations. In July 1999, NMFS announced that it intended to conduct five consultations and issue five opinions "instead of writing one biological opinion on all hatchery programs in the Columbia River Basin" (Smith 1999). Opinions would be issued for hatchery programs in the (1) Upper Willamette, (2) Middle Columbia River (MCR), (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS' first priority (Smith 1999). Between August 2002 and October 2003, NMFS completed consultations under the ESA for approximately twenty hatchery programs in the UCR. For the MCR, NMFS completed a draft opinion, and distributed it to hatchery operators and to funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basin-wide review and planning processes.

The increase in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of Federal funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) opinion was issued by NMFS (NMFS 2000a). The Northwest Power and Conservation Council (Council) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., HGMPs) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms. Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs under the FCRPS opinion was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Jones Jr. 2002; Foster 2004). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not ready for ESA consultation.

ESA consultations and an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total number of salmon and steelhead released into the Columbia River annually. These programs are located in the LCR and MCR and are operated by the FWS and by the Washington Department of Fish and Wildlife (WDFW). NMFS' opinion (NMFS 2007) determined that operation of the programs would not jeopardize salmon and steelhead protected under the ESA.

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008e) and an opinion and RPA actions for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008c). The SCA environmental baseline included "the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 7consultation, the effects of future operations cannot be included in the baseline. The FCRPS action agencies' Proposed Action did not encompass hatchery operations per se (the Proposed Action was concerned with operating the FCRPS, a series of multiple-purpose dams), and therefore no incidental take coverage was offered through the FCRPS biological opinion to hatcheries operating in the region. Instead, we expect hatchery program operators and funding entities, including federal agencies involved in hatchery operations, to address their obligations under the ESA in separate consultations, as required" (see NMFS 2008e, p. 5-40).

Because it was aware of the scope and complexity of ESA consultations facing the co-managers and hatchery operators, NMFS offered substantial advice and guidance to help with the consultations. In September 2008, NMFS announced its intent to conduct a series of ESA consultations and that "from a scientific perspective, it is advisable to review all hatchery programs (i.e., Federal and non-Federal) in the UCR affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again, the need for re-evaluation of UCR hatchery programs and provided a "framework for ensuring that these hatchery programs are in compliance with the Federal Endangered Species Act" (Jones Jr. 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones 2009).

On April 28, 2010 (Walton 2010), NMFS issued a letter to "co-managers, hatchery operators, and hatchery funding agencies" that described how NMFS "has been working with co-managers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal Endangered Species Act (ESA)." NMFS stated, "In order to facilitate the evaluation of hatchery and fishery plans, we want to clarify the process, including consistency with *U.S. v. Oregon*, habitat conservation plans and other agreements…." With respect to "Development of Hatchery and Harvest Plans for Submittal under the ESA," NMFS clarified: "The development of fishery and hatchery plans for review under the ESA should consider existing agreements and be based on best available science; any applicable multiparty agreements should be considered, and the submittal package should explicitly reference how such agreements were considered. In the Columbia River, for example, the *U.S. v. Oregon* agreement is the starting place for developing hatchery and harvest plans for ESA review…."

In 2005, WDFW submitted an HGMP for the RSH fall Chinook salmon 3.5M sub-yearling on-station release as part of the Corps JDM program. An ESA Section 7(a)(1) consultation for this level of production was completed in 2017 (NMFS 2017b). A new HGMP was completed by WDFW and the Corps for a proposed construction and expansion of the Ringold Springs Hatchery, as well as construction of a new facility on the lower Yakima River. The Corps never completed ESA Section 7(a)(1) consultation for the proposed action described in the 2014 HGMP. This HGMP is for updated construction and expansion plans at Ringold Springs Hatchery, which is intended to increase production of sub-yearling fall Chinook for the JDM program from 3.5M to 8.15M (USACE 2019; USACE and WDFW 2019). A portion of this increase, from 3.5M to 4.5M, is proposed to take place in 2020. All of the 8.15M subyearling releases will occur on-site, as will broodstock collection, rearing, and acclimation. Until the full expansion occurs, increases in production will occur both on-site and from excess brood from Priest Rapids.

NMFS reviewed the HGMP and the Corp's BA for sufficiency, and issued a letter indicating that the HGMP and BA were sufficient for consultation (Purcell 2019).

1.3. Proposed Federal Action

"Action," as applied under the ESA, means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). For EFH consultation, "Federal action" means any on-going or Proposed Action authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). In this section we describe: the proposed hatchery program that is part of the "Proposed Action" using information provided in the HGMP and other correspondence and the funding of those programs by the Corps. We considered, under the ESA, whether or not the Proposed Action would cause any other activities and determined that it would not.

The Federal Action considered in this opinion is the Corps' proposal to fund those operations of RSH to produce fall Chinook salmon as well as the expansion of those RSH facilities necessary to increase such production (Table 1), all in support of the Corps' JDM program.

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from the Corps' funding of RSH operations and expanded facilities in support of the JDM program. This Opinion will determine if the actions proposed by the Corps comply with the provisions of Section 7 of the ESA. These actions are explicitly incorporated into this Opinion and Incidental Take Statement (ITS). If these actions do not occur or are implemented differently than analyzed here, NMFS may reinitiate consultation in accordance with its regulations.

NMFS describes a hatchery program as a group of fish that have a distinct purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008c). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). Below is a description of the proposed activities.

The Corps implements its JDM program to mitigate for the loss of fall Chinook salmon caused by the construction and operation of The Dalles and John Day dams which inundated spawning and rearing habitat. The overall JDM program goal is to ensure that 30,000 adult URB fall Chinook salmon return to that portion of the Columbia River impacted by The Dalles and John Day dams. These adult URB fall Chinook salmon are harvested by treaty and non-treaty sport and commercial fishers. The Corps ensures that those JDM program hatchery operations it funds are carried out in a way that minimizes or avoids adverse effects on ESA-listed stocks, especially Snake River fall Chinook salmon. The Corps funding of URB Chinook salmon production from Ringold and the parent Priest Rapids Hatchery program contributes significantly to ocean, Columbia River commercial and recreational fisheries, and Treaty Indian fisheries in Zone 6 (which includes The Dalles and John Day impoundments). Harvest of these fall Chinook salmon takes place in: the Canadian Troll fishery, the Canadian sport and net fisheries, the

Washington/Oregon coastal sport and troll fisheries, Alaskan sport and troll fisheries, Columbia River net and freshwater sport fisheries and Treaty Indian fisheries in Zone 6. Impacts of these fisheries on ESA-listed species were evaluated in separate consultations (NMFS 2018).

The impacts of fisheries in the action area, including those that may target fish produced by the proposed program, on ESA-listed salmonids are included in the environmental baseline.

1.3.1. Continued Operation of the Ringold Springs Hatchery URB Fall Chinook Salmon Program

The Proposed Action includes the continued operation of the Ringold Springs Hatchery URB fall Chinook salmon program. Congress authorized the construction of The Dalles and John Day projects as part of the comprehensive plan for the improvement of the Columbia River Basin in the Flood Control Act of 1950. Congress authorized the implementation of The Dalles and John Day projects substantially in accordance with the plans of the Chief of Engineers contained within House Document 81-531 ("H.D. 531"). In H.D. 531, the Chief of Engineers recommended that the comprehensive plan be approved "generally in accordance with the plans outlined in the report of the division engineer and with such modifications as the Chief of Engineers may find advisable." The preliminary plans for The Dalles and John Day projects provided for hatcheries and specific fish-egg amounts to compensate for the pools inundating these spawning areas. Fish hatchery and rearing facilities would be included as part of John Day and The Dalles projects to offset any losses which might occur as a result of loss of spawning and rearing areas in the pools.

In its current form, JDM is achieved through adult egg take, incubation, and juvenile rearing using a combination of Priest Rapids, Ringold Springs, Little White Salmon, Spring Creek, and Prosser hatcheries (Washington), and Bonneville and Umatilla State Fish Hatcheries in Oregon.

Over the past 25 years, adjustments have been made to JDM to convert portions of the production from tule fall Chinook salmon to URBs (in-kind) with some of these fish moved upstream for acclimation and release (in-place).

Based on input from *U.S. v. Oregon* parties, the Corps has determined that while JDM has achieved the 30,000 adult escapement objective, it has not yet achieved "in-place" (i.e. fish returning to the impacted area) and "in-kind" (i.e., the appropriate fish species returning to the impacted area) mitigation. Specifically, the Corps is evaluating increasing the percentage of URBs that it produces, and releasing these fish further upstream so that they return to the areas impacted by The Dalles and John Day dams. Provisions to evaluate changes to JDM to mitigate losses "in-place and in-kind" are also identified in the 2008 Columbia Basin Fish Accords (Accords) between the Columbia River System (CRS) Action Agencies - Bonneville Power Administration (BPA), the Corps, and U.S. Bureau of Reclamation (USBR), and Columbia Basin Treaty Tribes.

In August 2011, in support of the Columbia River Fish Management Plan (CRFMP), the Corps formally initiated studies to address adjustments in JDM in order to achieve "in-place and in-kind" mitigation objectives. As a result of these studies, it was determined that hatchery improvements are needed to accommodate an increase in production of the URB fall Chinook, while at the same time minimizing effects on other ESA-listed Columbia River salmonids. During these studies, the *U.S. v. Oregon* parties recommended that the Corps use a method referred to as the "total adult production" (TAP) and "current smolt-to-adult survival ratio" (SAR) data to more accurately calculate the production level required to produce the 30,000 adult spawners under the authorized JDM. This methodology was accepted by the Corps in 2012.

Originally, the Corps evaluated expanding Ringold Spring Hatchery and additionally building a new acclimation facility on the lower Yakima River (USACE 2019; USACE and WDFW 2019). This action would have expanded Ringold to increase production there to 10.4M subyearlings, and built new facilities on the lower Yakima River to produce 3.75 subyearlings and 500,000 yearlings there. Adult returns and broodstock requirements would have been split between Ringold and the Yakima River site. However, this would have required major water supply improvements in the lower Yakima River, both in quantity and quality due to contaminants and elevated water temperatures. Additionally, a water supply intake sufficient to meet the water demands of the proposed facilities would have been a substantial infrastructure requirement. The size and location of the Yakima intake would have had significant impacts on migrating ESA-listed fish, specifically bull trout and Mid-Columbia steelhead.

In June 2019, the *U.S. v. Oregon* parties updated the fish production estimations in support of in-kind and in-place mitigation, and determined that an estimated 19.6 million fall Chinook salmon will need to be released at five release points based on a target ratio of 75 percent URB and 25 percent tule (Table 2).

Table 2. Mitigation Goal and Recommended Production Change.

	Recommended Production Increase to Complete Mitigation Goal: 25% Tule/75% URB		
	Release	Ocean	Return
Total Fish	19.61 M	107,000	30,000
Tule	4.15 M	27,000	7,500
URB	15.46 M	80,000	22,500

To meet these JDM goals, production will be adjusted at some facilities Table 3 and Figure 1. Production at both the Priest Rapids Hatchery (1.7 million JDM smolts) and the Spring Creek National Fish Hatchery (10.5 million JDM smolts) will be eliminated or reduced, while the 3.5 million JDM smolts currently being reared and released at Ringold Spring Hatchery would increase to 8.15 million JDM smolts. Overall production of JDM smolts will be replaced by the Proposed Action, but will not be additive to it. Changes have been implemented to the JDM program over the last ten years to increase in-kind and in-place mitigation to the extent possible with existing facilities. The current JDM production capacity at the up-river location (Ringold Springs Hatchery) is insufficient to fulfill the desired mitigation goal.

Table 3. Summary of JDM Baseline Condition and Proposed Action.

JDM Activity by Juvenile Release Location	Type	Smolt to Adult Ratio	Baseline		Proposed Action	
			Juveniles	Adults	Juveniles	Adults
Bonneville*	Tule	0.001226	0	0	0	0
	URB	0.003128	0	0	0	0
Spring Creek	Tule	0.004723	10,500,000	49,592	4,150,000	19,600
Little White Salmon	Tule	0.004723	0	0	0	0
	URB	0.003196	4,500,000	14,382	4,500,000	14,382
Ringold (Existing)	URB	0.001990	3,500,000	6,965	n/a	n/a
Ringold (Build-out)	URB	0.003840	n/a	n/a	8,150,000	31,296
Umatilla	URB y	0.013323	900,000	11,991	900,000	11,991
Priest Rapids	URB sy	0.003840	1,700,000	6,528	0	0
Prosser	URB sy	0.001990	1,700,000	3,383	1,700,000	3,383
	URB y	n/a	210,000	2,798	210,000	2,797
Sub-Total TULE			10,500,000	49,592	4,150,000	19,600
Sub-Total URB			12,510,000	46,047	15,460,000	63,849
TOTAL			**23,010,000**	**95,639**	**19,610,000**	**83,449**
Ratio Tule:URB				**52% : 48%**		**23% : 77%**

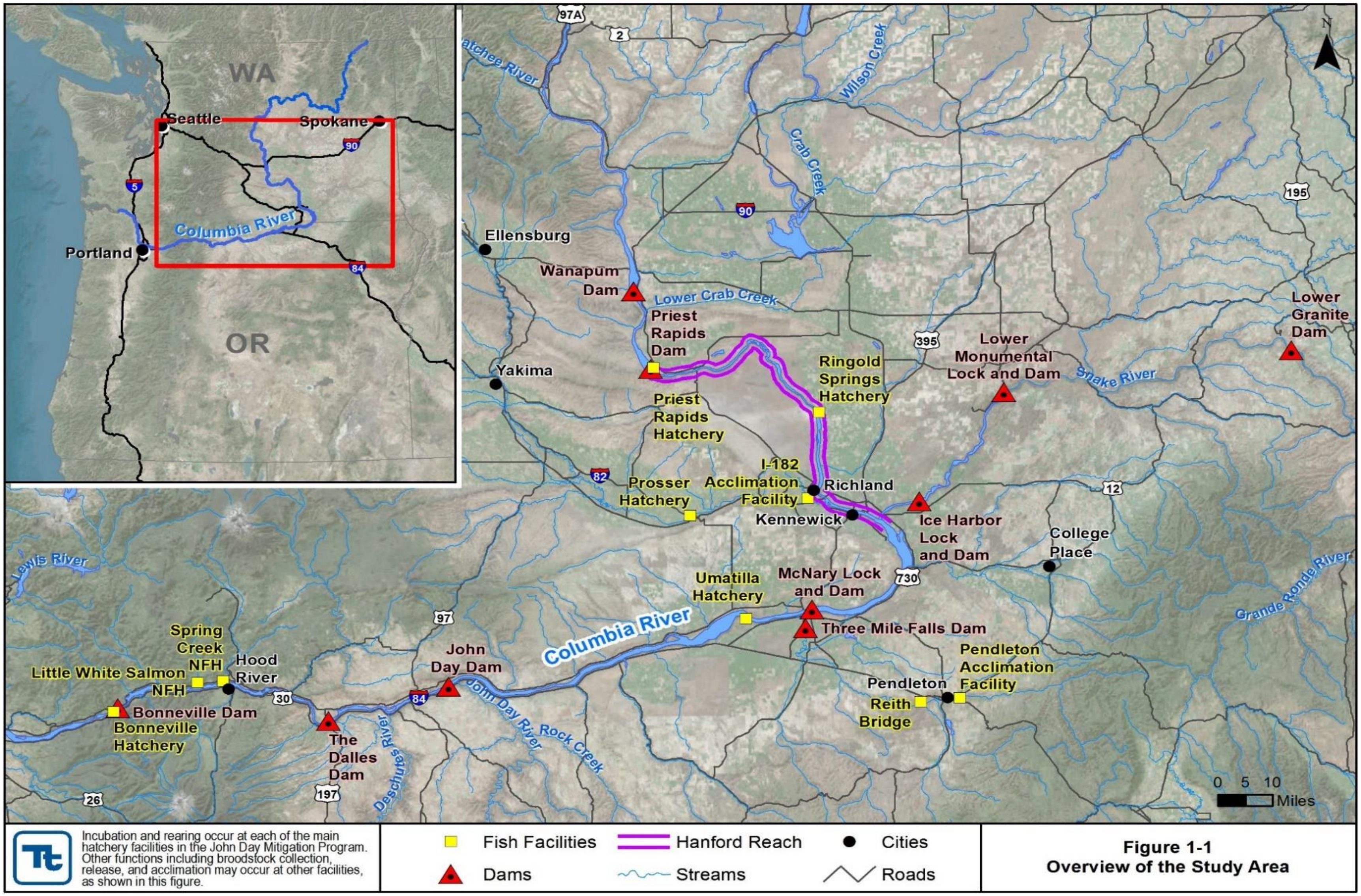

Figure 1. Overview of John Day/The Dalles Dams mitigation facilities in the Columbia River Basin.

RSH was initially built as part of the NMFS-funded Columbia River Fisheries Development Program. The primary goal of URB fall Chinook salmon production is to replace losses of wild URB fall Chinook salmon contributions to Treaty and non-Treaty sport and commercial fisheries due to federal hydropower and habitat degradation in the Columbia River Basin. The RSH will be expanded to accommodate the proposed program increase of releases of 8.15 million fall Chinook on-station (located on the Columbia River, at Rkm 567). Construction associated with expanding the Ringold Springs Hatchery is dependent on the Corps acquiring funding at the national level and the request will be forwarded after completion of all environmental compliance documentation including this biological opinion and incidental take statement.

The Ringold Springs program is operated as an "integrated" program with the intent to minimize the genetic and reproductive fitness differences between the locally derived hatchery broodstock and the naturally spawning population in Hanford Reach. The integration goal for the program is to include 30% natural-origin spawners. The current collection goal of up to 1,100 natural origin fall Chinook for use as broodstock out of a natural population which has averaged over 96,000 adults (2005-2018). To achieve this, WDFW will use the FWC Policy C-3619 for guidance for hatchery reform actions while coordinating with the co-managers/tribes and in a manner that is consistent with the *U.S. v. Oregon* Agreement. HSRG recommendations are implemented to degree there is agreement among the parties.

The annual production goal for the program is 8.15M subyearling smolts, which would require approximately 4,050 adults for broodstock with an egg-take goal of 9,100,000 green eggs. This assumes a one male to 2 female spawning ratio. The program goal is to target a 70% hatchery and 30% natural-origin broodstock composition. This equates to 2,835 hatchery adults and 1,215 natural-origin adults.

Broodstock used in the program will be collected from the run-at-large volunteering to the RSH adult trap, with the addition of natural-origin broodstock collected by volunteer anglers to achieve 30% natural origin broodstock objective, as needed. Since BY2008, fall Chinook salmon returns to Priest Rapids Hatchery (PRH) have been used as broodstock for the RSH fall Chinook production. Currently, PRH and the east off-ladder adult fish trap (OLAFT) at Priest Rapids Dam serves as a broodstock collection locations for both PRH and RSH. The design of the new intake and the adult collection facility at RSH is expected to recruit more natural-origin adults than the current facility (Table 4). Should there not be adequate returns to RSH to meet program goals, it would be possible to rely on adults returning to PRH or the OLAFT.

Table 4. Adults collected and surplused at Ringold Springs from 2007 to 2018.

Return Year	Females	Males	Jacks	Total
2007	11	18	0	29
2008	0	0	0	0
2009	27	78	1,410	1,515
2010	1,678	5,966	1,305	8,946
2011	2,779	2,855	1,289	6,923
2012	1,466	3,858	2,067	7,391
2013	11,709	4,728	530	16,967
2014	7,065	6,332	2,256	15,653
2015	5,892	9,084	381	15,357
2016	2,485	2,842	52	5,379
2017	1,276	771	48	2,095
2018	291	341	254	886
Average	**756**	**1,500**	**825**	**4,912**

Data Source: WDFW Hatcheries Headquarters Database 2019.

The adult trap was recently updated with a concrete floor, but otherwise has not been updated and currently does not have suitable adult holding facilities to complete the spawning to incubation step of production. Under the Proposed Action, the presort adult holding pond will be a rectangular concrete pond located upstream of the exit from the concrete fish ladder with a usable holding volume of 16,000 cf. The presort pond water supply will be 8 cfs from the same spring water on which Ringold juveniles were raised and imprinted. Water will enter the presort pond at the upstream end through an up-well in the floor, passes through the pond uniformly to the downstream end to the ladder, and out through the fish return channel. Level alarms will be installed to monitor the pond water surface. Fish will be held in the pond between the picket rack/v-trap located at the pond outlet to the west and the false weir on the east end. The primary components of the presort pond are the pond (horizontal) crowder, the vertical crowder, and the false weir.

The pond will provide the capacity to hold 3,100 returning adults. The number of fish entering the pond will be controlled by a gate at the fish ladder entrance. The gate actuator will be controlled by a fish counter that will send a close gate signal when the maximum presort pond capacity is reached. If the daily adult return is higher than 3,100, the remainder of the run will hold in the lower fish ladder.

The pond v-trap would allow adults to pass from the fish ladder into the pond, but prevent travel back down the upper fish ladder. The presort pond crowder is intended to coax fish with a flat vertical picket panel to move horizontally from the entrance through pond to the upstream end of the pond. A vertical crowder will be located at the upstream end of the Presort Pond to coax the last remaining fish in the pond vertically through the space formed between the between the horizontal crowder panel and the pond wall through the false weir. It is anticipated that many of the fish crowded toward the end of the pond are expected to clear the presort pond volitionally via the false weir.

Adults will be anesthetized using electro-anesthesia. The electro-anesthesia assembly will consist of two baskets that are submerged into tanks of water. Each 45-cf basket/tank will be able to anesthetize roughly 20 adult fall Chinook salmon. With the dual basket system, fish can be loaded, anesthetized, and moved onto the sorting table at approximately 2.5 minutes per cycle. In an 8-hour period, if operated continuously, 3,840 fish could be handled and sorted, which is slightly more than the capacity of the presort pond. Anesthetized fish are emptied onto a sorting table where fish can be sorted into tubes that direct fish back to the river via a recovery tank and flume, to adult holding ponds, or to be surplused. Those retained for spawning will be directed to the spawning table. All fish spawned and surplused are sampled for tags.

Spawners are selected and mated randomly from the population maintained in the hatchery holding ponds. Fish are spawned throughout the entire run to help ensure that the run timing for the stock is maintained. Jacks will not be used unless absolutely necessary. For daily egg-takes less than 500,000, adults will be spawned two males to two females in one bucket. For egg-takes greater than 500,000, adults will be spawned one male to two females in one bucket then two buckets will be combined.

Juveniles will be incubated and reared on station until they reach 50 fish per pound (fpp). Fish health staff monitor the fish throughout their rearing cycle for signs of disease. Mortalities are checked daily and live grab samples are taken monthly. Fish are also tested prior to release. Sampling, testing, and treatment/control procedures are outlined in and consistent with PNFHPC (1989); IHOT (1995); WWTIT and WDFW (2006).

Juvenile hatchery fish will be allowed to voluntarily emigrate from the dual use ponds (i.e., adult holding and juvenile rearing) into the outlet creek to the hatchery over a period of up to 4 days as the ponds are slowly lowered. Once full production is reached release groups will be staggered by approximately one week from May through early July.

All of the releases at RSH will be adipose fin-clipped with approximately 6% of the releases will be given a CWT. Up to 7,500 subyearlings will be PIT-tagged and released annually beginning in 2021.

1.3.1.1. **Proposed Expansion of The Ringold Springs Hatchery**

Also included in the Proposed Action is the expansion of the Ringold Springs Hatchery. The RSH is located on approximately 242 acres and the facility would be expanded by up to 16 acres under the Proposed Action. The hatchery infrastructure is owned by WDFW, and the property is owned by the USBR. The USBR-owned land is approximately 188 acres of the total site and leased to WDFW. The RSH site has the following components: 9-acre rearing pond, 5-acre rearing pond, 14 vinyl raceways, and an adult trap and holding pond. Water for the facilities is supplied by an existing water right of 70 cubic feet per second (cfs) from Ringold Creek, which provides a variable amount of water during the year, and a 10 cfs river water right from 1 January – 31 March. The amount of water withdrawn from both Ringold Creek and the Columbia River under proposed conditions would be changed to 50 cfs to provide a more consistent water supply.

The Corps proposes to implement the following actions to expand and improve the facilities at RSH (USACE 2019).

1. Replace the existing fishways with structures meeting current NMFS design criteria. The lower fish ladder would be a series of 18 precast concrete weirs, each 12 inches thick, to replace the existing ecology blocks in the Ringold Creek channel and would extend into a sufficiently deep section of the Columbia River to ensure fish access at low flows. Installation of the weirs would require driving thirty-six 12-inch pipe piles to a depth of forty feet. A holding pool would be excavated between each weir and would have a 3:1 side slope, a minimum depth of 6 inches below the lower weir elevation, and be would covered with crushed rock to prevent erosion within the channel. The upper fish ladder would be a weir and orifice design (also known as a half Ice Harbor fish ladder) using a 6-foot-wide concrete channel with 12-foot-high side walls. The upper fish ladder would contain 14 ladder pools and pass returning adult fish 14 vertical feet from the lower fish ladder to the pre-sort holding area. The upper fish channel would be a 6-foot-wide concrete channel with 12-foot-high walls provided from the upper fish ladder to both the pre-sort holding pond and the dual use ponds.

2. Construct a river intake structure in the Columbia River to supply additional river water to RSH. The proposed river water intake would be located approximately 2,000 feet south of the existing river intake and would be placed in a deeper portion of the Columbia River to provide a more reliable water supply. The intake would be a precast concrete structure supported on two drilled shafts, each 8 feet in diameter. Installation of the intake structure would require driving eight 24-inch pipe piles to a depth of forty feet. Barges would be needed to install the intake structure. Precast pile caps and support beams would be set between the two shafts. The intake structure would have a bridge approximately 480 feet in length and a crane, and the total area over water would be approximately 11,261 square feet. A stairway would extend from the bridge to the intake structure. Up to 50 cubic feet per second (cfs) would be withdrawn at this location, which is less than 1 percent of the river's average discharge. Three vertical intake screens would sit in slots located at the opening to the pump chamber. The screens would be oriented parallel to the river to prevent debris accumulation and accommodate sweeping flow (anticipated to be between 3 and 4 ft/sec at minimum river flows). An airburst cleaning system would assist when debris removal is necessary. The surface area of the screens would be adequate to limit intake velocity to below 0.4 ft/sec, per NMFS criteria for active screens. This water intake would supplement the current water intake structure on Ringold Creek.

3. Provide an adult return flume to return fish species not destined for spawning at RSH back into the Columbia River. The flume would be a high-density polyethylene pipe, 18 inches in diameter, and would run from the sorting facility to the shore end of the intake structure bridge. Installation of the flume would require driving two 24-inch pipe piles to a depth of forty feet. Most of the flume would be an elevated pipe supported by steel supports suspended from the bottom of the intake bridge structure; the remainder would be supported on pipe supports. The flume is designed to operate within a range of Columbia River water surface elevations (350.4 to 357.4 feet), which covers 90 percent

of the August to December period when the returning fish are expected to arrive at the site. Total area over water for this structure would be 216 square feet.

4. The lower fish ladder, river water intake, and adult return flume all require some element of in-water work. The entrance to the lower fish ladder extends into the Columbia River. Roughly half of the lower fish ladder (9 weirs) will require in-water work, which includes excavation, installing support pipe piles (18 of the 36 piles for the lower fish ladder will require in-water pile driving, 18 will occur out-of-water), installing precast concrete weirs (9 weirs), and placing riprap. This work would likely be accomplished using a barge-mounted crane. The river water intake requires barge-mounted equipment to install the drilled shafts and the precast concrete structure. The adult return flume would be installed under the intake structure bridge and would require work from a barge during the in-water work period. This in-water work would occur during the in-water work period, as designated by WDFW, from 16 July to 30 September. Details of the pile driving component of this action are given in Table 5.

Table 5. Pile driving details, Ringold Springs Hatchery Expansion.

Type/size piles	No. of Piles	No. of strikes / pile	No. driven / day	Total No. days	No. strikes / day
12” diameter (DIA) steel pipe (Lower Fish Ladder)	36 (18 in water)	50	6	6	300
96” DIA drilled shafts with permanent casings (River Intake)	2	0	2	1	0 (Installed with vibrating hammer)
24” DIA steel pipe (Adult Return Flume)	8	50	8	1	400

5. Construct a pre-sort holding pond to provide temporary holding and resting space for adult fish after exiting the upper fish ladder prior to sorting. This rectangular concrete pond would be approximately 113 feet in length and 20 feet in width, with pond walls 13 feet high and 8 feet of water depth. A v-trap would prevent adult fish from passing back into the upper fish ladder.

6. Construct three adult holding ponds, each 200 feet in length, 20 feet in width and 8 feet in depth, in the southern end of the existing 9-acre pond. Thirty round rearing ponds (see NZMS control, below) would be constructed north of the dual use ponds. The ponds would be covered with a metal roof for shade. Tensioned bird netting would completely surround the ponds to provide protection from avian predation.

7. Replace the existing above-grade corrugated metal supply line from the main (spring) intake. The new supply line would be a high-density polyethylene pipe, 42 inches in diameter, that would be covered by an earthen berm to reduce the effect of solar heating; it would be connected to the existing 42-inch supply line from the lower (spring) intake.

8. Install pre-engineered metal buildings to be used as a sorting facility, spawning shelter, and hatchery building (incubation room, office, restrooms/lockers).

9. Provide a new domestic well for potable water.

10. Grade the site for facility installation. The proposed earthwork at the site requires approximately 12,000 cubic yards of net fill.

11. Construct four bio-infiltration swales to capture stormwater from impervious surfaces (paved areas and buildings). The Corps would size these to store the first 6 inches of runoff. These would serve as temporary silt removal ponds during construction.

12. Construct a paved road 24 feet wide and 1200 feet long to provide access to the rearing ponds. All paved areas would be covered with a 3-inch-thick asphalt surface, underlain by an 8-inch-thick crushed base course.

13. Construct a reinforced concrete pollution control pond (120 by 160 feet) to be used to decant the uneaten food and fish feces vacuumed from the bottom of the rearing ponds. The decanted fluid outflow from the pollution abatement pond would be discharged through the process water discharge system and then into Ringold Creek. At the end of the rearing season, the pond would be drained and the solid matter allowed to dry. Once dry, it can be removed and disposed of in an approved disposal facility.

14. Install onsite septic system to treat sewage from the bathrooms in the incubation building.

15. Install round pond rearing systems as New Zealand Mud Snail (NZMS) control systems. The invasive NZMS were discovered to be present in the springs at RSH and it was determined that they could not be eradicated from the springs requiring the control of NZMS within the hatchery. The round pond rearing systems would use Cornell-style dual drain fish rearing tanks to remove as many NZMS as feasible from the juvenile rearing environment and implement partial water reuse technology to reduce water consumption. NZMS would be removed with other waste particles found in the fish rearing system, which consist mainly of fish waste and excess feed. Once removed, the NZMS would be collected and disposed of at an approved upland disposal site.

Partial water reuse systems are constantly removing fish waste and excess feed. At RSH, there would also be removal of NZMS and other suspended solids greater than 100 microns that are in the river water. This waste and river solids would mix in the waste stream. Once mixed with fish waste, the density of the solids would be relatively low and is ideal for treatment with a gravity thickening settler (GTS). This is a large cone-shaped settler that allows radial flow on the surface and solids to settle into a cone and compress. Waste from the GTS would be discharged into a holding tank that would be pumped into a tanker truck each week and disposed in an upland disposal site. In winter months, freezing temperatures are anticipated to kill most of the disposed NZMS within a day or two. The Corps will investigate means to prevent bird scavenging of the disposal site in warmer months. The overflow drain water throughout the circular tank system is clean enough to discharge directly to the river. Overflow drainage would mainly occur at the radial flow settlers and gravity thickening settler. The effluent treatment system would include several small sewage ejector pumps in manholes and an area in the tank building to hold the GTS. The holding tank is similar to a septic tank and would typically be installed below grade. Any discharges associated with operations at the expanded RSH would be covered by a National Pollutant Discharge Elimination System (NPDES) permit secured by WDFW.

1.3.2. Research, Monitoring, and Evaluation (RM&E)

RM&E activities at the RSH will be coordinated with RM&E activities by the regional PUD M&E plan (Hillman et al. 2017a). RSH proposes to continue RM&E activities described below:

- Broodstock (and mortalities at trap locations) would be sampled to determine sex, fecundity, age, genetic identity and diversity, and stray rates.
- Spawning ground surveys (for carcass recovery and redd survey) would be conducted to determine location, number, stray rates, and timing of naturally-spawning summer/fall and fall Chinook salmon in the Hanford Reach.
    - Carcass surveys and run composition assessment would be conducted in a manner to target about 10 to 20 percent of the escapement in a given area.
    - Analysis to determine potential coded wire tag and carcass recovery bias.
    - Determine hatchery fish effects on population productivity, genetic diversity, spawning distribution, and age and size at maturity.
- Operation and evaluation of PIT-tag detection systems for the purposes of stray analysis, secondary smolt-to-adult return estimate, migration timing, juvenile survival, etc.
- Research to improve or assess program performance (such as different mating strategies to improve PNI).
- Monitoring of each life-stage survival rates in the hatchery.

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 provide an opinion stating how the agency’s actions would affect listed species and their critical habitats. If incidental take is reasonably expected 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.

The Corps determined the proposed action is not likely to adversely affect ESA-listed Green Sturgeon, Southern Resident Killer Whales, and Eulachon 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 "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This 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 as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced 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.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

Range-wide status of the species and critical habitat

This section describes the status of species and critical habitat that are the subject of this opinion. The status review starts with a description of the general life history characteristics and the population structure of the ESU/DPS, including the strata or major population groups (MPG) where they occur. NMFS has developed specific guidance for analyzing the status of salmon and steelhead populations in a "viable salmonid populations" (VSP) paper (McElhany et al. 2000). The VSP approach considers four attributes, the abundance, productivity, spatial structure, and diversity of each population (natural-origin fish only), as part of the overall review of a species' status. For salmon and steelhead protected under the ESA, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the range-wide status of listed species, NMFS reviews available information on the VSP parameters including abundance, productivity trends (information on trends, supplements the assessment of abundance and productivity parameters), spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU/DPS, and the limiting factors and threats. To source this information, NMFS relies on viability assessments and criteria in technical recovery team documents, ESA Status Review updates, and recovery plans. We determine the status of critical habitat by examining its PBFs. Status of the species and critical habitat are discussed in Section 2.2.

Describing the environmental baseline
The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area* on ESA-listed species. 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. The environmental baseline is discussed in Section 2.3 of this opinion.

Cumulative effects
Cumulative effects, as defined in NMFS' 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. Cumulative effects are considered in Section 2.5 of this opinion.

Integration and synthesis
Integration and synthesis occurs in Section 2.6 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 2.4) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.3) and to cumulative effects (Section 2.5). Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations. These impacts are combined with the overall status of the MGP to determine the effects on the ESA-listed species (ESU/DPS), which will be used to formulate the agency's opinion as to whether the hatchery action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat.

Jeopardy and adverse modification
Based on the Integration and Synthesis analysis in section 2.6, the opinion determines whether the Proposed Action is likely to jeopardize ESA-protected species or destroy or adversely modify designated critical habitat in Section 2.7.

Reasonable and prudent alternative(s) to the proposed action
If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a RPA or RPAs to the proposed action.

2.2. Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action described in Table 6[1]. The status is determined by the level of

[1] ESA-listed bull trout (*Salvelinus confluentus*) are administered by the FWS and impacts on bull trout by the proposed hatchery program are addressed in a separate FWS section 7 consultation (USFWS 2015).

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' "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 function of the essential PBFs that help to form that conservation value.

Table 6. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA-listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Upper Columbia River Spring	Endangered 70 FR 37160; [1] June 28, 2005	70 FR 52630; Sept 2, 2005	ESA Section 9
Snake River Spring/summer	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005
Snake River Fall	Threatened, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52706, September 2, 2005	70 FR 37160, June 28, 2005
Upper Willamette River Spring	Threatened, 79 FR 20802, April 14, 2014	70 FR 52720, 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	ESA Section 9
Steelhead *(O. mykiss)*			
Upper Columbia River	Threatened 74 FR 42605; August 24, 2009	70 FR 52630; Sept 2, 2005	70 FR 37160; June 28, 2005
Snake River	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
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52808, September 2, 2005	70 FR 37160, June 28, 2005
Upper Willamette River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52848, September 2, 2005	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
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

[1] Citations to "FR" are citations to the Federal Register.

"Species" Definition: The ESA of 1973, as amended, 16 U.S.C. 1531 *et seq.* defines "species" to include any "distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature." To identify DPSs of salmon species, NMFS follows the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612, November 20, 1991). Under this policy, a group of Pacific salmon is considered a DPS and hence a "species" under the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. The group must satisfy two criteria to be considered an ESU: (1) It must be substantially reproductively isolated from other con-specific population units; and (2) It must represent an important component in the evolutionary legacy of the species. To identify DPSs of steelhead, NMFS applies the joint FWS-NMFS DPS policy (61 FR 4722, February 7, 1996). Under this policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon.

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 parameters or 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, on habitat quality and spatial configuration, and on 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 VSP parameters 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 have 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).

2.2.1.1. Upper Columbia River Spring Chinook Salmon ESU

Chinook salmon (*Oncorhynchus tshawytscha)* 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). ESA-listed UCR spring Chinook salmon are stream-type. Stream-type Chinook salmon spend 2 to 3 years in coastal ocean waters, and enter freshwater in February through April. Spring Chinook salmon also spawn and rear high in the watershed and reside in freshwater for a year.

The historical UCR Spring Chinook Salmon ESU comprises three major population groups (MPGs) and eight populations; however, the ESU is currently limited to one MPG (North Cascade MPG) and three extant populations (Wenatchee, Methow and Entiat). The Okanogan population has been extirpated. For the MPG to be considered viable, all three extant populations are required to meet viability (i.e., a 5 percent extinction risk over a 100-year period) criteria (UCSRB 2007).

Approximately half of the area that originally produced spring Chinook salmon in this ESU is 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). The ESU originally included six artificial propagation programs: the Twisp, Chewuch, Methow Composite, Winthrop NFH, Chiwawa, and White River hatchery programs (79 FR 20802, April 14, 2014). Currently, the three Methow Subbasin programs (Twisp, Chewuch, Methow Composite) are considered a single program, with two components: Twisp and Methow (the previous Chewuch and Methow programs combined). Furthermore, a Nason Creek program began in the Wenatchee Subbasin (Grant County PUD et al. 2009b), while the White River releases were discontinued after 2015 (Grant County PUD et al. 2009a).

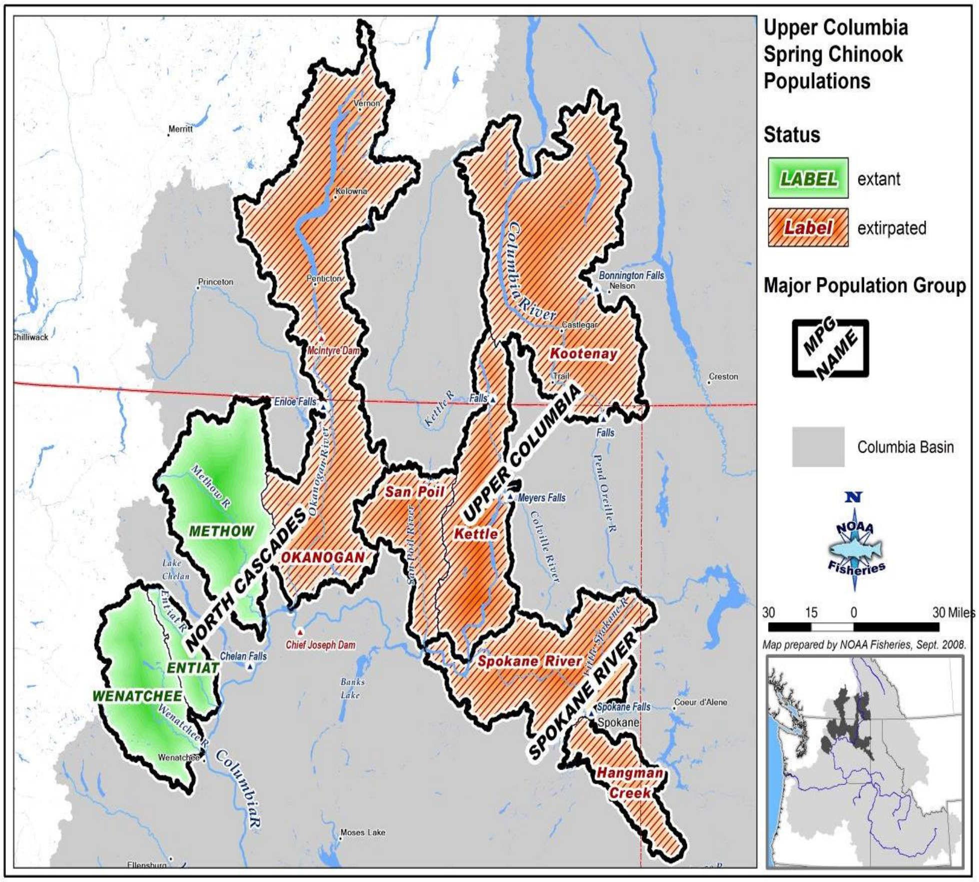

Figure 2. Upper Columbia River Spring Chinook Salmon ESU (ICTRT 2008).

For the most recent period (2005-2014), abundance has increased for all three populations, but productivity for all three populations remains below replacement (Table 7). Although increases in natural-origin abundance relative to the extremely low levels observed during the mid-1990s are encouraging, overall productivity has decreased to extremely low levels for the two largest populations (Wenatchee and Methow). The predominance of hatchery fish on the spawning grounds, particularly for the Wenatchee and Methow populations, is an increasing diversity risk, and populations that rely on hatchery spawners are not viable (McElhany et al. 2000). Natural-origin fish now make up fewer than fifty percent of the spawners for two of the three populations (Table 7). Based on the combined ratings for abundance/productivity and spatial structure/diversity, all three extant populations and the ESU remain at high risk of extinction (Table 7).

Table 7. Risk levels and viability ratings for natural-origin UCR spring Chinook salmon populations from the North Cascades MPG (NWFSC 2015).

Population	Minimum Abundance Threshold	Spawning Abundance (2005-2014)	Productivity (2005-2014)	% Natural-origin spawners (2010-2014)	Overall Risk
Wenatchee River	2000	545 (311-1030)	0.60	35	High
Entiat River	500	166 (78-354)	0.94	74	High
Methow River	2000	379 (189-929)	0.46	27	High
Okanogan	750	Extirpated			

Many factors affect the abundance, productivity, spatial structure, and diversity of the UCR Spring Chinook Salmon ESU. Factors limiting the ESU's survival and recovery include:

- past management practices such as the Grand Coulee Fish Maintenance Project
- survival through the FCRPS
- 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
- interbreeding and competition with hatchery fish that far outnumber fish from natural populations.

2.2.1.2. Snake River Spring/summer Chinook Salmon ESU

Spring/summer-run Chinook salmon from the Snake River basin exhibit stream-type life history characteristics. Chinook salmon return to the Columbia River from the ocean in early spring through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they emigrate up into tributary areas and spawn from mid- through late August. The eggs incubate over the following winter, and hatch in late winter and early spring of the following year. Juveniles rear through the summer, overwinter, and typically migrate to sea in the spring of their second year of life, although some juveniles may spend an additional year in fresh water. Snake River spring/summer-run Chinook salmon spend two or three years in the ocean before returning to tributary spawning grounds primarily as 4- and 5-year-old fish. A small fraction of the fish return as 3-year-old "jacks," heavily predominated by males.

Many factors negatively affect the abundance, productivity, spatial structure, and diversity of the Snake River Spring/summer Chinook Salmon ESU. Factors that limit the ESU's survival and recovery include migration through the Federal Columbia River Power System (FCRPS) dams, the degradation and loss of estuarine areas that help fish transition between fresh and marine waters, spawning and rearing areas that have lost deep pools, loss of cover, reductions in side-channel refuge areas, reductions in high-quality spawning gravels, and interbreeding and competition with hatchery fish that may outnumber natural-origin fish (Ford et al. 2011). The most serious risk factor is low natural productivity (spawner-to-spawner return rates) and the associated decline in abundance to low levels relative to historical returns. The biological review team (Ford et al. 2011) was concerned about the number of hatchery programs across the ESU, noting that these programs represent ongoing risks to natural populations and can make it difficult to assess trends in natural productivity. A more detailed description of the populations that are the focus of this consultation follows.

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for SEWA (SRSRB 2011) requires that the Tucannon River population be at low risk (no more than a 1 percent risk of extinction in 100 years). The Tucannon River population is required to meet highly viable status for delisting of the ESU because the Asotin Creek population is extirpated. The most recent status review by NMFS (NWFSC 2015) maintains that the Tucannon population remains at high risk (Table 8).

There are six extant independent populations of spring/summer Chinook salmon within the Grande Ronde/Imnaha MPG: Wenaha River, Lostine River, Minam River, Catherine Creek, Upper Grande Ronde River, and the Imnaha River. The remaining two populations, Lookingglass and Big Sheep Creeks, are functionally extirpated. The ICTRT criteria call for a minimum of four populations at viable or highly viable status. The potential scenario identified by the ICTRT (2007) would include viable populations in the Imnaha River (run timing), the Lostine/Wallowa River (large size) and at least one from each of the following pairs: Catherine Creek or Upper Grande Ronde (large size); and Minam or Wenaha Rivers. The most recent status review by NMFS (NMFS 2015b) maintains that all extant populations remain at high risk of extinction (Table 8).

Table 8. Risk levels and viability ratings for Snake River spring/summer Chinook salmon populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team. Data are from 2005-2014.

Population	ICTRT minimum threshold	Geometric mean natural spawning abundance (standard error)	Proportion natural-origin spawners	Geometric mean productivity (standard error)	Abundance and productivity risk	Spatial structure and diversity risk	Overall viability risk rating
Tucannon	750	267 (0.19)	0.67	0.69 (0.23)	High	Moderate	High
Asotin Creek	Extirpated						
Wenaha	750	399 (0.12)	0.76	0.93 (0.21)	High	Moderate	High
Lostine/Wallowa	1000	332 (0.24)	0.45	0.98 (0.12)	High	Moderate	High
Minam	750	475 (0.12)	0.89	0.94 (0.18)	High	Moderate	High
Catherine Creek	1000	110 (0.31)	0.45	0.95 (0.15)	High	Moderate	High
Up. Grande Ronde	1000	43 (0.26)	0.18	0.59 (0.28)	High	High	High
Imnaha River	750	328 (0.21)	0.35	1.2 (0.09)	High	Moderate	High
Lookingglass Creek	500	Extirpated					
Big Sheep Creek	Extirpated						

2.2.1.3. Snake River Fall Chinook Salmon ESU

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; 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 (mainly from fish that spawned in the Clearwater River), which prevents juveniles from reaching a suitable size to migrate out of the Snake River and on to the ocean.

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). All of the hatchery programs are included in the ESU along with a single natural-origin population that is currently viable, with a low risk for abundance/productivity and a moderate risk for spatial structure and diversity.

The recently released Draft NMFS Snake River Fall Chinook Recovery Plan (NMFS 2015c) says 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 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.

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. 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.

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. Such an increase could be generated by actions such as a reduction in harvest impacts (particularly when natural-origin spawner return levels are below the minimum abundance threshold) and/or further improvements in juvenile survivals during downstream migration. It is also possible that survival improvements resulting from various actions (e.g., improved flow-related conditions affecting spawning and rearing, expanded spill programs that increased passage survivals) in recent years have increased productivity, but that increase is effectively masked as a result of the relatively high spawning levels in recent years. A third possibility is that productivity levels may decrease over time as a result of negative impacts of chronically high hatchery proportions across natural spawning areas. Such a decrease would also be largely masked by the high annual spawning levels (NWFSC 2015).

The Snake River Fall-run Chinook Salmon ESU remains at threatened status (NMFS 2015b). Factors that limit the ESU’s survival and recovery include: hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford et al. 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 2012d).

2.2.1.4. **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 (Table 6). Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706) (Table 6).

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 9), 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 2005c). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005b).

Table 9. LCR Chinook Salmon ESU description and MPGs (NMFS 2013b; Jones 2015; NWFSC 2015).

ESU Description[1]	
Threatened	Listed under ESA in 1999; updated in 2014 (Table 6)
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 (2 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

ESU Description[1]	
	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 compose the LCR Chinook Salmon ESU. These are distributed through three ecological zones[3], which, 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 10). The run-timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Figure 3).

Table 10. Current status for LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013b).

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

[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 (2013b).

[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 (Myers 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]
	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

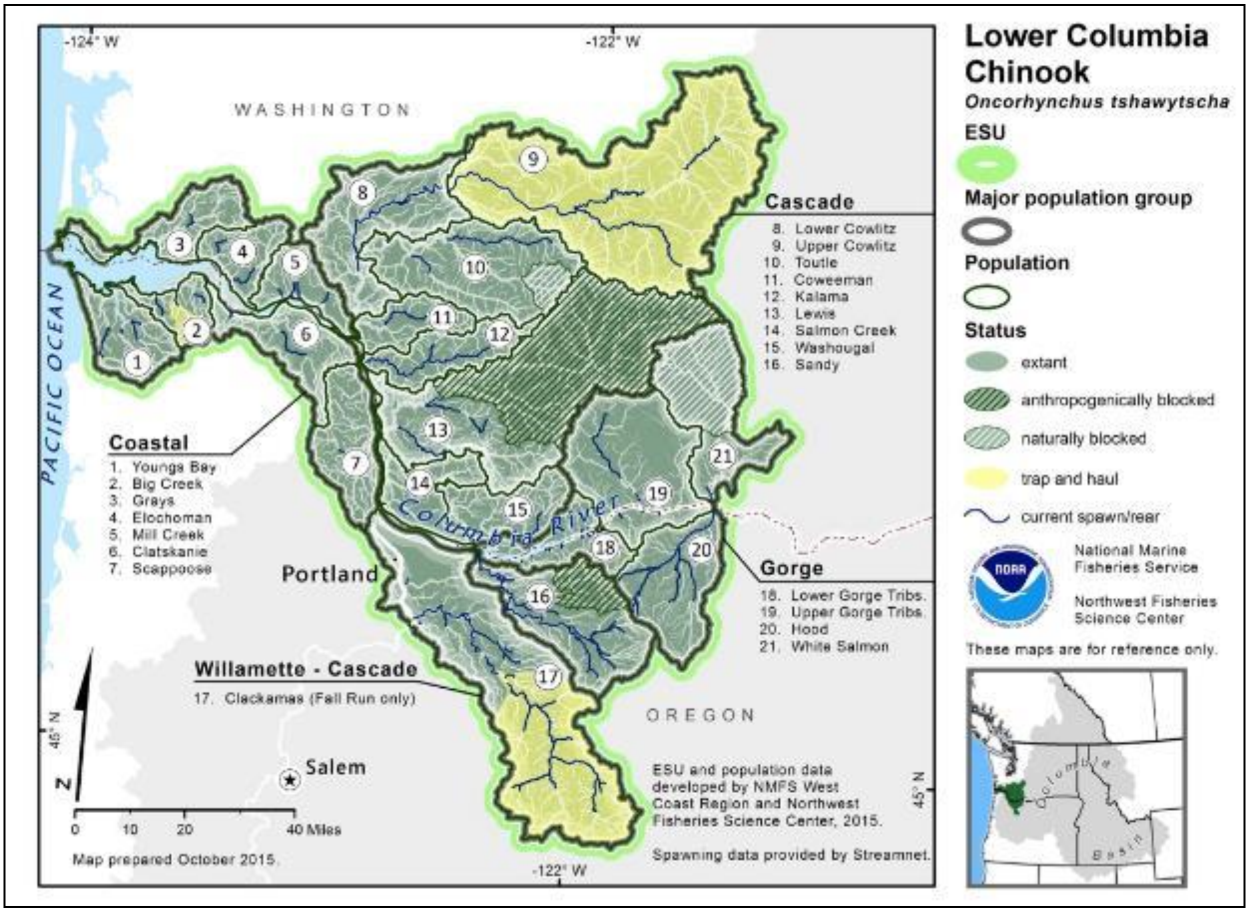

Figure 3. Map of the LCR Chinook Salmon ESU’s spawning and rearing areas, illustrating populations and MPGs. Several watersheds contain or historically contained both fall and spring runs; only the fall-run populations are illustrated here (NWFSC 2015).

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 11). 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 main stem Columbia (NMFS 2013b). 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 2013b).

Table 11. Life history and population characteristics of LCR Chinook salmon.

Characteristic	Life-History Features		
	Spring	Early-fall (tule)	Late-fall (bright)
Number of extant population	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	Main stem large tributaries	Main stem 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 main stem	Main stem, tributaries, sloughs, estuary	Main stem, 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) (LCFRB 2010). 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).

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 10, 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 10 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 (2013b) 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.

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 10 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.

2.2.1.5. **Upper Willamette River Spring 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 on April 14, 2014 (79 FR 20802) (Table 6). Critical habitat was designated on June 28, 2005 (70 FR 37160) (Table 6).

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 4). The ESU contains seven historical populations, within a single MPG (western Cascade Range, Table 12).

Table 12. UWR Chinook salmon ESU description and major population group (MPG) (Jones Jr. 2015; NMFS 2016b).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014 (see Table 6)
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, Middle Fork Willamette River
Artificial production	
Hatchery programs included in ESU (6)	McKenzie River spring, North Santiam spring, Mollala 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 serve 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 from reaching the UWR basin (NMFS and ODFW 2011).

The generalized life history traits of UWR Chinook are summarized in Table 13. Today, adult UWR Chinook salmon begin appearing in the lower Willamette River in January, with fish entering the Clackamas Rivers 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).

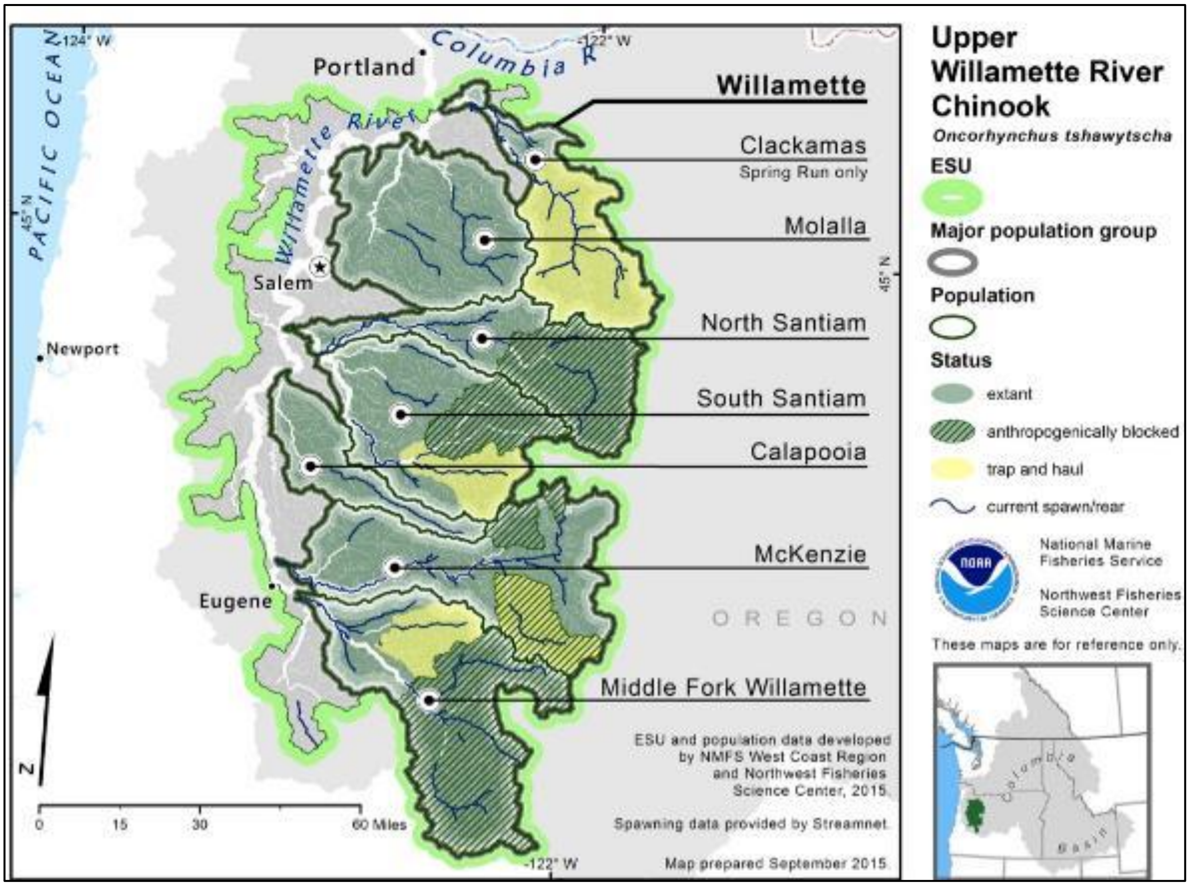

Figure 4. Map of the UWR Chinook Salmon ESU's spawning and rearing areas, illustrating populations and major population groups (From NWFSC 2015).

Chinook 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 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 Guilds Lakes. 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 13. 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

Life-History Trait	Characteristic
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	Predominately north, as far as southeast Alaska
Age at return	3-6 years, primarily 4-5 years

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

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 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 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, it is thought 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 individual 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 the North and South Santiam Rivers have risen since the last review (Ford et al. 2011), but still range only in the high hundreds of fish. Improvements in the status of the Middle Fork Willamette River population relates solely to the return of natural adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the Middle Fork Willamette River individual population. The status review incorporates valuable information from the Fall Creek program that is relevant to the use of reservoir draw downs as a method of juvenile downstream passage. The proportion of natural-origin spawners improved in the North and South Santiam Basins, but was still below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production in the Molalla River. Additionally, the Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but both individual populations experienced declines in abundance[4] (NWFSC 2015).

All seven historical populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the Western Cascade Range (Table 14).

Table 14. 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 (From NMFS 2016b).

The Clackamas and McKenzie River populations had the best overall risk ratings for A/P, spatial structure, and diversity, as of 2016. Data collected since the BRT status update in 2005 highlighted 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 (NMFS 2016b). Furthermore, no data is available for natural-origin spawner abundance for UWR Chinook salmon populations.

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 15) (NWFSC 2015).

[4] 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.

Table 15. 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	Middle Fork Willamette River	0	3

2.2.1.6. Upper Columbia River Steelhead DPS

Steelhead (*O. mykiss*) occur as two basic anadromous run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type (inland), or summer steelhead, enters freshwater in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type (coastal), or winter steelhead, enters freshwater with well-developed gonads and spawns shortly after river entry (Barnhart 1986).

UCR steelhead are summer steelhead, returning to freshwater between May and October, and require up to 1 year in freshwater to mature before spawning (Chapman et al. 1994). Spawning occurs between January and June. In general, summer steelhead prefer smaller, higher-gradient streams relative to other Pacific salmon, and they spawn farther upstream than winter steelhead (Behnke and American Fisheries Society 1992; Withler 1966). Progeny typically reside in freshwater for two years before migrating to the ocean, but freshwater residence can vary from 1-7 years (Peven et al. 1994). For UCR steelhead, marine residence is typically one year, although the proportion of two-year ocean fish can be substantial in some years. They migrate directly offshore during their first summer rather than migrating nearer to the coast as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986).

The UCR Steelhead DPS includes all naturally spawned steelhead populations below natural and man-made impassable barriers in streams in the Columbia River Basin upstream of the Yakima River, Washington to the U.S.–Canada border. The UCR Steelhead DPS also includes six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan rivers), WNFH, Omak Creek, and the Ringold steelhead hatchery programs.

The UCR Steelhead DPS consisted of three MPGs before the construction of Grand Coulee Dam, but it is currently limited to one MPG with four extant populations: Wenatchee, Methow, Okanogan, and Entiat. A fifth population in the Crab Creek drainage is believed to be functionally extinct. What remains of the DPS includes all naturally spawned populations in all tributaries accessible to steelhead upstream from the Yakima River in Washington State, to the U.S. – Canada border (
Figure **5**).

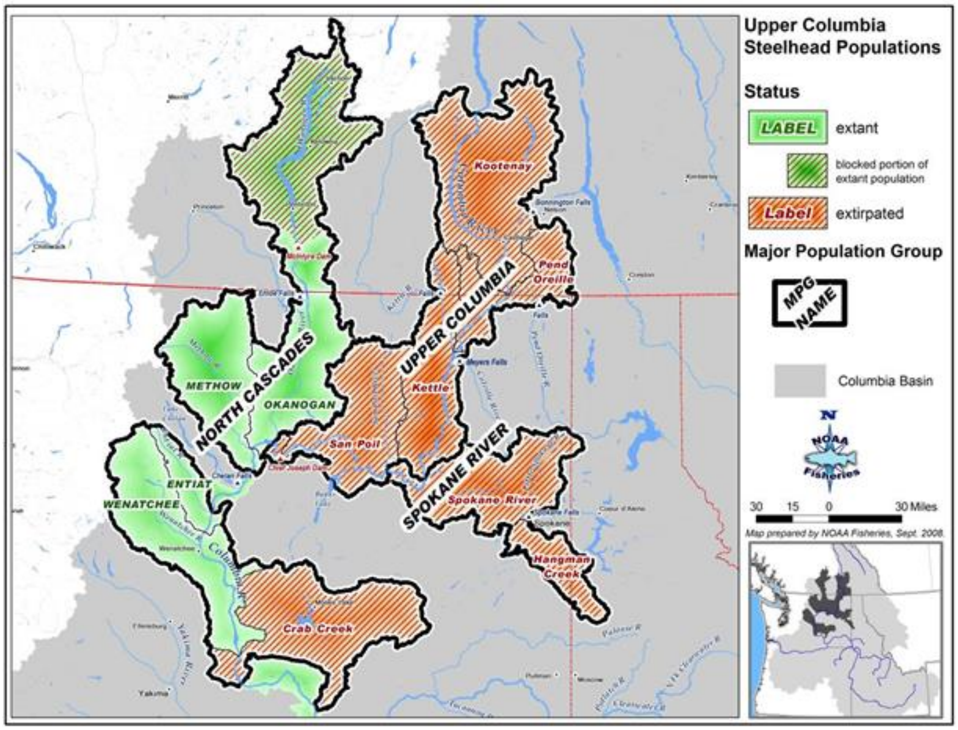

Figure 5. Upper Columbia River Steelhead DPS (ICTRT 2008).

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 UCR Steelhead DPS is at high risk and remains at threatened status. The ESA Recovery Plan (UCSRB 2007) requires each of the four extant steelhead populations to be viable. For the 2005-2014 period, abundance has increased for natural-origin spawners in each of the four extant populations (Table 16). However, natural-origin returns remain well below target levels for three of the four populations. Productivity remained the same for three of the four populations and decreased for the Entiat population relative to the last review (Ford et al. 2011). For spatial structure and diversity, hatchery origin returns continue to constitute a high fraction (Table 16) of total spawners in natural spawning areas for the DPS as a whole (NWFSC 2015). The predominance of hatchery fish on the spawning grounds is an increasing risk, and populations that rely solely on hatchery spawners are not viable over the long-term (McElhany et al. 2000). Based on the combined ratings for abundance/productivity and spatial structure/diversity, three of the four extant populations and the DPS remain at high risk of extinction.

Table 16. Risk levels and viability ratings for natural-origin UCR steelhead populations (NWFSC 2015).

Population	Minimum Abundance Threshold	Spawning Abundance (2005-2014)	Productivity (2005-2014)	% Natural-origin spawners (2010-2014)	Overall Risk
Wenatchee River	1000	1025 (386-2235)	1.207	58	Maintained
Entiat River	500	146 (59-310)	0.434	31	High
Methow River	1000	651 (365-1105*)*	0.371	24	High
Okanogan River	750	189 (107-310)	0.154	13	High

Many factors affect the abundance, productivity, spatial structure, and diversity of the UCR Steelhead DPS. Factors limiting the DPS's survival and recovery include:

- past management practices such as the Grand Coulee Fish Maintenance Project
- survival through the FCRPS
- 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
- predation by native and non-native species
- harvest
- interbreeding and competition with hatchery fish that far outnumber fish from natural populations

2.2.1.7. **Snake River Steelhead DPS**

O. mykiss exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident, and under some circumstances, yield offspring of the opposite form. Steelhead are the anadromous form. A non-anadromous form of *O. mykiss* (redband trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate. Steelhead can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus*, except *O. clarkii*, spawn once and then die (semelparous). Snake River steelhead are classified as summer-run because they enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn the following spring (March to May). Factors that limit the DPS's survival and recovery include: juvenile and adult migration through the FCRPS; the degradation and loss of estuarine areas that help fish transition between fresh and marine waters; spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, high quality spawning gravels, and; interbreeding and competition with hatchery fish that outnumber natural-origin fish. A more detailed description of the populations that are the focus of this consultation follows.

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for southeast Washington (SRSRB 2011) requires that the Tucannon River population be at moderate risk and for the Asotin Creek population to be at low risk of extinction. The most recent status review (NWFSC 2015) found that the Tucannon River population remains at high risk, and the Asotin Creek population is maintained (Table 17). However, both populations have insufficient data on abundance and productivity to assess accurately these metrics.

There are four independent populations of steelhead within the Grand Ronde MPG: Joseph Creek, Lower Grand Ronde River, Upper Grand Ronde River, and Wallowa River. The Draft ESA Recovery Plan for northeast Oregon (NMFS 2012a) requires that the Upper Grand Ronde and Wallowa River populations have a minimum of moderate risk, the Joseph Creek population maintain its current low risk status, and the Lower Grand Ronde population achieve low or moderate risk. Although these populations are close to achieving recovery requirements, there is a large amount of uncertainty in the data.

There is one independent population of steelhead within the Imnaha MPG, the Imnaha River population. The Draft ESA Recovery Plan for northeast Oregon (NMFS 2012a) requires that the Imnaha River population achieve low risk. NMFS' status review (NWFSC 2015) found that information for this population is insufficient to be able to assess risk reliably, but estimates the population is most likely at moderate risk of extinction (Table 17).

Table 17. Risk levels and viability ratings for Snake River steelhead populations (NWFSC 2015). Parentheses indicate range. Data are from 2004-2015. ID = insufficient data; ICTRT = Interior Columbia Technical Recovery Team.

Population	ICTRT minimum threshold	Natural spawning abundance	Productivity	Abundance and productivity risk	Spatial structure and diversity risk	Overall risk viability rating
Tucannon River	1000	ID	ID	High[1]	Moderate	High[1]
Asotin Creek	500	ID[2]	ID	Moderate[1]	Moderate	Moderate[1]
Lo. Grande Ronde	1000	ID	ID	[1]	Moderate	Moderate[1]
Joseph Creek	500	1839	1.86	Very low	Low	Low
Up. Grande Ronde	1500	1649 (0.21)	3.15 (0.4)	Moderate	Moderate	Moderate
Wallowa River	1000	ID	ID	High[1]	Moderate	High[1]
Imnaha River	1000	ID	ID	Moderate[1]	Moderate	Moderate[1]

[1]Uncertain due to lack of data, only a few years of data, or large gaps in data series.
2Monitoring beginning in 2005 suggests that the average annual natural-origin population seems is ~900-1100 (J. Bumgarner, WDFW, personal communication, April 6, 2017).

2.2.1.8. Mid-Columbia River Steelhead DPS

On March 25, 1999, NMFS listed the Mid-Columbia River 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 Mid-Columbia River steelhead was designated on September 2, 2005 (70 FR 52808) (Table 6).

The Mid-Columbia River 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 (Figure 6). Four MPGs, composed of 19 historical populations (2 extirpated), compose the Mid Columbia River Steelhead DPS (Figure 6). 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 18).

Table 18. MCR Steelhead DPS description and MPGs (Jones 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014 (see Table 6)
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 Mainsteam 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.

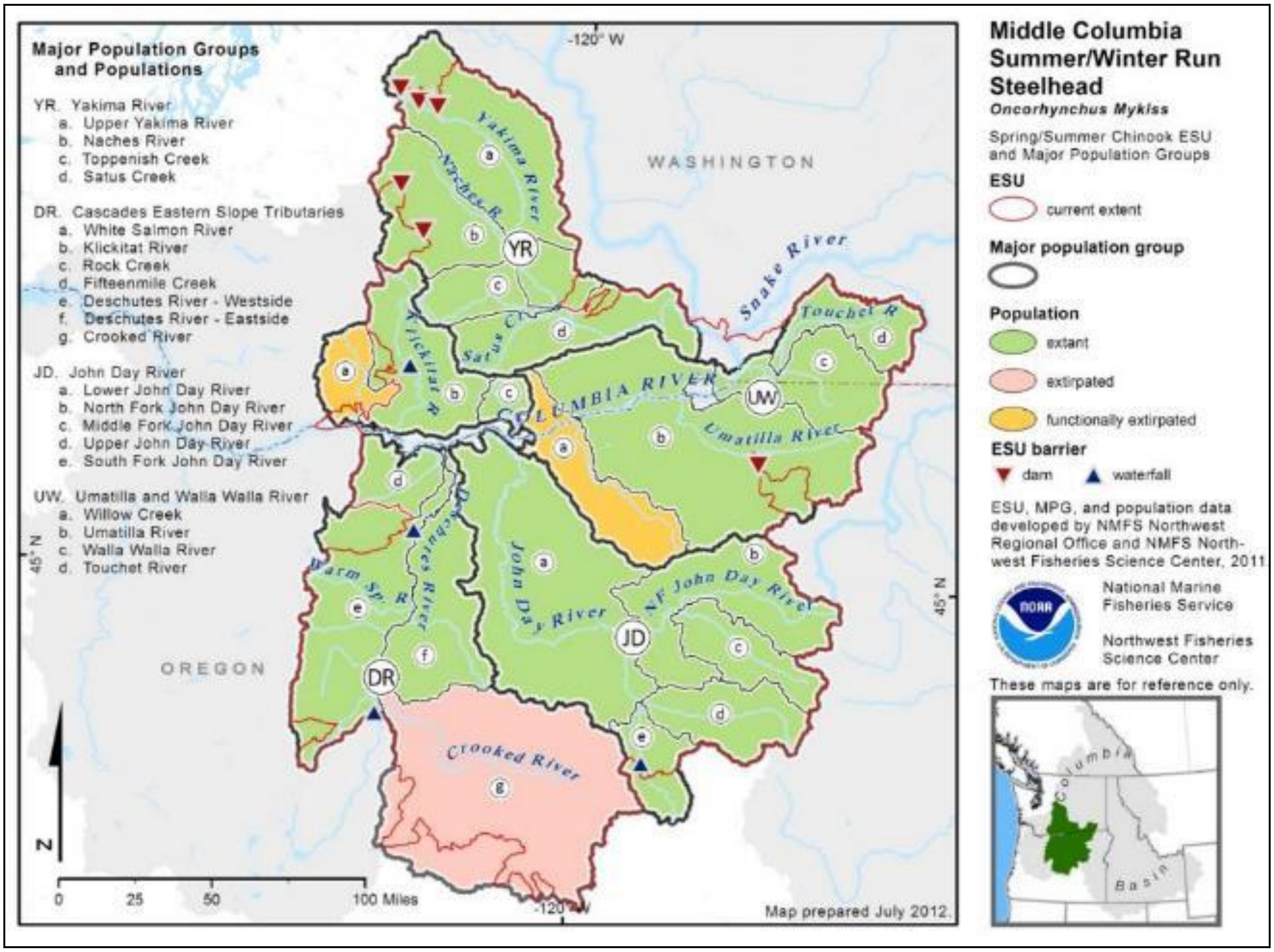

Figure 6. Map of the MCR Steelhead DPS's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering fresh water, where they may remain up to a year before spawning (Howell et al. 1985; BPA 1992). Summer steelhead typically enter freshwater from June through October with peak entry occurring in July (Busby et al. 1996). Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. A non-anadromous form of *O. mykiss* (redband trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate.

Best available information indicates that 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).

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 19) (NMFS 2009).

Table 19. 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 €. 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 are provided below; such information for the remaining three populations is not available. In the 2010 status review, Ford et al. (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 19). 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 19). 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 (http://odfwrecoverytracker.org/explorer/).

The most recent status review update (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).

2.2.1.9. **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) (Table 6). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833) (Table 6).

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).

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 20). Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, Oregon, and from the Little White Salmon and 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 22). There are six summer populations and seventeen winter populations (Figure *7*).

Table 20. LCR Steelhead DPS description and MPGs (Jones 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA in 1998; updated in 2014 (see Table 6)
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

DPS Description	
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 2013b).

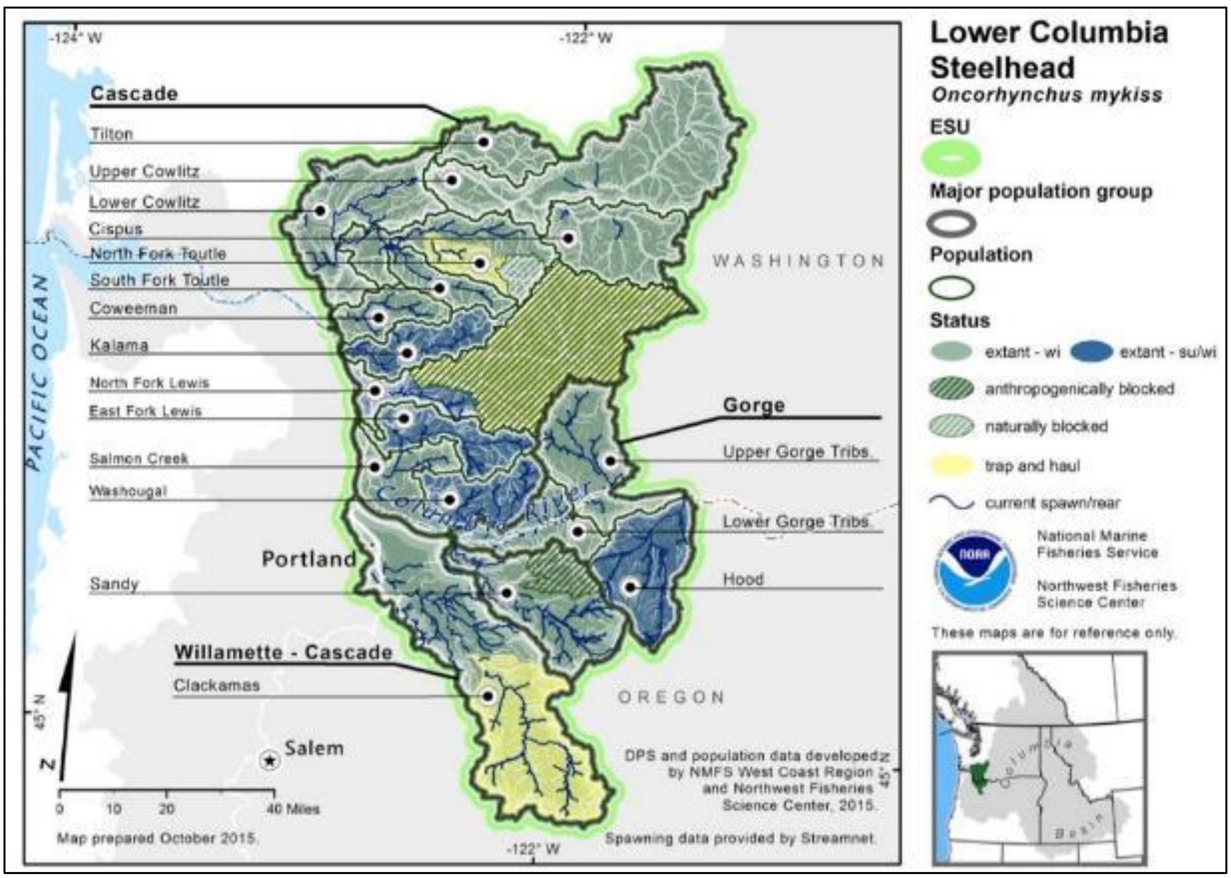

Figure 7. Map of populations in the LCR Steelhead DPS (NWFSC 2015).

LCR basin populations include summer and winter steelhead (Table 21). The two life history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013b). Generally, summer steelhead enter fresh water from May to October in a sexually immature condition, and require several months in fresh water to reach sexual maturity and spawn between late February and early April. Winter steelhead enter fresh water 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).

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 21, 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 21. Current status for LCR steelhead populations and recovery scenario targets (NMFS 2013b).

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 (2013b).
[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 2013b).
* 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 21 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 2013b).

NMFS (2013b) 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 number 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.

2.2.1.10. Upper Willamette River Steelhead DPS

On March 25, 1999, NMFS listed the Upper Willamette River (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) (Table 6). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52848) (Table 6).

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 4 historical populations, represents 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 22, Figure 8) (Jones 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).

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 8) (NWFSC 2015).

Table 22. UWR Steelhead DPS description and MPGs.[1]

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014 (see Table 6)
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 2015; NWFSC 2015).

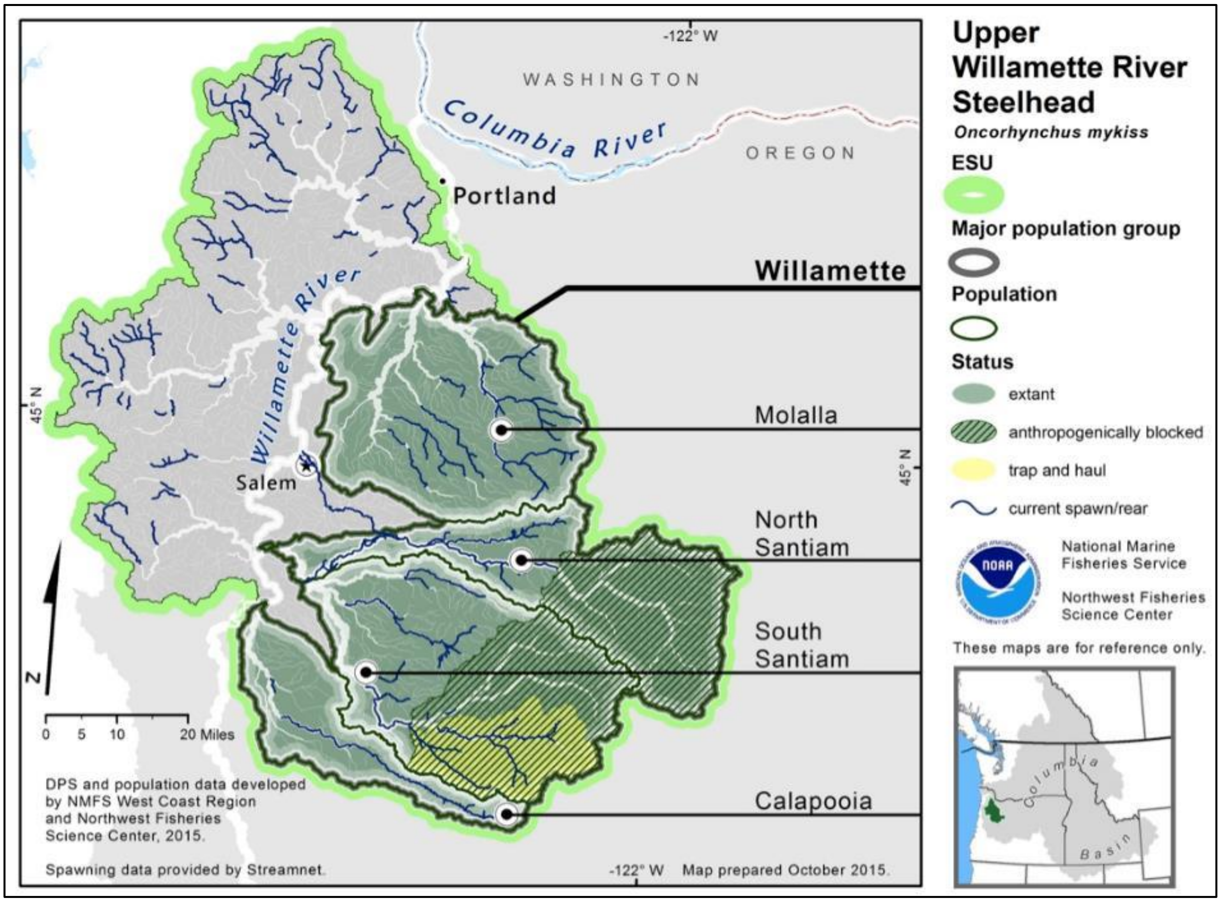

Figure 8. UWR Steelhead DPS spawning and rearing areas, illustrating populations and MPGs (From NWFSC 2015).

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). Table 23 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).

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, migration downstream through the mainstem Willamette and Columbia River estuaries and into the ocean occurs. The downstream migration speed depends on factors including river flow, temperature, turbidity, and others, but 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 Canada and Alaska and into the North Pacific including the Alaska Gyre (Table 23) (Myers et al. 2006; ODFW 2010b).

Table 23. A summary of the general life history characteristics and timing of UWR steelhead. Data are from (From 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 et al. 2011). There is additional incidental mortality in the commercial net fisheries for Chinook salmon and steelhead in the LCR. Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

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 Middle Fork 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 hybrids of summer and winter steelhead at Willamette Falls and in the Santiam Basin (Johnson et al. 2013; NWFSC 2015).

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 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, population abundance estimates based on spawner (redd) surveys are only available for the Molalla River and associated tributaries (Pudding River, Abiqua Creek) 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 migrational 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 (2010-1014) is only 1195 ± 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 the 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 online data on natural-origin spawner abundances for the four populations in the MPG are summarized below in Table 24.

Table 24. UWR Steelhead DPS natural-origin spawner abundance estimates for the four populations in the MPG from 1997-2008 (no data available after 2008) (ODFW Salmon & Steelhead Recovery Tracker[1])*.

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

[1] Data available at: http://odfwrecoverytracker.org/explorer/
*Date Accessed: April 29, 2016

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 25). The elimination of winter hatchery release 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 et al. 2011; NWFSC 2015).

Table 25. Scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall viability risk for UWR steelhead populations (NMFS 2011a).[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 viable 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 26).

Table 26. 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

Note: 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.

2.2.1.11. Snake River Sockeye Salmon ESU

While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historical population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean. 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, and to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are currently the southernmost population of sockeye salmon in the world (NMFS 2015a).

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). At this stage of the recovery efforts, there is only one extant population, and the ESU remains endangered with a high risk for spatial structure, diversity, abundance, and productivity (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 2015a).

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. 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) (NMFS 2018). 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).

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 2015a; 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 2015a; 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 2015a).

The recovery plan (NMFS 2015a) 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 2015a).

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).

2.2.1.12. **Columbia River Chum Salmon ESU**

On March 25, 1999, NMFS listed the Columbia River (CR) Chum Salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014 (Table 6). 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 27 lists these hatchery programs, with three included in the ESU and one excluded from the ESU.

Table 27. CR 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 2013b).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014 (see Table 6)
3 major population groups	17 historical populations
Major Population Group	**Populations**
Coast	Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamakowa (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 27. This ESU is composed of three MPGs, with 17 populations (Table 28). 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 9).

Table 28. Current status for CR chum salmon populations and recommended status under the recovery scenario (NMFS 2013b).

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/Skamakowa (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

Major Population Group	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution	Target Persistence Probability[2]	Abundance Target[3]
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.

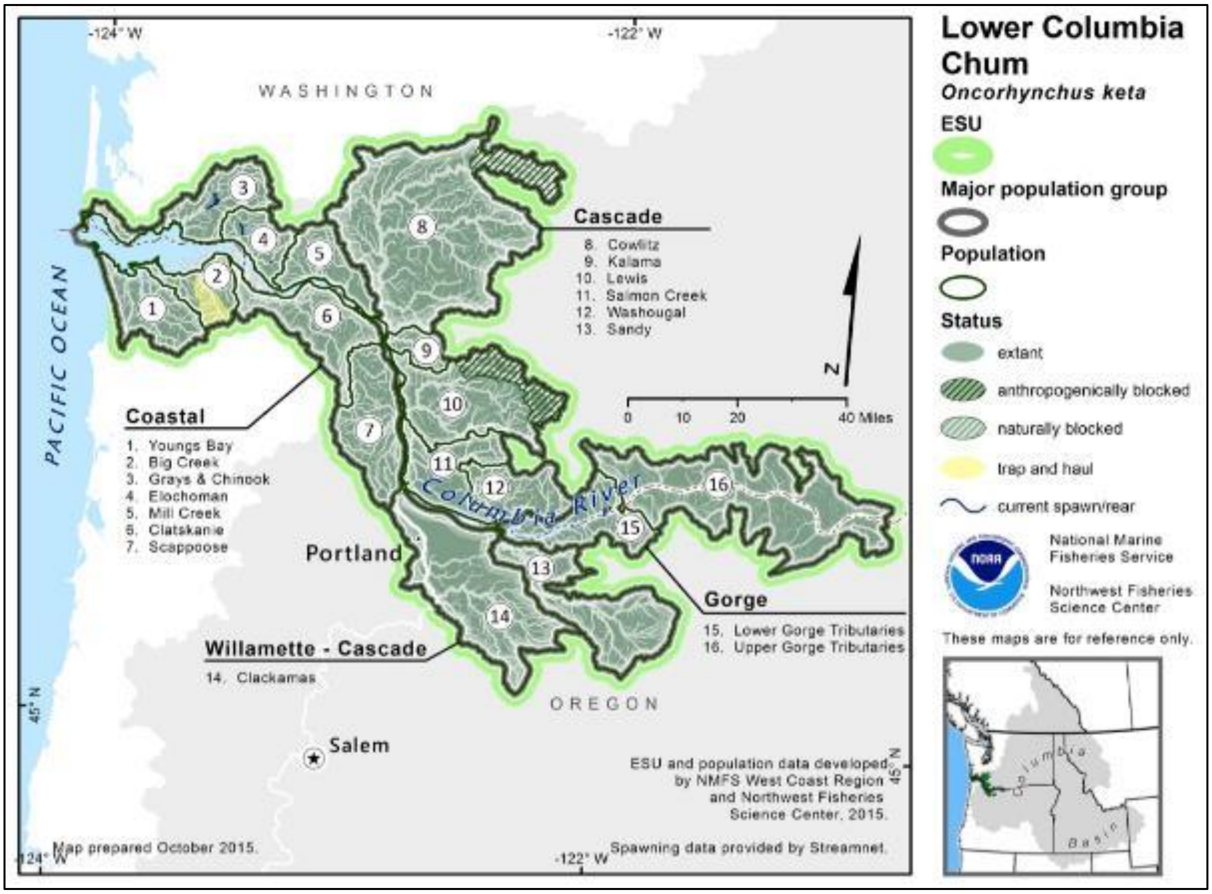

Figure 9. Map of the CR Chum Salmon ESU's spawning and rearing areas, illustrating populations and major population groups (From NWFSC 2015).

Columbia River chum salmon are classified as fall-run fish, entering fresh water from mid-October through November and spawning from early November to late December in the lower main stems of the 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 28). 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 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 2013c). 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 2013c). 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 2010). All chum salmon die after spawning once.

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 population baseline and target persistence probability is summarized in Table 28 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 greather 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 2013b). Of the 17 populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low, extirpated, or nearly so (Ford et al. 2011; NMFS 2013b; 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 28 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 and the Lower Gorge. The most recent total abundance information for Columbia River chum salmon in Washington is provided in Table 29, including chum salmon counted passing Bonneville Dam. For the other Washington populations not listed in Table 29 and all Oregon populations there are only occasional reports of only a few chum salmon (NWFSC 2015).

Table 29. Peak spawning ground counts for fall chum salmon in index reaches in the LCR, and Bonneville Dam counts 2001-2014 (from WDFW SCORE[1])*.

Return Year	Grays River				Hamilton Creek Total	Hardy Creek	Main stem 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	na	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

[1] online at https://fortress.wa.gov/dfw/score/score/species/chum.jsp?species=Chum
*Date Accessed: April 12, 2016.

The methods and results for categorizing spatial distribution from the LCFRB Plan (2010) for Columbia River chum salmon populations are reported in the recovery plan, and updated scores are summarized here in Table 31. 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 (LCRFRB 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 31). 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 30. 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 2013a).[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
Cascade Range	Summer	Cowlitz River (WA)	VL	L	L	VL
	Fall	Cowlitz River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		Lewis River (WA)	VL	H	L	VL
		Salmon Creek (WA)	VL	L	L	VL
		Clackamas River (OR)	*	*	*	VL
		Sandy River (OR)	*	*	*	VL
		Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Fall	Lower Gorge (WA & OR)	VH	H	VH	H
		Upper Gorge (WA & OR)	VL	L	L	VL

[1] Ratings range from low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2013b; NWFSC 2015).
* No data are available to make a quantitative assessment.

The most recent status review (NWFSC 2015) concluded that a total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0 (Table 31). 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 individual populations in this ESU remain at a high or very high risk category and considereable progress remains to be made to achieve the recovery goals (NWFSC 2015).

Table 31. Summary of VSP scores and recovery goals for CR chum salmon populations (NWFSC 2015).

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	Clatskamie	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

Notes: 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.

2.2.1.13. 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 for designation on January 14, 2013, and was finalized on January 24, 2016 (81 FR 9252) (Table 6).

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 10). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160). LCR coho salmon are divided into 3 major population groups, with the majority of the populations and associated hatchery programs located below Bonneville Dam (
Table 32). NMFS has determined that any effects from the Proposed Action would be limited to Gorge MPG, primarily the Upper Gorge/White Salmon, and the Upper Gorge/Hood River populations due to the proximity to the LWS NFH. Generally, these populations have low baseline persistence probabilities (Table 33).

Table 32. LCR Coho Salmon ESU description and MPGs (Jones Jr. 2011; NMFS 2013b).[5]

ESU Description	
Threatened	Listed under ESA in 2005; updated in 2014 (see Table 6)
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, 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 Jr. 2015)

Table 33. Current status for LCR coho salmon Gorge MPG populations and recommended status under the recovery scenario (NMFS 2013b).

Major Population Group	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution[2]	Target Persistence Probability	Abundance Target[3]
Gorge	Lower Gorge (WA/OR) - *Late*	VL	Primary	H	1,900
	Upper Gorge/White Salmon (WA) - *Late*	VL	Primary	H	1,900

[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.

Major Population Group	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution[2]	Target Persistence Probability	Abundance Target[3]
	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.

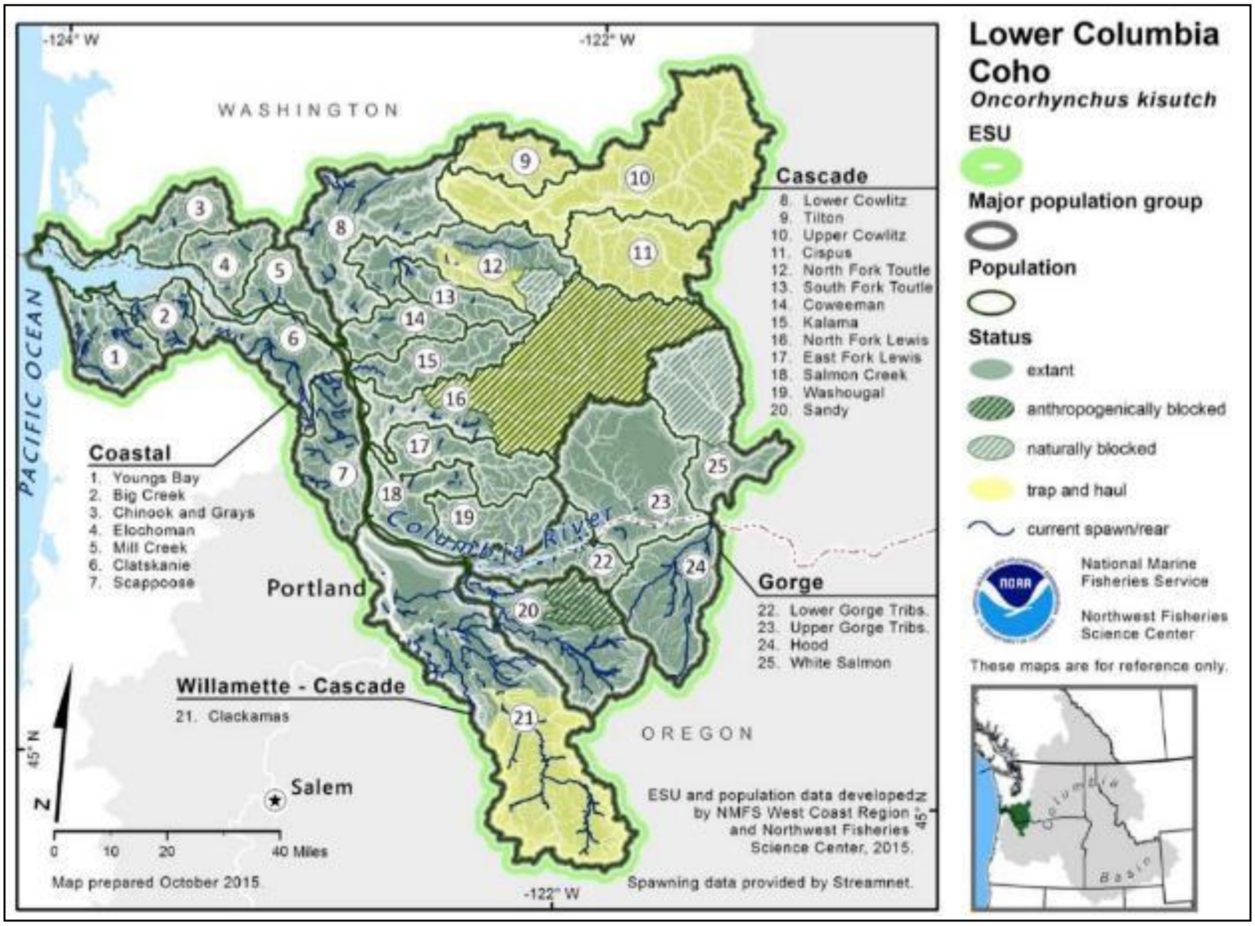

Figure 10. Map of the LCR Coho Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

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 34) 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 fresh water 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 2013b).

Table 34. 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

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 2013b).

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 LCR Coho Salmon ESU is at high risk and remains at threatened status. Each population's baseline and target persistence probabilities is summarized in Table 33, 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 persistence over 100 years less than 40%) to very high (probability greater than 99%).

Table 35 presents escapement of LCR coho salmon in Oregon Gorge tributaries (2002- 2015). Table 36 presents escapement of LCR coho salmon in Washington Gorge tributaries (2002 - 2015). 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.

Table 35. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015 (*http://www.odfwrecoverytracker.org/*)*.

Major Population Group	Oregon Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gorge	Lower Gorge	Natural	338	-	-	263	226	126	223	468	920	216	96	151	362	30
		pHOS	17%	-	-	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%	-	-	45%	48%	45%	29%	0%	85%	69%	78%	65%	76%	64%

*Date accessed: April 13, 2016.

Table 36. Natural-origin spawning escapement numbers and the proportion of all natural spawners composed of hatchery-origin fish (pHOS[1]) 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
Gorge	Lower Gorge	Natural	-	-	-	-	28	-	-	-	385	504	524	-	704	650
		pHOS	-	-	-	-	0%	-	-	-	29%	13%	20%	-	35%	11%
	Upper Gorge/ Hood	Natural	-	-	-	-	-	152	86	71	35	111	96	106	24	80
		pHOS	-	-	-	-	-	-	-	-	-	-	-	-	23%	24%

** Date accessed: April 13, 2016*

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.

In the 2015 status review (NWFSC 2015), NMFS 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 a very high risk and remains at threatened status.

2.2.2. Range-wide Status of Critical Habitat

NMFS determines the range-wide status of critical habitat by examining the condition of its PBFs 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. An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 6).

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
(2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;
(4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation;
(5) Near-shore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels;
(6) Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The status of critical habitat is based primarily on a watershed-level analysis of conservation value that focused on the presence of ESA-listed species and physical features that are essential to the species' conservation. NMFS organized information at the 5th field hydrologic unit code

(HUC) watershed scale because it corresponds to the spatial distribution and site fidelity scales of salmon and steelhead populations (McElhany et al. 2000). The analysis for the 2005 designations of salmon and steelhead species was completed by Critical Habitat Analytical Review Teams (CHARTs) that focused on large geographical areas corresponding approximately to recovery domains (NMFS 2005b). Each watershed was ranked using a conservation value attributed to the quantity of stream habitat with physical and biological features (PBFs; also known as primary and constituent elements ((PCEs)), the present condition of those PBFs, the likelihood of achieving PBF potential (either naturally or through active restoration), support for rare or important genetic or life history characteristics, support for abundant populations, and support for spawning and rearing populations. In some cases, our understanding of these interim conservation values has been further refined by the work of technical recovery teams and other recovery planning efforts that have better explained the habitat attributes, ecological interactions, and population characteristics important to each species.

The HUCs that have been identified as critical habitat for these species are largely ranked as having high conservation value. Conservation value reflects several factors: (1) how important the area is for various life history stages, (2) how necessary the area is to access other vital areas of habitat, and (3) the relative importance of the populations the area supports relative to the overall viability of the ESU or DPS.

No CHART reviews have been conducted for the two Snake River Chinook Salmon ESUs and Snake River Sockeye Salmon ESU. The description of critical habitat for the other species are described below.

Critical Habitat for Upper Columbia River Spring Chinook Salmon
The UCR Spring Chinook Salmon ESU's range consists of 31 watersheds. The CHART assigned 5 watersheds a medium rating, and 26 received a high rating of conservation value to the ESU (NMFS 2005b). The following are the major factors limiting the conservation value of UCR spring Chinook salmon critical habitat:

- Forestry practices
- Fire activity and disturbance
- Livestock grazing
- Agriculture
- Channel modifications/diking
- Road building/maintenance
- Urbanization
- Sand and gravel mining
- Mineral mining
- Dams
- Irrigation

Critical Habitat for Upper Columbia River Steelhead
The UCR Steelhead DPS's range includes 42 watersheds. The CHART assigned low, medium, and high conservation value ratings to 3, 8, and 31 watersheds, respectively (NMFS 2005b). The

following are the major factors limiting the conservation value of critical habitat for UCR steelhead:

- Forestry practices
- Grazing
- Agriculture
- Channel modifications/diking
- Road building/maintenance
- Urbanization
- Sand and gravel mining
- Mineral mining
- Dams
- Irrigation impoundments and withdrawals
- River, estuary, and ocean traffic
- Wetland loss/removal
- Beaver removal
- Exotic/invasive species introductions
- Forage fish/species harvest

Critical Habitat for Snake River Steelhead DPS
The Snake River Steelhead DPS's range includes 291 watersheds. The CHART assigned low, medium, and high conservation value ratings to 14, 43, and 230 watersheds, respectively (NMFS 2005b). They also identified 4 watersheds that had no conservation value. The following are the major factors limiting the conservation value of critical habitat for Snake River steelhead:

- Agriculture
- Channel modifications/diking
- Dams,
- Forestry
- Fire activity and disturbance
- Grazing
- Irrigation impoundments and withdrawals,
- Mineral mining
- Recreational facilities and activities management
- Exotic/ invasive species introductions

Critical Habitat for Mid-Columbia River Steelhead
The Mid-Columbia River Steelhead DPS's range includes 111 watersheds. The CHART assigned low, medium, and high conservation value ratings to 9, 24, and 78 watersheds, respectively (NMFS 2005a). They also identified 1 watershed with an unknown conservation value. The following are the major factors limiting the conservation value of critical habitat for Mid-Columbia River steelhead:

- Agriculture
- Channel modifications/diking
- Dams,

- Forestry
- Fire activity and disturbance
- Grazing
- Irrigation impoundments and withdrawals,
- Urbanization
- Road building/maintenance

2.2.3. Climate Change

Climate change has negative implications for salmonid species and designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). For a detailed discussion of climate change and how it affects salmonid species in the Pacific Northwest, see below in Section 2.4.2.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area resulting from this analysis includes the mainstem Columbia River from below Priest Rapids Dam on the mainstem Columbia River through the estuary (i.e., mouth of the Columbia River), which is a migration corridor for outmigrating juveniles.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. Habitat and Hydropower

A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017c). Here we summarize some of the key impacts on salmon and steelhead habitat in the Action Area.

Anywhere hydropower exists, some general effects exist on salmon habitat, though those effects vary depending on the hydropower system. In the Action Area, some of these general effects from hydropower systems on biotic and abiotic factors include, but are not limited to:

- Juvenile and adult passage survival (safe passage in the migration corridor);

- Water quantity (i.e., flow) and seasonal timing (water quantity and velocity and safe passage in the migration corridor; cover/shelter, food/prey, riparian vegetation, and space associated with the connectivity of the estuarine floodplain);
- Temperature in the reaches below the large mainstem storage projects (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 the migration corridor)

While harmful land-use practices continue in some areas, many land management activities, including forestry practices, now have fewer impacts on salmonid habitat due to 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. In addition, the Federal Conservation Reserve and Enhancement Program (CREP) began in the 1990's nearly 80 percent of all salmonid bearing streams in the area have been re-vegetated with native species and protected from impacts. Under the CREP, highly erodible and other environmentally sensitive lands that have produced crops are converted to a long-term resource-conserving vegetative cover. Participants in the CREP are required to seed native or introduced perennial grasses or a combination of shrubs and trees with native forbs and grasses.

Mainstem Columbia River
A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017c). The baseline includes all federally-authorized hydropower projects, including projects with licenses issued by the Federal Energy Regulatory Commission, the Federal Columbia River Power System, and other developments which have undergone ESA §7 consultation. Furthermore, the mainstem dams and the associated reservoirs present fish-passage hazards, 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 (NMFS 2017c). Mainstem dams and reservoirs can also affect water quality by influencing temperature due to storage, diversions, and irrigation return flows, reducing turbidity, increasing total dissolved gas, and contributing toxic contaminants. All of these impacts affect the migration of adults and juveniles in the mainstem Columbia River.

2.4.2. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. As the climate changes, air temperatures in the Pacific Northwest are expected to increase <1°C in the Columbia Basin by the 2020s and 2°C to 8°C by the 2080s (Mantua et al. 2010). Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2015c).

These changes will not be spatially homogenous across the entire Pacific Northwest. There is likely no trend in precipitation (neither strongly increase nor decrease), although summers may become drier and winters wetter due to changes in the same amount of precipitation being subjected to altered seasonal temperatures (Mote and Eric P. Salathé Jr. 2010; PCIC 2016). Warmer winters will result in reduced snowpack throughout the Pacific Northwest, leading to substantial reductions in stream volume and changes in the magnitude and timing of low and high flow patterns (Beechie et al. 2013; Dalton et al. 2013). Many basins that currently have a snowmelt-dominated hydrological regime (maximum flows during spring snow melt) will become either transitional (high flows during both spring snowmelt and fall-winter) or rain-dominated (high flows during fall-winter floods; (Beechie et al. 2013; Schnorbus et al. 2014). Summer low flows are expected to be reduced between 10-70% in areas west of the Cascade Mountains over the next century, while increased precipitation and snowpack is expected for the Canadian Rockies. More precipitation falling as rain and larger future flood events are expected to increase maximum flows by 10-50% across the region (Beechie et al. 2013). Climate change is also 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.

The effects of climate change are likely to be already occurring, though the effects are difficult to distinguish from effects of climate variability in the near term. Climate change is currently causing, and is predicted to cause in the future, a variety of impacts on Pacific salmon as well as their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some impacts (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific (e.g., stream flow variation in freshwater). Effects are likely to include:

- Warmer air temperatures will result in diminished snowpacks 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, seasonal hydrology in Pacific Northwest watersheds will shift to more frequent and severe early large storms, changing stream flow timing, which may limit salmon survival (Mantua et al. 2009).
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

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 on fish physiology
- Temperature-induced changes to stream flow patterns
- Alterations to freshwater, estuarine, and marine food webs

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). Dittmer (2013) suggests that juveniles may outmigrate earlier if they are faced with less tributary water. Lower and warmer summer flows may be challenging for returning adults. In addition, the warmer water temperatures in the summer months may persist for longer periods and more frequently reach and exceed thermal tolerance thresholds for salmon and steelhead (Mantua et al. 2009). Larger winter streamflows may increase redd scouring for those adults that do reach spawning areas and successfully spawn. Climate change may also have long-term effects that include accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007). The uncertainty associated with these potential outcomes of climate change do provide some justification for hatchery programs as reservoirs for some salmon stocks. For more detail on climate change effects, see NMFS (2017c).

2.4.3. Hatcheries

A broader discussion of hatchery programs in the Action Area can be found in our opinions on:

- Mitchell Act-funded programs (NMFS 2017c).
- UCR-Ringold Springs summer-fall Chinook salmon programs (NMFS 2017b).
- Yakima River Hatchery programs (NMFS 2013a)

Presently, Priest Rapids Hatchery releases approximately 8,026,000 fall Chinook salmon subyearlings annually into the Hanford Reach below Priest Rapids Dam. Under the Proposed Action, the production and release of 1.7M subyearlings would be transferred to the expanded Ringold Springs facility, with Priest Rapids Hatchery continuing to release 6,326,000 subyearling fall Chinook salmon annually. These releases are included in the Environmental Baseline—the ongoing effects of the hatchery programs or facilities which have undergone Federal review under the ESA, as well as the past effects of programs which have not yet undergone such review, including those found in the Proposed Action. A more comprehensive discussion of hatchery programs in the Columbia Basin can be found in our opinion on Mitchell Act funded programs (NMFS 2017c). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species (NWFSC 2015) and was summarized in Section 2.2.1 of this Opinion. In the past, hatcheries have been used to compensate for factors that limit anadromous salmonid viability (e.g., harvest, human development) by maintaining fishable returns of adult salmon and steelhead. A new role for hatcheries emerged during the 1980s and 1990s as a tool to conserve the genetic resources of depressed natural populations and to reduce short-term extinction risk (e.g., Snake River sockeye salmon). Hatchery programs also can be used to help improve viability by supplementing natural population abundance and expanding spatial distribution. However, the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014). Therefore, fixing the factors limiting viability is essential for long-term viability.

2.4.4. Harvest

There are many fisheries action area that harvest or encounter ESA-listed fish. These fisheries are roughly categorized into *U.S. v. Oregon* fisheries and fisheries above Priest Rapids Dam, and take place from Buoy 10 up through the tributaries of the Columbia River.

***U.S. v. Oregon* Fisheries**

The fisheries that take place as a result of the *U.S. v. Oregon* Agreement occur between Buoy 10 and Priest Rapids Dam. A detailed discussion of the history of *U.S. v. Oregon* agreement can be found in NMFS (2017a). Within this area, fisheries are divided into six zones below McNary Dam, and fisheries also take place between McNary Dam and Priest Rapids Dam (i.e., Hanford Reach). Commercial and recreational fisheries take place in Zones 1 through 5 (between Buoy 10 and Bonneville Dam), while tribal and recreational fisheries take place in Zone 6 (between Bonneville Dam and McNary Dam) and in the Hanford Reach. The effects of these fisheries on ESA-listed species are analyzed in NMFS (2008b). The expected incidental take and the actual harvest that occurred from these fisheries are summarized in Table 37 and in Table 38, respectively.

Table 37. Expected incidental take (as proportion of total run-size) of listed anadromous salmonids for non-Indian and treaty Indian fisheries included in the 2008 *U.S. v. Oregon* Agreement.

ESU or DPS	Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Snake River fall-run Chinook Salmon	21.5 – 45.0 [1]	20.0 – 30.0	1.5 – 15.0
Snake River spring/summer-run Chinook Salmon	5.5 – 17.0 [2]	5.0 – 14.3 [2]	0.5 – 2.7
LCR Chinook Salmon	Managed by components listed below		
spring-run component	Managed For Hatchery Escapement Goals	0	[3]
tule component (early-fall run)	41% Exploitation Rate[4]	0	41% exploitation rate[4]
bright component (late-fall run)	Managed For Escapement Goal	0	5,700 escapement goal
UWR Chinook Salmon	15.0	0	15.0
Snake River Basin Steelhead	Managed by components listed below		
A-Run Component	4.0 [5]	[6]	4.0
B-Run Component	15 – 22 [7]	13 – 20 [7]	2.0 [7]
LCR Steelhead	Managed by components listed below		
winter component	2.0	[6]	2.0
summer component	4.0 [5]	[6]	4.0

ESU or DPS	Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
UWR Steelhead	2.0 [5]	0	2.0
MCR Steelhead	Managed by components listed below		
winter component	2.0	[6]	2.0
summer component	4.0 [5]	[6]	4.0
UCR spring-run Chinook Salmon	5.5 – 17.0 [2]	5.0 – 14.3 [2]	0.5 – 2.7
CR Chum Salmon	5.0	0	5.0
UCR Steelhead	Managed by components listed below		
Natural-Origin Component	4.0 [5]	[6]	4.0
Hatchery- Origin Component	[8]	[8]	[8]
Snake River Sockeye Salmon	6.0 – 8.0 [1]	5.0 – 7.0	1.0
LCR Coho Salmon	10 – 30 [9]	0	10 – 30 [9]
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-run summer steelhead.
[7] For fall fisheries only.
[8] There is no take prohibition on ad-clipped hatchery fish even if they are part of a threatened ESA-listed group.
[9] Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2017c) evaluated the PFMC's harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.
[10] Total exploitation rate limits include ocean and inriver fisheries.

2.4.5. New Zealand Mud Snails

New Zealand mud snails (NZMS), an invasive species, were discovered at the Ringold Hatchery in 2014. In the state of Washington, the NZMS are classified as prohibited because they pose a risk of harming or threatening the state's environmental, economic, or human resources (information accessed 3-26-2020 from **https://wdfw.wa.gov/species-habitats/invasive/potamopyrgus-antipodarum#invasive**). Due to rapid self-reproduction, the species can quickly achieve densities of more than 500,000 snails per square meter. These mudsnails feed on the algae and detritus that are important to native aquatic insects, which are critical food source for juvenile native salmon. NZMS are not an alternative food source to native fish since they have very low nutritional value and most often pass through a fish's digestive track unharmed. After moving into a lake or stream, these mudsnails are nearly impossible to remove without damaging other aspects of the habitat.

Table 38. Annual post season performance of fisheries managed under the 2008 U.S. v. Oregon Agreement (Jording 2020).

ESU or DPS		Total impact annually achieved based on postseason reporting							
Combined Rates[1]		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Snake River spring/ summer-run Chinook		8.8%	10.6%	9.2%	12.5%	13.4%	11.3%	8.6%	11.2%
UCR spring-run Chinook		8.7%	10.5%	9.1%	12.4%	13.4%	11.3%	8.6%	11.2%
UWR spring-run Chinook	In spring fisheries	12.9%	10.0%	9.3%	8.9%	9.0%	5.1%	4.9%	6.1%
LCR Chinook	Spring component[3]	yes	yes	yes	yes	yes	yes	yes	yes
	Fall tule component[2]	40.8%	44.5%	32.9%	40.8%	34.90%	36.0%	35.8%	34.5%
	Fall bright component[4]	8,205	8,143	15,197	20,809	2,149			5,203
Snake River fall-run Chinook		33.0%	34.6%	31.3%	34.8%	31.3%	37.9%	39.3%	29.6%
LCR Coho[2]		13.5%	14.0%	13.7%	17.4%	24.4%	9.4%	10.8%	10.8%
CR Chum		0.1%	0.1%		0.8%	1.4%	0.0%	0.0%	0.0%
Snake River 5Sockeye		7.8%	9.7%	4.7%	5.0%	6.2%	4.9%	4.9%	3.85%
Separate Rates									
Tribal only	Steelhead B-Run (in fall fisheries)	21.1%	13.5%	14.0%	12.5%	12.1%	10.1%	6.0%	5.3%
Non-tribal only									
Snake River Steelhead	Group A Index (in winter/spring/summer fisheries)	1.5%	1.9%	0.9%	0.8%	0.5%	0.5%	0.6%	0.4%
Snake River Steelhead	Group B Index (in winter/spring/summer fisheries)	1.9%	0.2%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%
Snake River Steelhead	Group A Index (in fall fisheries)	1.5%	1.2%	1.6%	1.3%	1.1%	1.4%	1.1%	1.4%
Snake River Steelhead	Group B Index (in fall fisheries)	1.9%	1.8%	2.0%	1.6%	2.0%	1.5%	2.0%	1.0%
UCR Steelhead	In winter/spring/summer fisheries	1.5%	1.9%	0.9%	0.8%	0.5%	0.4%	0.6%	0.4%
UCR Steelhead	In fall fisheries	1.5%	1.2%	1.6%	1.3%	1.1%	1.4%	1.1%	1.4%
MCR Steelhead	Summer component (in winter/spring/summer fisheries)	1.5%	1.9%	0.9%	0.8%	0.5%	0.4%	0.6%	0.4%
MCR Steelhead	Summer Component (in fall fisheries)	0.3%	1.2%	1.6%	1.2%	1.1%	1.4%	1.1%	1.4%
MCR Steelhead	Winter Component (winter fisheries)	0.7%	0.3%	0.6%	0.7%	0.0%	0.6%	0.3%	0.3%
LCR Steelhead	Summer component (in winter/spring/summer fisheries)	0.3%	0.6%	0.6%	0.6%	0.3%	0.2%	0.1%	0.7%
LCR Steelhead	Summer Component (in fall fisheries)	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LCR Steelhead	Winter Component (in winter fisheries)	0.7%	0.5%	0.6%	0.6%	0.6%	0.4%	0.3%	0.0%
UWR Steelhead	Winter Component (in winter fisheries)	0.3%	0.5%	0.6%	0.6%	0.6%	0.4%	0.3%	0.3%

[1] Rate allocations are specified in 2008 *U.S. v. Oregon* Agreement, but can be added together for reporting purposes.
[2] Rate set annually in coordination with PFMC for combined exploitation rate for ocean and Columbia River mainstem fisheries up to Bonneville Dam.
[3] Managed for hatchery escapement goals to the Cowlitz, Lewis and Sandy Rivers. If annual box is yes, then H.E. goal was met 100%.
[4] Managed for an escapement goal of 5,700 fish in the North Lewis River.

NZMS are small (an average of 1/8 inches long) and cone-shaped. Their shells have five to six whorls, fairly uniform in size, and vary in color from light-brown to black. This species of mudsnail is hearty, surviving in a variety of salinity, water temperature and quality. A movable cover at the opening of its shell (the "operculum") allows the mudsnail to protect itself from short-term exposure to most chemicals. The NZMS also survives out of water for quite some time and has no known predators or parasites in Washington state that can keep populations in check. A single female snail can rapidly reproduce through cloning, adding 230 snails to the population annually. That initial snail, along with its offspring, can build a population into the billions of snails within a four-year timeframe. NZMS mostly feed at night on algae, sediment, plant and animal detritus – all of which would otherwise be consumed by native snails and insects.

NZMS are not native to the United States and were initially detected in 1987 on Idaho's Snake River. The species is now found in many locations throughout the West. NZMS invasive history in Washington state goes back to 2002 when they were discovered in the Lower Columbia River estuary. Since then, the species has been found in several locations in Washington including Lake Washington, the Chehalis River, and Capitol Lake in Olympia.

The source of the infection at RSH is Ringold Springs Creek, which supplies water to the hatchery. Eliminating NZMS from the creek would require dewatering the creek and torching the area. As just one snail can reproduce asexually and recolonize the creek, this effort has not been undertaken due to the low likelihood of success. Current mitigation efforts are to take fish off feed for a week prior to release to purge their stomachs, lethally subsample a small number of fish, and examine the stomach contents for NZMS (Mike Erickson, WDFW, pers. comm.). To date no NZMS have been found in the subsampled juvenile Chinook.

The presence and spread of NZMS into stream habitat used by listed species would be expected to reduce the food base of the listed species. As described above the NZMS consume algae, sediment, plant and animal detritus that would otherwise be used by native snails and insects. It is these native snails and insects that contribute to the food base upon which listed species feed. In addition, the NZMS are not an alternative food source for listed species because they have low nutritional value and most often pass through a fish's digestive track unharmed.

2.5. Effects on ESA Protected Species and on Designated Critical Habitat

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Appendix A and application of the methodology and analysis of the Proposed Action is in Section 2.4.2. Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the Proposed Action, including the consequences of other activities that are caused by the Proposed Action. A consequence is caused by the Proposed Action if it would not occur but for the Proposed Action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.5.1. Factors That Are Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science (Hard et al. 1992; McElhany et al. 2000; NMFS 2004b; 2005c; Jones 2006; NMFS 2008a; 2011b). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes; abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

"Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard et al. 1992). A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability: abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS and designated critical habitat "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (70 FR 37215, June 28, 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU".

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the seven factors of hatchery operation on each listed species at the population level (in Section 2.5.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.8).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or 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, migratory corridor, estuary, and ocean
(4) RM&E that exists because of the hatchery program
(5) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
(6) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

NMFS analysis assigns an effect category for each factor (negative, negligible, or positive/beneficial) on population viability. The effect category assigned is based on: (1) an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure, and diversity; (2) the role or importance of the affected natural population(s) in salmon ESU or steelhead DPS recovery; (3) the target viability for the affected natural population(s) and; (4) the Environmental Baseline, including the factors currently limiting population viability. For more information on how NMFS evaluates each factor, please see Appendix A.

2.5.2. Effects of the Proposed Action

This section discusses the effects of the Proposed Action on the ESA-listed species in the action area. Most of the effects here focus on Upper Columbia River spring Chinook salmon and Upper Columbia River steelhead because the facilities operate and releases occur in the Upper Columbia River basin. The effects analysis of juvenile outmigration (Section 2.5.2.3, Factor 3) looks at the effects on other ESA-listed salmonids, such as the Snake River, Mid-Columbia, Lower Columbia, and Willamette species.

2.5.2.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for broodstock

Because the RSH program propagates non-ESA-listed fall Chinook salmon, which is a different species/run of salmonid than the listed Upper Columbia River spring Chinook salmon and steelhead, no fish from natural populations of listed species will be removed for hatchery broodstock. The other ESA-listed species considered in this opinion do not occur in areas where broodstock collection takes place, so they would not be exposed to broodstock collection activities. Therefore, there is no overall effect of this factor on these species. Inadvertent collection of listed species will be considered under Factor 2.

2.5.2.2. Factor 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

The proposed hatchery program may pose risks to UCR steelhead during broodstock collection activities. The program poses no genetic risks because the fall Chinook salmon do not interbreed with any ESA-listed individuals. The overall effect of this factor on these Upper Columbia River species is negligible. There is no effect of this factor on other ESA-listed species because those species are not present on the spawning grounds or in adult collection facilities of these hatchery fish.

Genetic Effects
Because the fish from the Proposed Action return to the Hanford Reach portion of the UCR Basin as adults that could potentially spawn naturally, the only listed species that are present in the UCR (i.e., UCR spring Chinook salmon and UCR and MCR steelhead) have the potential to be affected genetically by the Proposed Action. However, spring Chinook salmon do not interbreed with hatchery-origin fall Chinook salmon because spring Chinook salmon would finish spawning before fall Chinook salmon would start spawning (Table 39) and their spawning spatial distributions do not overlap. Also, steelhead do not interbreed with Chinook salmon, so there are no genetic effects on UCR and MCR steelhead from hatchery-origin summer/fall or fall Chinook salmon. These same factors would also apply to these listed species: Snake River spring summer Chinook salmon, Lower Columbia River Chinook salmon, Upper Willamette River spring Chinook salmon, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Snake River sockeye salmon, Columbia River chum salmon, and Lower Columbia coho salmon and thus these species would not experience genetic effects due to the Proposed Action.

There is the potential for adults returning from the releases at RSH to stray into the Snake River and interact with ESA-listed fall Chinook salmon. Stray rates were estimated by expanding recoveries of CWT RSH fall Chinook salmon on spawning grounds and within and outside the Hanford Reach by the juvenile mark rate and survey sample rate. Targets for strays based on return year (recovery year) and brood year should be less than 5%. The percentage and number of RSH fall Chinook salmon straying into hatcheries and other basins outside the Hanford Reach has been very low; zero straying outside the Hanford Reach was estimated to have occurred since brood year 2001.

As production at Ringold increases, the potential for Ringold Springs Hatchery stock to stray into the Snake River would increase. This increased straying would be offset under the proposed Ringold Springs Hatchery expansion, as homing is expected to improve as a result of raising smolts to full term on-station, and because the water in which URB fall Chinook would be reared and imprinted on is unique and should result in increased homing back to the hatchery in adult returns. Additionally, once the Ringold expansion occurs, fish would be spawned, incubated, reared, and released at Ringold, eliminating the need to transport fish between Priest Rapids, Bonneville, and Ringold Springs hatcheries and potentially increasing homing. The number of strays that occur will be tracked by clipping the adipose fin of all fish before release, ensuring that a high number of fish (450,000) have coded wire tags, as well as implementing a PIT tagging program of ~7,500 PIT-tagged fish. At the present time, NMFS expects that the stray rate into the Snake River could increase above the previously observed zero percent, but probably would not exceed one percent of the Snake River natural spawning population and thus would not be expected have any genetic effects on ESA-listed species.

Table 39. Timing of adult return and spawning for UCR salmonids.

Fish Run and Species	Freshwater Entry	Spawning Duration	Spawning Peak
Summer/fall Chinook Salmon	June to August	Late September to end of November	Early to mid-October
Fall Chinook Salmon	Mid-August to October	Late October to early December	November
Spring Chinook Salmon	May to June	Early August to mid-September	Mid to late August
Summer Steelhead	July to mid-June	March to mid-July	April to May

Sources: (WDFW 2002)

Ecological Effects

Ecological effects from returning adult hatchery-origin fish include redd superimposition, competition for spawning grounds, and contribution of marine-derived nutrients. As described above, interactions on the spawning ground are not expected between listed species in the tributaries due to differences in spawn timing and high homing fidelity back to Hanford Reach. Predation by the returning adult hatchery-origin is not likely to be an ecological effect because these adult fish cease to eat upon freshwater entry.

Spawning site competition and redd superimposition by the hatchery-origin fish could occur when there is a spatial overlap between RSH adults and listed-species. Spawning site competition and redd superimposition are not likely to occur between spring Chinook salmon and fall Chinook salmon because the distributions do not overlap. Fall Chinook salmon spawn primarily in the mainstem Columbia River and the extreme downstream reaches of the tributary mainstems, while spring Chinook salmon spawn primarily in the upper tributaries and upper reaches of the mainstem of the Wenatchee, Entiat, and Methow Rivers, so there is virtually no overlap between fall and spring Chinook salmon in space. Thus, spawning site competition and redd superimposition are not likely to occur between spring Chinook salmon and fall Chinook salmon. These same factors – RSH adults spawning only in the Hanford Reach – will also eliminate the possibility of spawning site competition and redd superimposition from occurring between RSH fish and Snake River spring summer Chinook salmon, Snake River fall Chinook salmon, Lower Columbia River Chinook salmon, Upper Willamette River spring Chinook salmon, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Snake River sockeye salmon, Columbia River chum salmon, and Lower Columbia coho salmon.

Hatchery fish contribute marine-derived nutrients to the ecosystem in the Hanford Reach area of the Columbia River. The Priest Rapids and Ringold Springs programs as currently operated contribute an estimated 253.76 kg of phosphorous annually to the Hanford Reach area (Table 40), which is approximately 15% of the marine derived phosphorus input into the area – the 15%

represents the proportion Priest Rapids Hatchery and RSH adults in the naturally spawning population in Hanford Reach. After the proposed expansion of the RSH, it is estimated that returning hatchery fall Chinook salmon will contribute 316.44 kg of marine-derived phosphorous, which would be a 26% increase over current levels.

Table 40. Total phosphorous imported by adult returns from the proposed hatchery programs based on the equation, mean adult mass and phosphorous concentration in Scheuerell et al. (2005). Escapement and pHOS estimates from Hillman et al. (2017b), Richards and Pearsons (2015), and Snow et al. (2016).

Program	Subbasin Location	Total Escapement	Proportion of hatchery adults spawning in Hanford Reach	Number of Hatchery -origin Adults[1]	Average adult mass (kg)[2]	Concentration of phosphorous (kg/adult)[3]	Phosphorous imported (kg/year)	
							From hatchery -origin adults (only)[4]	Total[5]
Priest Rapids/ Ringold Springs	Hanford Reach (Columbia River mainstem)	65,518	0.151	9,893	6.75	0.0038	253.76	1,680.54

[1] The number of hatchery-origin adults are determined by multiplying total escapement numbers by pHOS.
[2] Source: Cederholm et al. (2000).
[3] Source: Scheuerell et al. (2005).
[4] These numbers are determined by multiplying together the number of hatchery-origin adults, average adult mass, and concentration of phosphorus.
[5] These numbers are determined by multiplying together the number of total escapement, average adult mass, and concentration of phosphorus.
[6] Analysis for Priest Rapids and Ringold Springs hatchery programs are combined for this table because the escapement numbers are from the Hanford Reach, which includes both programs.

Adult Collection Facilities

Negligible: While broodstock collection for this program targets fall Chinook salmon, ESA-listed steelhead could be encountered incidentally to the broodstock collection; these encountered steelhead are handled and released. For the Priest Rapids and Ringold Springs programs, the broodstock collection can occur at the volunteer trap at the Priest Rapids Hatchery, at the OLAFT, or through hook-and-line angling in Hanford Reach. The effects of broodstock collection at Priest Rapids Hatchery and the OLAFT, and hook-and-line angling, on ESA-listed species was already evaluated in a separate consultation (NMFS 2017b) and is therefore included in the environmental baseline for this Opinion. The expansion of the RSH program under the Proposed Action is not expected to increase broodstock collection effects beyond those that were evaluated in the Environmental Baseline, even if Priest Rapids Hatchery and the OLAFT are used as alternative broodstock sources, because the operation of these facilities would not change under the Proposed Action.

At the RSH, steelhead are occasionally handled during broodstock collection. When they are collected, they are immediately released upstream of the hatchery discharge channel in the Columbia River, through a new pipe that was recently installed to replace hauling in a truck, which used to occur (USACE and WDFW 2017). The HGMP estimates that up to 130 NOR UCR steelhead adults could be handled and released at RSH during broodstock collection activities, with an estimated 6 mortalities. This is based on the expected increase in flows used to attract returning fall Chinook salmon to the hatchery after the facility expansion. This is expected to have only a negligible effect on the UCR Steelhead DPS, which has a recent 5-year geomean of 16.989 NOR adults returning to the UCR. Actual encounter rates at the RSH have been very low; five natural-origin steelhead (visually identified as ad-present) were encountered in 2010 and three in 2011(USACE and WDFW 2017), none of which encounters resulted in mortality during handling.

2.5.2.3. 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 and migratory corridors. Because the fish released under the Proposed Action are likely to affect natural-origin fish as they emigrate, the effects analysis here includes the distance through the estuary (i.e., mouth of the Columbia River). This factor can have effects on the productivity VSP parameter (Section 2.5) of the natural population. The effect of this factor on all listed salmonid species is negative. It is important to keep in mind that some results of the model below are an overestimation of interaction and predation values for those fish that also includes non-listed species (e.g., summer/fall Chinook salmon in Upper Columbia River) because of uncertainty in the data used for the model run. While we cannot characterize or quantify the amount of overestimation, this approach is a precautionary approach because it assumes the maximum possible effect on listed species.

Hatchery release competition and predation effects

In reviewing competition and predation effects in the mainstem Columbia River, NMFS used the PCD Risk model of Pearsons and Busack (2012) to quantify the potential number of natural-origin salmon and steelhead juveniles lost to competition and predation from the release of hatchery-origin juveniles. Although model logic is still largely as described in the 2012, the PCD Risk model has undergone considerable modification since then to increase supportability and reliability. Notably, the current version no longer operates in a Windows environment and no longer has a probabilistic mode. We also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run. The one modification to the logic was a 2018 elimination of competition equivalents and replacement of the disease function with a delayed mortality parameter. The rationale behind this change was to make the model more realistic; competition rarely directly results in death in the model because it takes many competitive interactions to suffer enough weight loss to kill a fish. Weight loss is how adverse competitive interactions are captured in the model. However, fish that are competed with and suffer some degree of weight loss are likely more vulnerable to mortality from other factors such as disease. Now, at the end of each run, the competitive impacts for each fish are assessed, and each fish has a probability of delayed mortality based on the competitive impacts. This function will be subject to refinement based on research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20%

probability of delayed death, (0.2 = 0.1/0.5). Parameter values used in the model runs are shown in Table 41 - Table 44.

For our model runs, we assumed a 100 percent population overlap between hatchery fish and all natural-origin species present. Hatchery fall Chinook salmon are released anywhere between May-July, with a large proportion being released in June. These releases may overlap with natural-origin chum, coho, sockeye, spring, and fall Chinook salmon, and steelhead in the Action Area. Fish are directly released from the RSH into the mainstem Columbia River and thus would not overlap with young of the year juveniles in the tributaries, but would overlap with juvenile non-listed fall Chinook salmon in the Hanford Reach.

The model was run in two segments: from release to McNary Dam, and as an aggregate run from McNary Dam through the estuary. Release location to McNary Dam: Releases from the RSH were analyzed for this stretch because all fish migrate through this area. The following assumptions were made for these model runs:

- Travel (residence) time was proportional to what the fish's travel time was from release to McNary Dam.
- Survival rate of hatchery fish was assumed to be the same as the survival from release to McNary Dam.
- Temperatures at the release sites were used in model runs.
- Model runs account for hatchery fish predation and competition effects on natural-origin age 0 and age 1 Chinook salmon, age 2 steelhead and sockeye salmon age 1 and 2 (combined), because these fish commingle with the hatchery-origin fish at in the Columbia River above McNary Dam.
- Natural-origin fish sampled at McNary Dam were used to determine the mean fish length that was used for input into the model. NMFS believes this provides an accurate estimate of the fish sizes that would be encountered by RSH releases.

For the aggregate model run from McNary Dam through the estuary the following assumptions were made for these model runs:

- Travel (residence) time was proportional to what the fish's travel time was from release to McNary Dam and averaged by grouping to obtain one travel time per group.
- Survival rate of hatchery fish from McNary Dam to Bonneville Dam was used as proxy by assuming that the survival rate of hatchery fish below Bonneville Dam to the mouth of the Columbia River is 100 percent.
- Hatchery-origin fish numbers for the RSH release were reduced from the original release number by using the survival rate to McNary Dam.
- Temperatures at McNary Dam forebay were used in model runs.
- Model runs account for hatchery fish predation and competition effects on natural-origin Chinook salmon age 0 and 1, steelhead age 2, sockeye salmon age 1 and 2 (combined), and coho salmon age 2.

- Chum salmon and coho salmon were not included in the analysis because they emigrate from the Lower Columbia River by the end of May and thus would not be present when RSH fall Chinook salmon reach the estuary (NMFS 2013b).

Table 41. Parameters from the PCD Risk model that are the same across all programs.

Parameter	Value[1]
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for Chinook salmon; 0.6 for all other species
Dominance mode	3
Piscivory	0.002 for Chinook, Coho, and Chum salmon (when interacting with yearling summer/fall Chinook salmon); 0 for all other species
Maximum encounters per day	3
Predator:prey length ratio for predation	0.25[2]

[1] All values from HETT (2014) unless otherwise noted.
[2] Daly et al. (2014)

Table 42. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

Species	Age Class	Size in mm (SD)	Source
Chinook salmon	0	113 (13.5)	1
	1	145 (15.8)	1
Steelhead	2	197 (25.4)	1
Sockeye salmon		124 (22)	1
Coho salmon	2	90 (20)	1

[1] Fish Passage Center, last accessed: March 2, 2020 (Smolt Monitoring Program 2019 Juveniles at McNary Dam)(mean size for natural-origin (unclipped) subyearling and yearling Chinook Salmon, yearling steelhead, yearling sockeye and coho salmon).

Table 43. Hatchery fish parameter values for the PCD Risk model run from release of fish to McNary Dam.

Program	Release Site	Release Number	Size in mm (SD) at release	Survival Rates to McNary (mean)	Travel (residence) Time (median days)				Temp. at release (°C)
					Release to UCR mouth (if applica-ble)	Mouth of trib. to mouth of Snake River	Snake confluence to McNary	Release to McNary	
Ringold Springs fall Chinook salmon (subyearlings)	Columbia River (RM 352)	8,150,000	103 (20)	0.68	n/a	6	7	13	13.3[1]

[1] Data from http://www.cbr.washington.edu/dart/query/river_graph_text; access date August 16, 2017. 10 year average (2007-2016) of temperature (WQM).

Table 44. Hatchery fish parameter values for aggregate fall Chinook salmon releases for the PCD Risk model, starting at McNary Dam through to the estuary.

Aggregate Run Group	Program	Number of Hatchery Fish Survived to McNary Dam	Mean sizes in mm (SD)	Survival Rates (mean for McNary to Bonneville[1])	Travel (residence) Time (median days)	Temperature (°C) at McNary (mean)[2]
Fall Chinook subyearling salmon	Ringold Springs fall Chinook salmon (subyearlings)	5,297,500	103(20)	0.17	64.7	16.1

[1] Survival rate of hatchery fish from McNary Dam to Bonneville Dam was used as surrogate by assuming that survival rate of hatchery fish is the same through the estuary as it is to the Bonneville Dam because we have no other survival data.

[2] Fish Passage Center, last accessed: September 19, 2017 (average McNary forebay temperature from May 20-31, 2007-2016 used for summer Chinook yearlings and subyearlings model runs, and June 15-30, 2007-2016 average McNary forebay temperatures used for fall Chinook subyearling model runs).

We conducted model runs with natural-origin fish numbers at the point where all possible hatchery-origin fish interactions are exhausted at the end of each day. In doing this, we erred on the side of running the models with natural-origin juvenile abundances that exceed actual numbers available. Using natural-origin juvenile numbers in this manner, at the point where all possible hatchery-origin fish interactions are exhausted at the end of each day, allows us to estimate worst-case impacts on listed natural-origin fish.

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 (Kozfkay 2017). This ESU makes up approximately 2% of the estimated 2.9 million sockeye salmon juveniles entering the Columbia River (Zabel 2015; 2017), thus, we used 3,050,000 (61,000/0.02) as the natural-origin sockeye salmon abundance within the Action Area in the model. This number was reduced to 1,059,312 to reflect the proportion of the sockeye outmigration remaining above McNary Dam after May 15th.

Juvenile hatchery fall Chinook salmon are not expected to be released from the RSH until after May 15th at the earliest and thus only fish remaining above McNary Dam would be encountered. To ensure the effects due to competition and predation are within our model estimates, we will continue to monitor median travel times from release to McNary Dam on an annual basis (using a 5-year rolling median) compared to the values used in our analyses (see Table 43).

The resulting juveniles lost from release to McNary Dam for all natural-origin species are summarized in Table 45. The resulting juveniles lost from McNary Dam through the estuary are summarized in Table 46. Using the smolt-to-adult survival rate (SAR) representative of each species, these lost juveniles equate to 2,488 Chinook salmon, 517 steelhead, 68 sockeye salmon, 0 chum salmon, and 0 coho salmon adult equivalents (Table 45, Table 52) from release to the mouth of the Columbia River.

Table 45. Maximum numbers of juvenile natural-origin salmon and steelhead lost to competition (C) and delayed mortality (D) from hatchery-origin fall Chinook salmon for model runs from release to McNary Dam.

Program	**Release Site**	**Chinook Salmon[1]**		**Steelhead[2]**		**Sockeye Salmon[3]**	
		C[4]	**D[5]**	**C[4]**	**D[5]**	**C[4]**	**D[5]**
Ringold Springs fall Chinook salmon (subyearlings)	Columbia River (RM 352)	0	13,608	0	8	0	3,012
Total		13,608		8		3,012[7]	
SAR[6]		0.0037		0.011		0.005	
Adult Equivalents		50		0		15	

[1] The Chinook salmon lost here includes age 0 and age 1 fish from release to the mouth of the respective tributaries, age 1 fish from mouth of the respective tributaries to McNary Dam, and age 0 Snake River Chinook salmon from the confluence of the Columbia River and Snake River to McNary Dam.
[2] The steelhead lost here includes age 1 and 2 fish from release to the mouth of the respective tributaries and age 2 fish from mouth of the respective tributaries to McNary Dam.
[3] The sockeye salmon lost here includes age 1 and 2 fish from the confluence of the Columbia River and Snake River to McNary Dam because there are no listed species of sockeye salmon in UCR.
[4] Competition, as used here, is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter value.
[5] Delayed mortality, as used here, is equal to the proportion of a fish’s weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20% probability of delayed death, (0.2 = 0.1/0.5).
[6] SAR for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016a), steelhead (NMFS 2017d), and sockeye (IDFG 2012).
[7] Adjusted to represent the proportion of Snake River Sockeye salmon impacts (total estimated impacts times proportion Snake River sockeye (2%)).

Table 46. Maximum numbers of juvenile natural-origin salmon and steelhead lost to competition (C) and delayed mortality (D) with hatchery-origin fall Chinook salmon from the RSH for model runs from McNary Dam through the estuary.

Aggregate Group	Program(s) in Group	Chinook salmon[1]		Steelhead[2]		Sockeye salmon[3]		Chum salmon[4]		Coho salmon[5]	
		C[6]	D[7]	C[7]	D[7]	C[7]	D[7]	C[6]	D[7]	C[6]	D[7]
Fall Chinook subyearling salmon	Priest Rapids, Ringold Springs	21,042	148,988	2	96	1,493[10]	9,080[10]	N/A[8]	N/A[8]	N/A[8]	N/A[8]
Total		170,030		98		10,573[10]					
SAR[9]		0.0041		0.017		0.005					
Adult Equivalents		697		2		53					

[1] The Chinook salmon lost here includes age 0 and age 1 fish.
[2] The steelhead lost here are only age 2 fish.
[3] The sockeye salmon lost here includes age 1 and age 2 fish.
[4] Chum salmon lost here are only age 0 fish.
[5] The coho salmon lost here are age 2 fish.
[6] Competition, as used here, is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values.
[7] Delayed mortality, as used here, is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20% probability of delayed death, (0.2 = 0.1/0.5).
[8] Summer/fall and fall Chinook subyearlings are not likely to interact with chum and coho salmon because the chum and coho salmon would already be emigrated out of the freshwater system before the subyearlings reach White Salmon River (where chum and coho salmon would spatially overlap with the hatchery releases).
[9] Smolt-to-adult survival rate for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016a; 2017e; 2017f), steelhead (average of: NMFS 2017d; 2017f; 2017e), sockeye (IDFG 2012), chum (Hillson 2015), and coho salmon (ODFW 2011).
[10] Adjusted to represent the proportion of Snake River Sockeye salmon impacts (total estimated impacts times proportion Snake River sockeye (2%)).

Table 46 summarizes the likely number of adults that would be lost from each ESU between McNary Dam through the estuary. While these numbers represent the maximum potential effect from the Proposed Action, these ecological interactions also occur between natural-origin species; thus, the effects attributable to the Proposed Action are only that portion that exceeds the natural level of ecological interactions. Because the Chinook salmon lost to ecological effects between release and the estuary includes both listed and non-listed fish, only a portion of the lost adult Chinook salmon equivalents are likely to be listed. However, our analysis assumes that all Chinook salmon lost are listed in order to represent an absolute maximum total (and in the absence of more precise data). In addition, the SAR for subyearlings tends to be lower than for yearlings, so adult equivalents for subyearlings may actually be lower than what was calculated in Table 46. We also assume that the effects on each population within each ESU is proportional to their ESU composition. For example, if a single population represents 5 percent of the natural-origin adults, then the loss our model predicts would be some percentage of the 5 percent contribution of that population to the ESU.

Impacts on listed species may be less because we assumed in our analysis that the fish would continue to travel at the same rate below McNary Dam as the rate from release to McNary Dam, this assumption likely overestimates the effect these fish would have on natural-origin fish below McNary Dam because these hatchery-origin fish are likely to be traveling quicker as they get closer to the mouth of the Columbia River. To understand the potential effect on each Chinook ESU, we calculated the likely number of adults that would be lost from each ESU between release to McNary Dam (Table 48) using the percent of listed wild yearlings (96) and subyearlings (4), and proportion of each attributable to each listed ESU at McNary Dam (taking the average of values from 2012 through 2016; Table 7a of: Zabel 2013; 2014a; 2014b; 2015; 2017). We then applied a similar methodology at Tongue Point (i.e., mouth of the Columbia River) for the reach from McNary Dam to the Columbia River mouth, where 27 percent of listed Chinook salmon are likely to be yearlings, while 73 percent of listed Chinook salmon are likely to be subyearlings, to be able to estimate ESU level loss (taking the average of values from 2012 through 2016; Table 7a of: Zabel 2013; 2014a; 2014b; 2015; 2017). In addition, we applied the ratio of UCR spring Chinook salmon returns compared to the UCR summer/fall Chinook salmon returns (0.24) in order to calculate the UCR spring Chinook salmon adult equivalent for each segment of the run (9 and 1, respectively) to better estimate the effect on UCR Spring Chinook Salmon ESU.

Effects on all ESUs are less than 1 percent, except for Snake River sockeye salmon and LCR Chinook salmon, with percent losses of 4.2% and 1.4%, respectively. The estimated impacts on Snake River sockeye salmon from ecological interactions are considered to be a maximum because the model assumes that the rate of travel below McNary Dam for the RSH subyearlings is the same from the RSH to McNary Dam. This assumption likely overestimates the effect these fish would have on natural-origin fish below McNary Dam because these hatchery-origin fish are likely to be traveling quicker as they get closer to the mouth of the Columbia River. For illustrative purposes, we also ran the model for effects on natural-origin sockeye salmon between McNary Dam through the estuary using the travel rate of 8 days for subyearling fall Chinook salmon from McMichael et al. (2011). The results are compared below in Table 47, which summarizes the effect on Snake River sockeye salmon juveniles.

Table 47. Comparison of results based on different travel times.

Aggregate Group	Program(s) in Group	Sockeye salmon from Table 53		Sockeye salmon from quicker travel time	
		C	D	C	D
Fall Chinook subyearling salmon	Ringold Springs	1,493	9,080	0	1,361
Total		10,573		1,361	
SAR[1]		0.005		0.005	
Adult Equivalents		53		7	

[1] SAR for sockeye (IDFG 2012).

This change in the rate of travel for subyearling fall Chinook salmon substantially reduces the impacts on Snake River sockeye salmon to 1.3%. Depending on the assumptions used in the model, the effects on Snake River sockeye salmon abundance and productivity due to ecological interactions with outmigrating hatchery juveniles could be adverse or negligible. To address the assumptions, the Corps have proposed to tag up to 7,500 juveniles with PIT-tags to provide data on survival and rates of travel between RSH and Bonneville Dam. This data can be used in the model to more accurately estimate the ecological effects of the RSH releases on Snake River sockeye salmon.

Our analysis shows that loss of steelhead adult equivalents due to ecological effects with outmigrating juvenile hatchery fish would be approaching zero for each of the listed DPSs (Table 48). Thus, we believe this would not be expected to have any effect on DPS abundance and productivity.

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). The percentages of chum and coho salmon adult equivalents lost to ecological interactions are zero because out migrating juvenile chum salmon and steelhead have exited the lower Columbia River and estuary before RSH are released and reach Bonneville Dam.

Table 48. Maximum total ESA-listed natural-origin adult equivalents lost through competition and predation with juvenile hatchery fish by ESU/DPS compared to returning adults of respective ESU/DPS.

Listed Species (ESU/DPS)		Percent Yearlings at McNary Dam	Yearling AEs from Release to McNary Dam	Percent subyearlings at McNary Dam		Subyearling AEs from Release to McNary Dam	Percent Yearlings at Tongue Point	Yearling AEs from McNary Dam to Tongue Point	Percent Subyearlings at Tongue Point	Subyearling AEs from McNary Dam to Tongue Point	Total Lost AEs	Total Adults at Mouth of Columbia River	Percentage of Lost Adults to Total Adults at Mouth
Chinook Salmon	Total	100	48	100		2	100	188	100	508	746	141,728	0.5
	Snake River Spring/Summer Chinook Salmon ESU	28	14	0		0	26	49	0	0	63	32,823[3]	0.2
	Snake River Fall Chinook Salmon ESU	0	0	100		2	0	0	4	20	22	23,198[4]	0.09
	UCR Spring Chinook Salmon ESU	72	9[1]	0		0	5	1[2]	0	0	10	5,064[5]	0.2
	Lower Columbia River Chinook Salmon ESU	0	0	0		0	33	62	96	488	550	38,464[6]	1.4
	Upper Willamette River Spring Chinook Salmon ESU	0	0	0		0	36	68	0	0	68	9,356[7]	0.7
Steelhead	Total	100	0	0		0	100	1	0	0	1	115,833	0
	Snake River Steelhead DPS	11	0	0		0	47	1	0	0	1	54,414[8]	0
	UCR Steelhead DPS	45	0	0		0	6	0	0	0	0	6,929[8]	0
	Middle Columbia Steelhead DPS	42	0	0		0	19	0	0	0	0	22,300[8]	0
	Lower Columbia	0	0	0		0	19	0	0	0	0	22,031[8]	0

Listed Species (ESU/DPS)		Percent Yearlings at McNary Dam	Yearling AEs from Release to McNary Dam	Percent subyearlings at McNary Dam		Subyearling AEs from Release to McNary Dam	Percent Yearlings at Tongue Point	Yearling AEs from McNary Dam to Tongue Point	Percent Subyearlings at Tongue Point	Subyearling AEs from McNary Dam to Tongue Point	Total Lost AEs	Total Adults at Mouth of Columbia River	Percentage of Lost Adults to Total Adults at Mouth
	River Steelhead DPS												
	Upper Willamette River Steelhead DPS	0	0	0		0	9	0	0	0	0	10,159[8]	0
Snake River Sockeye Salmon ESU		100	5	0		0	100	31	0	0	68	1,623[9]	4.2
Columbia River Chum Salmon ESU		0	0	0		0	0	0	100	0	0	18,498[10]	0
Lower Columbia River Coho Salmon ESU		0	0	0		0	100	0	0	0	0	267,060[11]	0

[1] We accounted for effects on the listed UCR Spring Chinook Salmon ESU from our model by applying the total Chinook adult equivalents to McNary 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 summer Chinook salmon (Table 10 of ODFW and WDFW 2016) from 2011-2015, and then dividing the total UCR spring Chinook return into this sum. We then applied this average proportion (0.24) of UCR spring Chinook to the total number of UCR Chinook salmon adult equivalents estimated to be lost from our model analysis (781).

[2] We accounted for effects on the listed UCR Spring Chinook Salmon ESU from our model by applying the total Chinook adult equivalents from McNary to the mouth of Columbia River by applying the ratio of UCR spring Chinook salmon to UCR River summer Chinook salmon described above (0.24) to the total number of UCR Chinook salmon adult equivalents estimated to be lost from our model analysis (18).

[3] This number was obtained by taking the average number of wild adult returns to the Columbia River from 2011 to 2015 from Table 9 of ODFW and WDFW (2016).

[4] This number was obtained by taking the average number of adult returns to the Columbia River from 2011 to 2015 from Table 5 of WDFW and ODFW (2017).

[5] This number was obtained by taking the average number of wild adult returns to the Columbia River from 2011 to 2015 from Table 8 of ODFW and WDFW (2016).

[6] This number was obtained by taking the average of the sum of the estimated number of Lower Columbia River fall bright Chinook salmon, fall tule Chinook salmon, and spring/summer Chinook salmon for 2011 to 2015. The fall bright Chinook salmon numbers were obtained by summing the total natural spawner abundance estimates of each population from Tables 2.1.12 through 2.1.14 of TAC (2017) from 2011 to 2015. Then, we accounted for harvest impacts using LRH impact numbers of sport and commercial fisheries from the respective (Table 9 of TAC 2012; Table 12 of TAC 2013; Table 16 of TAC 2014; Table 17 of TAC 2015; Table 18 of TAC 2016). The fall tule Chinook salmon numbers were obtained from Table 4 of WDFW and ODFW (2017) by using the 2011 to 2015 actual return numbers for the Lower River Wild stock. The spring/summer Chinook salmon numbers were obtained by summing the total natural spawner abundance estimates of each population from Tables 2.1.10 and 2.1.11 of TAC (2017) from 2011 to 2015. Then, we accounted for harvest impacts using the total impact of the Upper Willamette River spring-run Chinook salmon fishery from the respective years (Table 88 of NMFS 2017c) as a surrogate.

[7] This number was obtained by taking the average number of estimated natural-origin returns to the Columbia River mouth from 2011 to 2015. For each year, the natural-origin returns number was estimated by multiplying the projected spring Chinook run size by the percent of unmarked fish (100 minus total mark rate) obtained from http://www.dfw.state.or.us/fish/fish_counts/willamette/archives.asp, last accessed on October 30, 2017.

[8] To obtain these numbers, we summed the total wild summer steelhead returns (Table 6 of WDFW and ODFW 2017) and total wild winter steelhead returns (Table 11 of ODFW and WDFW 2016) for 2011 to 2015, then applied the proportions of DPS obtained from Zabel (2013; 2014a; 2014b; 2015; 2017), described above.
[9] This number was obtained by taking the average number of Snake River sockeye returns to the Columbia River from 2011 to 2015 from Table 18 of ODFW and WDFW (2016).
[10] This number was obtained by taking the average number of total Columbia River Chum abundance from Table 12 of WDFW and ODFW (2017).
[11] This number was obtained by taking the average number of total coho salmon returns minus hatchery coho returns; Table 8 in WDFW and ODFW (2017).

Another effect on natural-origin fish can result from released fish that residualize in a tributary. Residual hatchery fish are those fish that do not emigrate following release from the hatchery. These fish have the potential to compete with and prey on natural-origin juvenile fish for a longer period of time relative to migrants. Residuals are not explicitly accounted for in our model at this time. The ecological impacts of hatchery fish residualizing are likely to occur in the tributaries, where natural-origin fish are rearing because residual fish would compete with or prey on rearing fish. Conversely, residuals from programs that release into mainstem Columbia River, as proposed for the RSH program, would not be expected to have any effect if they stay in the mainstem Columbia River; however, if they migrate to a tributary, they could also have ecological effects on natural-origin fish. Because natural-origin summer/fall Chinook salmon migrate out as subyearlings, the risk that subyearlings released through the RSH program would remain to residualize and affect ESA-listed species is negligible.

Naturally-produced progeny competition

Naturally spawning hatchery-origin fall Chinook salmon are likely to be less efficient at reproduction than their natural-origin counterparts (Christie et al. 2014), but the progeny of such hatchery-origin spawners are likely to make up a sizable portion of the juvenile fish population. This is actually a desired result for integrated recovery programs when their goal is to increase the abundance of the natural-origin population. Therefore, added production could result in a density-dependent response of decreasing growth/mortality, earlier migration due to high densities, and potential exceedance of habitat capacity. However, these impacts are expected to be small because the expansion of the facility is expected to increase homing back to the hatchery which will reduce the number of hatchery fish spawning naturally to meet the low pHOS goal for the Hanford Reach.

Because fall Chinook salmon historically coexisted in substantial numbers with listed salmon and steelhead in the Columbia Basin, it follows that there must have been adequate passage and habitat to allow both species to be productive and abundant. It does not follow automatically, however, that the historical situation can be restored under present-day conditions. In the short-term, we do not believe current densities are limiting natural-origin salmon and steelhead production. NMFS expects that the monitoring efforts would detect negative impacts before they reach problematic levels, and we include language in the ITS (Section 2.9) to ensure that appropriate density monitoring takes place.

Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for the hatchery program. This is because no detections of exotic pathogens have occurred in the last three years and epidemics have all been caused by endemic pathogens with available treatments. In 2014, and outbreak of *Ichthyophthirius multifiliis* that resulted in an early release of the affected fish. Mortality was not elevated at the time of diagnosis. In 2018, fall Chinook salmon in the 2.5-acre pond developed bacterial coldwater disease (BCWD) (*Flavobacterium psychrophilum*) and were released early. Mortality was markedly elevated in the pond at the time of release with an average daily loss of 0.89% relative to a 0.02% daily loss. These outbreaks are expected to be reduced after the expansion of the hatchery that will improved the ability to control factors (e.g., stress, water quality) that contribute to the outbreaks as well as treatment if they do occur.

Early-arriving adults selected for spawning at RSH will be injected with Liquamycin (LA-200), prior to transfer to holding ponds. The injection dose was 0.5 cc per 10 lbs. of fish. Total use of Liquamycin was 900 milliliters for the season. This treatment was for the prevention of *Columnaris* and *Furunculosis*. Formalin treatments on adults will be at a rate of 1:6000 every day, starting the first day of ponding. Formalin on adults is used to prevent fungus. Fish health procedures used for disease prevention during fertilization include water hardening of eggs in an iodophor solution at spawning and biological sampling of spawners. ELISA is used for all female broodstock to test for Bacteria Kidney Disease (*Renibacterium salmoninarum)*.

IHOT fish health guidelines are followed to prevent disease transmission between lots of fish on site or transmission or amplification to or within the watershed. The juvenile rearing density and loading guidelines used at the facility are based on standardized agency guidelines, life-stage specific survival studies conducted on-site, life-stage specific survival studies conducted at other facilities and staff experience. Based on these preventative measures, NMFS expects the risk of pathogen transmission to wild fish from hatchery fish and amplification of pathogens in the natural environment is low.

Non-endemic Species

New Zealand mud snails (NZMS), an invasive species, were discovered at the RSH in 2014. The source of the infection is Ringold Springs Creek, which supplies water to the hatchery. As part of the Proposed Action the Corps would implement measures to prevent the spread NZMS throughout the mid-Columbia region as a result of the construction or operation of Ringold Springs Hatchery. Eliminating NZMS from the creek would require dewatering the creek and torching the area. As just one snail can reproduce asexually and recolonize the creek, this effort has not been undertaken due to the low likelihood of success. Current mitigation efforts are to take fish off feed for a week prior to release to purge their stomachs, lethally subsample a small number of fish, and examine the stomach contents for NZMS (Mike Erickson, WDFW, pers. comm.). To date, no NZMS have been found in the subsampled juvenile Chinook.

2.5.2.4. **Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program**

Research, monitoring, and evaluation (RM&E) activities under the Proposed Action are described in Section 1.3.2, above, and consist of RM&E activities within the hatchery and spawning ground surveys and carcass recovery.

The RM&E activities are not expected to have an effect on any ESA-listed species because no adult listed spring Chinook salmon or steelhead are likely to be present when the spawning and carcass surveys occur for these programs are conducted. Even if some listed species are present during the spawning ground surveys (e.g., steelhead, rearing juveniles), the typical response of fish to spawning and carcass survey is within the range of normal behaviors (i.e., startling response to a predator) and would not adversely affect listed species.

2.5.2.5. Factor 5. Construction, operation, and maintenance of facilities that exist because of the hatchery program

Most hatchery facility operations have no effect on ESA-listed species. The RSH fall Chinook salmon program has in the past withdrawn water from non-anadromous water (i.e., ditches designed to collect rain water, which do not allow natural-origin salmonid passage, are the source of the hatchery water), and thus there was no effect on ESA-listed salmonids as a result of water withdrawals. Under the proposed expansion of the facility, a new intake will be constructed that will withdraw water directly from the Columbia River. The new intake will be screened and operated in compliance with NMFS criteria for their intake structures and thus would not likely to adversely affect ESA-listed salmonids through impingement or entrainment.

The proposed withdrawal of water from the mainstem Columbia River could affect Upper Columbia River spring Chinook salmon or steelhead by reducing the flows. However, the proportion of withdrawal compared to the amount of available instream flow are not at levels that adversely affect any ESA-listed species. Under the proposed expansion, the RSH would withdraw up to 50 cubic feet per second (cfs) with the new intake in the mainstem Columbia River, which is approximately 1.4% of the average minimum flow at Priest Rapids Dam during the period of operations from September through June. The removal of up to 1.4% of the flow would have no discernable effect on fish passage though the main stem Columbia River at the RSH.

The RSH will be operated under a NPDES permit. Facility effluent is monitored to ensure compliance with permit requirements. Though compliance with NPDES permit conditions is not an assurance that effects on ESA-listed salmonids will not occur, the facilities use the water specifically for the purposes of rearing Chinook salmon, which have a low mortality during hatchery residence compared to survival in the natural-environment (~70 percent compared to 7 percent (Bradford 1995)). This suggests that the effects of effluent, which is further diluted once discharged, will have a minimal impact on ESA-listed salmonids in the area, as discussed below.

The total facility discharges proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary, very low, or undetectable levels of contaminants. General effects of various biological waste in hatchery effluent are summarized in NMFS (2004a), though the biological waste is not likely to have a detectable effect on listed species because of an abatement pond that reduces the biological waste, as well as the small volume of effluent compared to the stream flow.

Therapeutic chemicals used to control or eliminate pathogens (i.e., formaldehyde, sodium chloride, iodine, potassium permanganate, hydrogen peroxide, antibiotics) can also be present in hatchery effluent. However, these chemicals are not likely to be problematic for ESA-listed species because they are administered under veterinary instructions, quickly diluted beyond manufacturer’s instructions when added to the total effluent, and again after discharge into the recipient water body. Therapeutants are also used periodically, and not constantly during hatchery rearing. In addition, many of them break down quickly in the water and/or are not likely to bioaccumulate in the environment. For example, formaldehyde readily biodegrades within 30 to 40 hours in stagnant waters. Similarly, potassium permanganate would be reduced to compounds of low toxicity within several minutes. Aquatic organisms are also capable of transforming formaldehyde through various metabolic pathways.

The Corps identified the invasive New Zealand Mud Snail (NZMS) were present in the springs at RSH and it was determined that they could not be eradicated from the springs, requiring the control of NZMS within the hatchery. The Corps proposes to install round pond rearing systems that would use Cornell-style dual drain fish rearing tanks to remove as many NZMS as feasible from the juvenile rearing environment and to implement partial water reuse technology to reduce water consumption. NZMS would be removed with other waste particles found in the fish rearing system, which consist mainly of fish waste and excess feed. Once removed, the NZMS would be collected and disposed of at an approved upland disposal site. These actions are expected to eliminate or substantially reduce the potential for release and spread of NZMS at the RSH. For more information on the design of the NZMS control system, see the (USACE 2019).

Construction Activities
Under the Proposed Action the Corps would rebuild the RSH to increase production at the hatchery to meet JDM. A description of the proposed changes at the hatchery are provided in, Proposed Action, Section 1.3.1. Not all of the construction activities are expected to potentially impact listed species (e.g., construction of the hatchery building and raceways) because these activities would take place in upland areas away from the water and riparian habitat. For those construction activities that would require in-water work (e.g., installation of the intake structure, lower adult fish ladder, and adult fish return tube), the Corps has proposed a number of measures designed to minimize impacts on listed species. These actions are listed below.

- All in-water work would be conducted within the in-water work window of July 16-September 15.
- Erosion control would be implemented for construction of roadway paving, foundation work for ponds and pre-fabricated structures, and the new fish ladder. Erosion control would be implemented according to the storm water pollution prevention plan (SWPPP) that the Corps prepares and in compliance with Section 402 of the Clean Water Act.
- Improvements would be designed based on the "NMFS Anadromous Salmonid Passage Facility Design" and guidance in the 2000 "WDFW Fishway Guidelines for Washington State (Draft)".
- Impacts on riparian vegetation would occur during construction and upon completion of the work the Corps would replant impacted areas. The Corps would oversee site re-grading and the replanting of disturbed areas with native species.
- The Corps would install silt barriers at the site during work to prevent/reduce sediment from entering the river.
- The Corps would obtain all appropriate state and federal permits before work is initiated.
- The Corps would clean all materials used prior to placement below the ordinary high water (OHW).
- The Corps would clean all equipment to ensure it is free of vegetation, external oil, grease, dirt, NZMS, and mud before equipment is brought to the site and prior to removal from the project area.

- The Corps would operate all equipment above OHW or in the dry whenever possible to reduce impacts.
- The Corps would make absorbent material available on site to collect any lubricants in case of a pressurized line failure. Dispose of all used materials in facilities permitted and operated to contain such materials.
- The Corps would stage and fuel all equipment in appropriate areas above the OHW mark and within the proposed project boundaries.
- Before in-water work activities commence, fish would be driven from the project site using an approved method and excluded from returning with the use of exclusion fencing to minimize risk of injury. Low-impact methods would be used to remove fish (e.g., herding of fish using seines).
- The Corps would cease operations if, at any time, fish are observed in distress as a result of the activities.
- The Corps would prepare and implement a pollution and erosion control plan to prevent pollution for construction activities in accordance with Section 402 of the Clean Water Act. The plan would be made available for inspection on request by NMFS and USFWS.
- The Corps would use approved oils / lubricants when working below the OHW mark.
- The Corps would use construction best management practices to limit turbidity impacts on surface waters to no more than a 10 percent cumulative increase over the baseline turbidity level, as measured relative to a control point immediately upstream of construction.
- During construction, the Corps would inspect all erosion controls daily to ensure they are working adequately. If inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs or to install replacements or additional controls as necessary.
- The Corps would implement a spill prevention and response plan that requires storage of fuel and other potential pollutants in a secure location at least 150 feet from water bodies; ensures that spill containment and cleanup materials are readily available on site and restocked within 24 hours, if used; and ensures that, in the event of a spill, contractors are trained to immediately contain the spill, eliminate the source, and deploy appropriate measures to clean and dispose of spilled materials in accordance with federal, state, and local regulations.
- The Corps would inspect all equipment daily for fuel, oil, or hydraulic leaks, and maintain vehicles to prevent any of these fluids from entering the river.
- The Corps would use pumps, funnels, absorbent pads, and drip pans when fueling or servicing vehicles.
- The Corps would store, fuel, and maintain vehicles and equipment in designated staging areas located a minimum of 150 feet from the river.
- Prior to any dewatering, removal and relocation procedures would be discussed with USFWS and NMFS. A qualified biologist would be onsite during placement of isolation features and dewatering to remove and relocate fish from dewatered areas as necessary consistent with approved state and federal protocols for this practice, including:
    - Use low-impact methods to remove fish (e.g., herding of fish using seines).
    - If electrofishing is needed for fish salvage, biologists would follow NMFS'

Backpack Electrofishing Guidelines (NMFS 2000).

- Employ vibratory pile-driving equipment, whenever possible, to reduce sound levels to below fish-injury thresholds and use sound attenuation measures, as feasible, for impact driving of piles.
- Pile driving shall occur only during daylight hours with the sun above the horizon to avoid peak movement time for juvenile and adult salmonids (dawn or dusk).
- Surround the piling being driven by a confined bubble curtain (e.g., a bubble ring surrounded by a fabric or metal sleeve) that would distribute air bubbles around the entire piling perimeter for the full depth of the water column.
- Additional attenuation: Other attenuation measures such as the use of a cushioning block may be employed as necessary to reduce sound levels. Cushioning blocks used between a hammer and pile (during impact pile installation) can reduce noise up to 26 decibel (dB) and would be used during all impact pile installation activities. In the event where noise generation is shown to exceed levels calculated for this analysis, by way of behavior observations of stressed fish, the implementation of additional attenuation devices would be reevaluated, and discussions with NMFS and USFWS would be initiated in order to pursue a better strategy that would more effectively attenuate noise propagation in the aquatic environment.
- Soft Start Technique: A 'soft-start' technique would be used at the beginning of each day's in-water pile installation or removal activities or if pile-related activities have ceased for more than 1 hour. This technique would allow any fish that may be in the immediate area to leave before pile driving reaches full energy. For impact pile installation, contractors would be required to provide an initial set of three strikes from the impact hammer at 40 percent energy, followed by a 1-minute waiting period, then two subsequent three-strike sets.

Potential impacts on listed species from the construction activities associated with the proposed expansion of the RSH are expected to be negligible. The in-water work would be done in the wet, and the work area would not be isolated. Temporary disturbance of aquatic habitat within the Columbia River would be required for installation of the intake structure, and permanent loss of streambed would occur at the location of the footings. The remaining infrastructure, which includes precast support beams that will sit between the two pile shafts, precast intake boxes, and a cap beam will likely require a second in-water work period to be installed after the initial shafts are driven.
In-water work associated with installation of the intake structure and the fish ladder would occur during the Columbia River in-water work window of July 16 – September 15, when fish are least likely to be present. Potential direct construction effects include harassment or direct mortality through contact with construction equipment during in-water work; stress related to fish displacement, handling, or removal; increased suspended sediment and deposition, blocked migration, and disrupted or disturbed behavior. Potential adverse effects on suitable habitat and critical habitat include temporary loss of riparian vegetation, temporary loss or imbalance of nutrients and food supply, and permanent loss of streambed beneath the fish ladder.

Construction of the lower fish ladder would take place primarily within Ringold Springs Creek, in which listed species are not found, and the effects would be primarily due to sediment disturbance and turbidity during construction. The lower end of the fish ladder would be located within the Columbia River. Disturbance would occur primarily during lower ladder construction for the portion within the river, and would occur over a short construction period. Effects on listed fish species from construction of the lower fish ladder would be similar to effects from construction of the water intake structure.

The effects of turbidity on fish depends on the size and shape of the sediment particle, concentration, water temperature, duration of exposure as well as the age and species of fish. In-water construction projects typically have transient plumes of turbidity lasting a few minutes to a few hours. Because mortality first occurs at turbidity levels that far exceed typical construction projects, direct mortality from suspended sediment is not expected to occur during this project (USACE 2019). Turbidity can also have physiological effects (USACE 2019), but, given the ability of both juvenile and adult salmonids to avoid areas with less than favorable conditions and the timing of work within the in-water work window, when juveniles are unlikely to be present, impacts are not expected.

Disturbance includes physical actions associated with excavation in the streambed or installation of pilings. The installation of piles within 30 feet of the edge of water, which may generate noise in excess of thresholds normally considered within the range that listed salmonids can tolerate. Excessive and high levels of noise are known to result in deleterious behavioral and neurological changes in aquatic organisms (USACE 2019). Adult and juvenile salmonids may respond to excessive in-water noise through avoidance, stress, or injury (USACE 2019). Examples of behavioral changes include rapid turning or movement away from the noise, or temporary cessation of feeding. All pile driving and in-water drilling in the Ringold construction sites would be preceded by a “soft-start period”, during which reduced sound levels would be generated to allow fish to leave the area in which effects would be most pronounced (USACE 2019). Work would occur during the summer in-water work window of July 16-Sept. 15, when listed fish are least likely to occur in the work area.

Because noise levels associated with vibratory hammers are typically not as high as with impact pile drivers (WSDOT 2014), construction would use vibratory pile insertion to the degree possible. Where such use is not possible, conservation measures above would be implemented. However, the effects of installation of in-water structures in this instance may affect fish behavior for up to 10,000 meters from the construction site. Given the distance at which behavioral effects may occur during in-water work at the Ringold Springs work area, any listed fish migrating past the construction area would be affected. Adult Upper Columbia spring Chinook have completed their upstream migration before the in-water work window as well as, juveniles of the species. Non-listed summer Chinook salmon and sockeye salmon would be migrating upstream during this period.

Juvenile Upper Columbia steelhead will have completed their downstream migration prior to the work window, but adults are present in the river year-round. Steelhead adults are not expected to be actively migrating, and the number of listed steelhead migrating through the Hanford Reach is anticipated to be near its lowest point. The relatively short duration of the in-water work at the Ringold site (6 days), and the limited footprint of the construction site relative to the mainstem Columbia River, would provide enough opportunity for any adult steelhead present in the reach to avoid impacts from the in-water work.

Due to the transient nature and lower levels of turbidity and the noise expected to be generated from the construction activities at Ringold Springs Hatchery, the most likely effect on salmon and steelhead due to construction would be avoidance of the work area during construction. The mainstem Columbia River is over 750 meters in width at the facility, and this would provide enough habitat for natural-origin fish to avoid construction effects. NMFS expects that the implementation of the conservation measures listed above, and the location of the construction activities in the mainstem Columbia River within the Hanford Reach, would result in negligible impacts on listed species from the construction activities such that no take would be likely to occur.

2.5.2.6. Factor 6. Fisheries that exist because of the hatchery programs

There are no fisheries that exist because of the Proposed Action. The effects of fisheries that may impact fish produced by these programs are described in Section 2.4.4.

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 and 402.17(a)). 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. For the purpose of this analysis, the action area is that part of the Columbia River Basin described in Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline (whether they are Federal, state, tribal or private). This includes the impacts of other hatchery programs in the action area that were included in the environmental baseline (Section 2.4). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future until an opinion for the take permit has been issued.

State, tribal, and local governments have developed plans and initiatives to benefit listed species and these plans must be implemented and sustained in a comprehensive manner for NMFS to consider them "reasonably foreseeable" in its analysis of cumulative effects. Recovery Plans for various species in the Columbia River Basin (UCSRB 2007; NMFS 2009; NMFS and ODFW 2011; NMFS 2013b; 2015a; 2015c; 2016c) are such plans and it describes, in detail, the on-going and proposed Federal, state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon and steelhead in the Columbia River Basin. It is acknowledged, however, that such future state, tribal, and local government actions would likely be in the form of legislation, administrative rules, or policy initiatives, and land-use and other types of permits, and that government actions are subject to political, legislative, and fiscal uncertainties.

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).

A full discussion of cumulative effects can also be found in the FCRPS Biological Opinion (NMFS 2008c) and the Mitchell Act Biological Opinion (NMFS 2017a), much of which is relevant to this Action Area. It should be noted that the actions in the FCRPS Biological Opinion – the operation of the Columbia River Federal Hydropower system – and the Mitchell Act biological opinion – the operation of Columbia River hatchery programs – are included in the baseline for this opinion.

The cumulative impacts from these programs contribute to the total impacts from hatcheries in the entire Columbia River Basin, which is noted in the Mitchell Act Biological Opinion (NMFS 2017a). Between those programs which have already undergone consultation and those for which consultation is underway[6], it is likely (though uncertain for ongoing consultations) that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the Columbia River Basin 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 programs funded and operated by non-federal agencies and tribes in the Columbia River Basin have had 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 (NMFS 2018). 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. Where needed, 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
- Incorporation of new research results and improved best management practices for hatchery operations
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches

These potential changes to hatchery operations across the region combined with the Proposed Action result in a net improvement over current conditions. While the hatchery programs around the basin contribute to negative impacts on listed salmonid species as described above, when the beneficial changes to hatchery practices, those that reduce genetic effects and ecological interactions, and improve hatchery operations, are also combined with the potential negative impacts from these hatchery programs and the rest of the operations in the Columbia River basin,

[6]Within the Columbia River there are an estimated 17 hatchery programs that are undergoing consultation, of which 4 of the hatchery programs are above Bonneville Dam.

a net beneficial result is expected as hatchery practices continue to improve and reduce their impacts on listed species.

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, NMFS adds the effects of the Proposed Action (Section 2.5.2) to the environmental baseline (Section 2.4) and to cumulative effects (Section 2.6) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (Sections 2.2.1).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.5.2., above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the listed species and their designated critical habitat.

2.7.1. UCR ESUs/DPS, Snake River ESUs/DPS, Mid-Columbia River Steelhead DPS, Columbia River Chum Salmon ESU, Lower Columbia River ESUs/DPS, and Upper Willamette River ESU/DPS

Best available information indicates that the UCR Spring Chinook, Snake River Spring/Summer Chinook, Fall Chinook, and Sockeye Salmon ESUs, UCR Steelhead DPS, Snake River Steelhead DPS, Mid-Columbia River Steelhead DPS, Columbia River Chum Salmon ESU, Lower Columbia River Chinook and Coho Salmon ESUs, Lower Columbia River Steelhead DPS, Upper Willamette River Spring Chinook Salmon ESU, and Upper Willamette River Steelhead DPS are all at high risk and remain threatened. The Snake River Sockeye Salmon ESU is at high risk and remains endangered (NWFSC 2015). However, after taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs and DPSs in the wild.

Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on these species. Although all may have contributed to the listing of these species, all factors have also seen improvements in the way they are managed/operated. The improvements made by the changes in these factors are measured as changes in the status of the listed species. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects of climate change (e.g., hatcheries serving a genetic reserve for natural populations).

The effects of the Proposed Action on these ESUs and DPSs are limited to ecological interactions, between hatchery-origin juvenile fish from the RSH and natural-origin fish, when they overlap in outmigration timing and location. Note, however that there is also some straying of RSH Chinook salmon into the Snake River, but at levels that would be expected to have no more than a negligible effect on listed-species. The Proposed Action is not expected to have any effects on the other factors in the environmental baseline (i.e., hydropower, habitat, or harvest) and their impacts on listed species. The results of our analysis are summarized in Table 49. Impacts from the release of fall Chinook salmon subyearlings from the RSH equates to a potential loss ranging from 550 adult equivalents from the Lower Columbia River Chinook Salmon ESU to 0 chum salmon and steelhead adult equivalents from the Lower Columbia River ESU/DPS. These impacts are also characterized as a proportion of lost adults compared to the total returning adults from each ESU/DPS at the mouth of the Columbia River, ranging from 0 percent for the Lower Columbia River Coho Salmon ESU to 4.2 percent for the Snake River Sockeye Salmon ESU.

As described in the analysis in Section 2.5.2.3, the modeled impacts represent the maximum level of potential impacts based on the assumptions used in the model. Impacts on listed species may actually be less than what was modeled. The 8.15M subyearling release in the Proposed Action includes 1.7M subyearlings that are currently being released at Priest Rapids Hatchery and 3.5M subyearlings that are being released at RSH. The effects of the 5.2M subyearlings being released into the Hanford Reach are already reflected in the baseline, and the impacts are represented by number of adults returning to the various ESUs/DPSs (Table 48). The increase in production to 8.15M subyearlings represents an increase of approximately 36% over current release levels. The impacts on listed species from the additional release of 2.95M subyearlings would be approximately 36% of that which has been modelled because the model assumes this is a new program. Thus, the estimated small percentage loss within the majority of the ESUs and DPSs encountered would be substantially less and is unlikely to substantially affect the abundance and productivity of these natural-origin fish in the Columbia River Basin.

Table 49. Natural-origin adults (in terms of estimated adult equivalents) lost as a result of the proposed action compared to returning adults from each ESU/DPS at the mouth of the Columbia River.

Species (ESU/DPS)		**Total Lost Adult Equivalents**	**Proportion of Lost Adults to Total Returning Adults from ESU/DPS (%)**
Chinook Salmon	Snake River Spring/Summer Chinook Salmon ESU	63	0.2
	Snake River Fall Chinook Salmon ESU	22	0.09
	Upper Columbia River Spring Chinook Salmon ESU	10	0.2
	Lower Columbia River Chinook Salmon ESU	550	1.4
	Upper Willamette River Spring Chinook Salmon ESU	68	0.7
Steelhead	Snake River Steelhead DPS	1	0

Species (ESU/DPS)		Total Lost Adult Equivalents	Proportion of Lost Adults to Total Returning Adults from ESU/DPS (%)
	Upper Columbia River Steelhead DPS	0	0
	Middle Columbia Steelhead DPS	0	0
	Lower Columbia River Steelhead DPS	0	0
	Upper Willamette River Steelhead DPS	0	0
Snake River Sockeye Salmon ESU		68	4.2
Columbia River Chum Salmon ESU		0	0
Lower Columbia River Coho Salmon ESU		0	0

The results of the PCDrisk model run showed an estimated 68 Snake River sockeye salmon or 4.2% of the average annual adult returns would be lost due to ecological interactions. As describe above and in Section 2.5.2.3, this estimated impact is a result of the model output and the assumptions used. In one model run it is assumed that the rate of travel from McNary Dam to Bonneville Dam is the same as the median rate from RSH to McNary, but this does not reflect the tendency for fish to migrate faster as they mature (McMichael et al. 2011). Changing the assumed rate of travel from McNary Dam to Bonneville decreased impacts from 53 to 7 adults, which represents 1.3% of the total returning adults. The potential annual loss of between 68 and 22 of the returning Snake River sockeye salmon, as estimated from the model output, would be a substantial impact on the species abundance and potentially its productivity. As described above, the model evaluated the effects of the full 8.15M subyearling release to estimate the potential number of adult equivalents lost. This estimate was compared to the recent adult escapements for the various listed ESUs and DPSs (Table 48), however, these recent escapements reflect the impacts from the current going releases of 1.7M at Priest Rapids Hatchery and 3.5M at RSH. The impacts from the additional release of 2.95M subyearlings would represent an increase of approximately 36% of the total estimated impacts or between 24 and 8 adult Snake River sockeye salmon lost. These additional impacts represent between 1.4% and 0.5% of the recent mean escapement. Because these impacts are the result of the assumptions used in the PCDrisk model, NMFS will require that the Corps and WDFW closely monitor and report to NMFS, the travel time and survival of PIT tagged fish from the RSH once it becomes fully operational. Under the Proposed Action, up to 7,500 subyearling juveniles will annually be given a PIT-tag, and it is expected that these tags will provide better estimates of travel and survival rates that can be used to address assumptions used to model ecological interactions between RSH juveniles and listed species.

The potential reduction in overall abundance naturally spawning Snake River sockeye salmon not likely to affect the long-term recovery of the ESU because NMFS is certain that benefits to the ESU will continue to accrue. The benefits from completed habitat restoration projects, hydrosystem passage improvement completions, and site specific Columbia River 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 (TAC 2017). The current increases reflect substantial positive changes in biological status.

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, the expansion and release of fall Chinook salmon from the RSH 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.

With regards to the other ESUs and DPSs considered in this opinion, we evaluated the addition of the Species' Status, Environmental Baseline, and effects of the Proposed Action to the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for each ESU and DPS describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs and steelhead DPSs. The release of URB fall Chinook salmon under the Proposed Action is also expected to reduce impacts on listed species. NMFS expects the Proposed Action will contribute to the trend continuing and could lead to increases in abundance, productivity, spatial structure, and diversity.

After taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the small effects of the Proposed Action on abundance, productivity, spatial structure, and diversity, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs and DPSs in the wild.

2.7.2. Critical Habitat

Only the PBFs for UCR spring Chinook salmon and UCR steelhead are likely to be affected from the Proposed Action. The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat for UCR spring Chinook salmon and UCR steelhead in the mainstem Columbia River (Section 2.5.2.5). Existing hatchery facilities and the proposed expansion are expected to have negligible effects on channel morphology but would be expected to impact channel stability, reduce and degrade floodplain connectivity, contribute to excessive sediment input, and contribute to the loss of habitat diversity. However, the impacts to these habitat features is expected to minor, due to the temporary nature of the in-water construction activities, and the small footprint of the intake structure and adult fish ladder relative to the expansive mainstem Columbia River at Hanford Reach (Section 2.5.2.5). Thus, the impact on the spawning, rearing, and migration PBFs of UCR spring Chinook salmon and UCR steelhead within the Hanford Reach area of the Columbia River will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

Climate change may have some effects on critical habitat as discussed in Section 2.4.2. With continued losses in snowpack and increasing water temperatures, it is possible that increases in the density and residence time of fish using cold-water refugia could result in increases in ecological interactions between hatchery and natural-origin fish of all life stages, with unknown, but likely small, effects. The continued restoration of habitat may, however, provide additional refugia for fish. The Proposed Action is not expected to acerbate the effects of climate change on species critical habitat because impacts on critical habitat is limited to a very small footprint in the Hanford Reach area of the mainstem Columbia River that would not affect cold water refugia or habitat restoration actions.

After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

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, the effects of other activities caused by the Proposed Action, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of any of the ESUs and DPSs listed in the Columbia River Basin (Table 50), or destroy or adversely modify designated critical habitat.

Table 50. Summary of NMFS determination of effects.

ESA-Listed Species (Status)	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Upper Columbia River Spring Chinook salmon (Endangered)	Yes	Yes	No	No
Snake River Spring/Summer Chinook salmon (Threatened)	Yes	No	No	No
Snake River Fall Chinook salmon (Threatened)	Yes	No	No	No
Lower Columbia River Chinook salmon (Threatened)	Yes	No	No	No
Upper Willamette River Spring Chinook salmon (Threatened)	Yes	No	No	No
Upper Columbia River steelhead (Threatened)	Yes	Yes	No	No
Snake River steelhead (Threatened)	Yes	No	No	No
Middle Columbia River steelhead (Threatened)	Yes	No	No	No
Lower Columbia River steelhead (Threatened)	Yes	No	No	No
Upper Willamette River steelhead (Threatened)	No	No	No	No
Snake River sockeye salmon (Endangered)	Yes	No	No	No
Columbia River chum salmon (Threatened)	No	No	No	No
Lower Columbia River coho salmon (Threatened)	No	No	No	No

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulation 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[7], harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to

[7] NMFS recognizes the benefit of providing guidance on the interpretation of the term "harass". As a first step, for use on an interim basis, NMFS will interpret harass in a manner similar to the USFWS regulatory definition for non-captive wildlife: “Create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” NMFS interprets the phrase “significantly disrupt normal behavioral patterns” to mean a change in the animal’s behavior (breeding, feeding, sheltering, resting, migrating, etc.) that could reasonably be expected, alone or in concert with other factors, to create or increase the risk of injury to an [ESA-listed] animal when added to the condition of the exposed animal before the disruption occurred. See Weiting (2016) for more information on the interim definition of “harass.”

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 of ESA-listed steelhead and Chinook salmon is reasonably certain to occur as a result of the Proposed Action for the following factors. Take as a result of Factor 1 does not apply here, as none of the ESA-listed salmon and steelhead species affected here are explicitly targeted for broodstock collection—incidental take of these species during collection of target fish for broodstock is addressed under Factor 2.

Factor 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

At the Ringold Springs Rearing Facility, up to 130 ESA-listed Upper Columbia River steelhead could be encountered annually, with up to 6 mortalities as a result of handling. These constitute incidences of take by harm or harassment. Thus, the extent of take through this pathway is up to 130 UCR steelhead taken via handling, with up to 6 mortalities associated with that take.

Factor 3: Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas and the migratory corridor

Predation and competition (collectively referred to as ecological interactions for the purposes of this opinion) between natural-origin juvenile salmon and steelhead and hatchery fall Chinook salmon smolts could result in take of natural-origin salmon and steelhead through both harassment and harm. However, it is difficult to quantify this take because ecological interactions cannot be directly or reliably measured and/or observed. Thus, we will monitor ecological effects using a surrogate related to how quickly hatchery summer/fall and fall Chinook salmon leave the system.

For ecological effects of competition and predation caused by emigrating hatchery fall Chinook salmon, NMFS applies a take surrogate that relates to the median travel time for hatchery fish to reach McNary Dam and Bonneville Dam after release. Because modeling data for travel time between McNary Dam and Bonneville Dam was based on the median travel time from RSH to McNary Dam, the extent of take from interactions between hatchery and natural-origin juvenile salmonids are measured as follows: the travel time for emigrating juvenile hatchery subyearling fall Chinook salmon is five days longer than the median value (which equates to 50% of the fish) of 13 days (RSH to McNary Dam) for 3 of the previous 5 years of 5-year running medians. This surrogate has a causal link to the extent of incidental take because, if travel time increases in more years than not, it is a sign that fish are not exiting the action area as quickly as expected, and that the recurring increase in time indicates that the issue is not related to a single external factor but to a more fundamental change in migration timing which will increase the number or frequency of potentially harmful ecological interactions. The proposed annual tagging of 7,500 with PIT tags will provide reliable monitoring of this threshold and provide data for travel time from McNary Dam to Bonneville Dam. Five years after the first release of juveniles from the expanded RSH, NMFS, the Corps, and WDFW will reevaluate this surrogate and associated impacts. This threshold can be reliably monitored using emigration estimates from PIT tags, though NMFS expects the operators to develop additional juvenile monitoring techniques during the Proposed Action.

Factor 5: Operation of facilities that exist because of the hatchery program

Take from facility operations is anticipated to occur through harassment from sediment disturbance and noise, both of which will arise from construction activities. In the case of take caused by sediment disturbance, this take cannot be meaningfully quantified, because it cannot be observed. Therefore, NMFS will rely on a surrogate measure of take in the form of the area impacted by sediment. The extent of the area impacted by sediment is not to exceed 300 feet downstream of the construction site and not exceed state water quality standards during construction (less than five Nephelometric Turbidity Units [NTU] above background levels). This surrogate is rationally connected to the extent of potential take, since the larger the area affected by sediment, the more take will occur. This is equally true of the sediment levels, which increase take as the NTUs increase. This surrogate will be monitored during construction activities by measuring the extent and concentration of the suspended sediment downstream of the construction site (USACE 2019).

For take caused by noise impacts, here too the take cannot be meaningfully quantified because the disturbance of listed salmonids by noise impacts cannot be observed. Therefore, NMFS will rely on a surrogate in the form of the number of days in which pile driving will occur. NMFS expects pile driving, the source of noise impacts, to not exceed more than six days in the construction period. The surrogate is rationally connected to the extent of take, because the duration of displacement of fish due to noise impacts increases the severity of the harassment they experience. This surrogate can be monitored by the number of days piling driving occurs. .

2.9.2. Effect of the Take

In Section 2.8, 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 to minimize 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 incidental take. NMFS and the Corps shall ensure that:

1. The Corps and WDFW implement the hatchery programs and operate the hatchery facilities as described in the Proposed Action (Section 1.3) and in the submitted HGMP.
2. The Corps implement the construction of the Ringold Spring Hatchery Expansion as described in the Proposed Action (Section 1.3) and in the submitted Biological Assessment.
3. The applicants provide reports to SFD annually for all hatchery programs, and associated RM&E.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps and WDFW must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps and WDFW have 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 incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply, NMFS would consider whether it is necessary to reinitiate consultation.

The Corps shall ensure for the Ringold Springs fall Chinook salmon that:

1.a. The WDFW implement the hatchery program as described in the Proposed Action (Section 1.3) and in the submitted HGMP, including:

- i. Providing advance notice to NMFS of any change in hatchery program operation (including early releases) that potentially increases the amount or extent of take, or results in an effect of take not previously considered.
- ii. Providing notice if monitoring reveals an increase in the amount or extent of take beyond that described here, or discovers an effect of the Proposed Action not considered in this opinion.
- iii. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.

1.b The applicants implement the annual application of at least 7,500 PIT-tags for the Ringold Springs fall Chinook salmon program to adequately track the program's hatchery-origin fish emigration time and survival. The Corps shall secure funding for this monitoring starting with the next available fiscal year budget submittal (2021), and the applicants shall implement this monitoring thereafter. If the Corps cannot secure the funding, the Corps shall notify NMFS.

2.a. The Corps will implement the construction of the Ringold Springs Hatchery expansion as described in the Proposed Action (Section 1.3) and in the submitted Biological Assessment, including:

- i. Providing, in writing, advance notice and review to NMFS of any change in the design and construction of the hatchery expansion.
- ii. Allowing NMFS to accompany any employee or representative field personnel to inspect construction activities.

iii. Allowing NMFS to accompany any employee or representative field personnel to inspect the intake structure and other facilities prior to and during the initiation of operations.

2.b. During construction activities, the Corps will:

i. Monitor sediment distribution and concentration such that it does not exceed 300 feet downstream of the construction site and exceed five Nephelometric Turbidity Units [NTU] above background levels.

ii. Limit pile driving activities not to exceed 6 days total.

3. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.

i. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Rich Turner (503) 736-4737, *rich.turner@noaa.gov*.

ii. Applicants will report annually on the travel rates and survival of PIT-tagged juveniles released at the Ringold Springs Hatchery.

ii. Applicants will notify NMFS SFD within 48 hours after knowledge of exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded within two weeks of the event.

iii. Applicants will include the reporting information detailed in the WDFW's section 10 permits in their reports.

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 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 (50 CFR 402.02). NMFS did not identify a conservation recommendation appropriate to the Proposed Action:

2.11. Re-initiation of Consultation

This concludes formal consultation on the approval and implementation of Ringold Springs Hatchery expansion and the rearing and release Upriver Bright fall Chinook salmon in the UCR Basin.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service 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 identified action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in the biological 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

The applicable standard to find that a Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat is that all of the effects of the action are expected to be either discountable or insignificant, or the action is expected to be wholly beneficial (USFWS and NMFS 1998). Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur. NMFS has determined that the Proposed Action may affect, but is not likely to adversely affect, the Green Sturgeon Southern DPS, the Southern Resident Killer Whale DPS, and the southern DPS of eulachon.

2.12.1.1. Life History and Status of the Green Sturgeon Southern DPS

The Green Sturgeon Southern DPS may be affected by the proposed summer/fall and fall Chinook salmon programs as a result of increased competition for resources between hatchery salmonids and green sturgeon, but the DPS is not likely to be adversely affected, as described here.

The anadromous North American green sturgeon occurs throughout the West Coast from El Socorro Bay, Baja California, to the Bering Sea, Alaska, inhabiting coastal bays and estuaries and migrating to spawning habitats in cool, deep freshwater rivers. Juveniles rear in their natal rivers for two to three years before migrating to the ocean. Two Distinct Population Segments are recognized based on spawning site fidelity and genetic analyses, with the Southern DPS spawning only in the Sacramento River system and the Northern DPS spawning only in the Klamath and Rogue rivers (NMFS and NOAA 2006). The Southern DPS was listed as threatened April 7, 2006 (71 FR 17757) and the Northern DPS was determined to be a NMFS Species of Concern. The population size of the Southern DPS is estimated to be smaller than the Northern DPS. Although the populations overlap in their marine and estuarine distribution, high spawning fidelity has resulted in genetic differentiation between the two green sturgeon DPSs (Israel et al. 2009).

Major threats to the Southern DPS include alterations to aquatic habit such as barriers to migration, insufficient flows, increased temperatures, and pollution (NMFS 2006), none of which apply to the current Proposed Action.

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, California, to Cape Flattery, Washington, 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).

The release of hatchery summer/fall and fall Chinook salmon has not been identified as a threat to the survival or persistence of Southern Green Sturgeon DPS. An in-depth literature search has revealed no identified interactions between green sturgeon and hatchery released fish even though both Northern and Southern Green Sturgeon DPS occur in the Columbia estuary and

River up to Bonneville Dam. One potential effect is increased competition for resources between hatchery salmonids and green sturgeon. This may be a concern for large releases of hatchery salmonids in natal rivers; however, the Columbia River is not a natal river for green sturgeon. The green sturgeon found in the Columbia River estuary are subadults and adults (Moser and Lindley 2007) and do not occupy the same foraging habitats as URB fall Chinook salmon juveniles, making the potential increase in competition unlikely and, therefore, discountable. Based on this analysis, NMFS concludes that the Proposed Action is not likely to adversely affect the Southern Green Sturgeon DPS or their designated critical habitat.

2.12.1.2. **Southern Resident Killer Whale DPS and Proposed Critical Habitat**

The Southern Resident Killer Whales (SRKW; Southern Residents) DPS consist of three pods (J, K, and L) and was listed as endangered on February 16, 2006 (70 FR 69903). The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008d). Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, it is likely that multiple threats are acting together to impact the whales (NMFS 2008d).

Critical habitat for the Southern Resident killer whale DPS was designated on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters of Washington in 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. Based on the natural history of SRKWs 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. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi2) (40,472.7 square kilometers (km2)) of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California. In the proposed rule (84 FR 49214), NMFS states that the “proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection.” The three physical or biological features essential to conservation in the 2006 designated critical habitat were also identified for the six new areas along the U.S. West Coast.

Southern Residents 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 2008d; Hanson et al. 2013; Carretta et al. 2019). During the spring, summer, and fall months, Southern Residents have typically spent 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 et al. 2000; Krahn et al. 2004; Hanson and Emmons 2010). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; The Whale Museum unpubl. data). Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research conducted have provided an updated estimate of the whales' coastal range that extends from the Monterey Bay area in California, north to Chatham Strait in southeast Alaska. In March 2005, L pod was sighted working a circuit across the Columbia River plume from the North Jetty across to the South Jetty during the spring Chinook salmon run in the Columbia River (Zamon et al. 2007). Recent evidence shows K and L pods are spending significantly more time off of the Columbia River in March than previously recognized, suggesting the importance of Columbia River spring Chinook salmon in their diet (Hanson et al. 2013). Detection rates of K and L pods on passive acoustic recorders indicate the whales occur with greater frequency off Columbia River and Westport and are most common in March (Hanson et al. 2013). Satellite-linked tag deployments on K and L pod individuals have also provided more data on the whales' movements in the winter (Hanson et al. 2017; Hanson et al. 2018). These data indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months, whereas J pod occurs more frequently in inland waters, particularly in the northern Georgia Strait.

The only potential effect of the Proposed Action on SRKW and proposed critical habitat is as a result of changes in prey availability. The Proposed Action affects SRKW prey availability in two ways: by producing fish that the whales can feed on, and by reducing (through hatchery-production-related effects described in greater detail elsewhere) the number of natural-origin fish that would ultimately be available to the whales as prey.

Southern Residents consume a variety of fish species but salmon are identified as their primary prey (i.e., a high percentage of prey consumed during spring, summer and fall, from long-term studies of resident killer whale diet; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). 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 in inland waters from May to September indicate that Southern Residents' diet consists of a high percentage of Chinook, with an overall average of 88% Chinook across the timeframe and monthly proportions as high as >90% Chinook (Hanson et al. 2010; Ford et al. 2016). Prey and fecal samples collected in the winter months also indicate the whales' primary prey is Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut in their diet (Hanson et al. In prep). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kcal/kg) (O'Neill et al. 2014). Chinook genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 14 U.S. west coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. in review). In an effort to prioritize local recovery efforts to increase SRKW prey base, NMFS and WDFW developed a report identifying Chinook salmon stocks thought to be of high importance to SRKW along the West Coast (NMFS and WDFW 2018). Fall upriver brights are considered a high priority stock.

The Proposed Action may affect SRKWs indirectly by affecting the availability of their primary prey, Chinook salmon. Hatchery-produced Chinook salmon may benefit SRKW by enhancing prey availability, as scarcity of prey has been identified as a threat to SRKW survival and recovery, and hatchery fish often contribute to the salmon stocks consumed by SRKW (Hanson et al. 2010). The release of 8,150,000 fall Chinook salmon subyearlings under the Proposed Action could potentially increase the number of Chinook salmon available to the SRKW in coastal waters by 24,124 fall Chinook salmon adults annually. These adult survival numbers are calculated by applying the Chinook salmon SARs to the release numbers[8]. Because SARs account for mortality occurring after adult salmon re-enter freshwater, these adult numbers are an underestimation of the available prey for SRKW. PFMC (2020) estimated Chinook salmon abundance during 1992-2016 coastwide that could potentially be prey for SRKW. The most recent 10 year average coast Chinook salmon abundance was estimated to be 3,679,539 fish, was approximately 2,035,778 fish (PFMC 2020). Although it is difficult to assess how changes in prey abundance may vary throughout proposed critical habitat, but the contribution of fall Chinook salmon from RSH, considered a high priority stock releases to this total is approximately 1.2% of the total Chinook salmon abundance.

As described in Section 2.5.2.3, the release of hatchery fish in the Upper Columbia River Basin may affect the natural-origin Chinook salmon production in the basin and reduce the number of natural-origin fish available to SRKW as prey by some amount because of competition or predation between hatchery-origin and natural-origin juveniles as they emigrate. These losses of juveniles equate to a range from 0.2 to 1.4 percent of returning adults at the mouth within each ESU, though, as mentioned above, these numbers are likely an overestimate (see section 2.5.2.3 and Table 48); however, these lost natural-origin fish would be replaced by the hatchery fish, and natural-origin fish numbers may increase over time as the goal of the program is to increase the number of naturally-produced fish spawning in the Upper Columbia River Basin. Based on the current natural-origin abundance in the Upper Columbia River Basin, any increase or decrease in overall natural-origin abundance would not have any discernible effect on the total abundance of Chinook salmon off the west coast. It is unlikely that SRKW would have encountered and consumed all of these fish lost to competition and predation (Table 48) annually because the spatial and temporal distributions of SRKW and Chinook salmon are not entirely overlapping, and there is a low probability that all of these lost natural-origin Chinook would be intercepted by SRKW across their vast range in the absence of the Proposed Action. Therefore, any adverse effect on SRKW as a result of reductions in natural-origin Chinook salmon as prey would be insignificant.

Our analysis of the Proposed Action focuses on effects to Chinook salmon availability because the best available information indicates that SRKWs prefer Chinook salmon and this provides a conservative approach to assessing impacts from prey reductions. Focusing on Chinook salmon provides a conservative estimate of potential effects of the action on SRKWs because the total abundance of all salmon and other potential prey species is orders of magnitude larger than the total abundance of Chinook salmon.

Given the Proposed Action is likely to benefit SRKW with production of hatchery fall Chinook salmon and provide an increase (though minor) in prey availability, and the effects of the action on the status of listed salmon is small, the release of fall Chinook salmon in the Hanford reach of

[8]For the fall Chinook salmon releases, we used the average SARs for the Priest Rapids Hatchery program for brood years 2004-2008 ((Richards and Pearsons 2015)).

the Columbia River under the Proposed Action is not likely to adversely affect the SRKW or its proposed critical habitat.

2.12.1.3. **Eulachon**

Eulachon (*Thaleichthys pacificus*) are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. There are two distinct population segments (DPS); the northern DPS and the southern DPS. The southern DPS of eulachon is composed of fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010), and was listed as a threatened species under the ESA on March 18, 2010 (75 FR 13012). NMFS' 2016 ESA five-year review concluded that the DPS's threatened designation remained appropriate. Critical habitat was designated under the ESA for eulachon on October 20, 2011 (76 FR 65324).

The Columbia River and its tributaries support the largest eulachon run in the world (Hay et al. 2002). Eulachon use the mainstem Columbia River to migrate to spawning grounds as adults and to emigrate from freshwater into marine waters as larvae. Smith and Saalfeld (1955) stated that eulachon spawned in the Hood River (river-mile 169.5) and the Klickitat River (river-mile 180) above Bonneville Dam before the construction of Bonneville Dam in 1938, but were not known to ascend beyond Cascade Rapids until 1896, when the locks and canal were built for steamboat passage.

Adult eulachon migrate into the Columbia River November through June, with peak migration typically occurring in January through March. Following spawning, eulachon eggs hatch in 20 to 40 days with incubation time dependent on water temperature (Gustafson et al. 2010). Shortly after hatching, larvae are carried downstream and are dispersed by river, estuarine, tidal, and ocean currents to the ocean. However, larval eulachon may remain in low salinity, surface waters of estuaries for several weeks or longer before entering the ocean (Hay and McCarter 2000)(Hay and McCarter 2000). Timing of peak larval emergence-drift in the Columbia River estuary occurs January through April, and non-peak larval emergence-drift occurs November through July.

Effects of the Action

The effects of the Proposed Action considered here include competition for space and predation on eulachon. Eulachon larvae and salmon juveniles/smolts, especially hatchery fish, have different habitat requirements. Larval eulachon are carried downstream and are dispersed by river, estuarine, and tidal currents, and are generally distributed throughout the water column, whereas, once salmon juveniles/smolts pass through/over Bonneville Dam, they generally migrate rapidly through the Columbia River estuary to the ocean, with most juveniles/smolts migrating in or near the navigation channel. Therefore, effects of the Proposed Action as a result of competition for space are likely to be minor, if any occur at all, and therefore insignificant.

Release and down-river migration (May through August) of hatchery fish considered in this opinion may overlap with the presence of eulachon larvae (November through July) in the Columbia River estuary. Therefore, the potential for hatchery salmon juveniles to prey on larval eulachon exists, but it is considered to be unlikely, and therefore discountable, based on (1) the timing of peak eulachon larval emergence-drift prey (January through April) occurring earlier than the peak salmon outmigration period, and (2) the best available information regarding prey resources for juvenile salmon and steelhead in freshwater or estuarine habitats, which indicates a prey preference for juvenile salmon that is not primarily eulachon:

> A review by Weitkamp et al. (2014) found that the primary prey consumed by salmon and steelhead in tidal freshwater are aquatic and terrestrial insects (e.g., dipterans, hemipteran), amphipods, mysids, and freshwater crustaceans. In the brackish waters, primary prey are larval and juvenile fish, amphipods, insects, krill (euphasiids), and copepods. In the estuary, the diets of Chinook and coho salmon and steelhead are dominated by amphipods and dipteran insects.

Based on the above information, especially information regarding the diet composition of juvenile salmonid fishes in freshwater and estuarine habitats, the release of fall Chinook salmon in the Hanford Reach of the Columbia River under the Proposed Action is not likely to adversely affect the southern DPS of eulachon or its designated critical habitat.

2.12.1.4. **Other ESA-listed Species in the Action Area**

The USFWS completed a consultation (USFWS 2020) evaluating the effects of the RSH program and expansion on ESA-listed species under the preview and concurred with the Corps that the proposed program may affect but likely to adversely affect the Columbia River distinct population segment (DPS) of bull trout (*Salvelinus confluentus*) and its critical habitat, and a determination of no effect for ten terrestrial species under the purview of the Service, in accordance with section 7(a) (2) of the Endangered Species Act of 1973 (Act), as amended (l6 U.S.C. 153 1 e/ seg.).

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 descriptions of EFH for Pacific Coast salmon (PFMC 2014) 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

The Proposed Action is the expansion and operation of the RSH fall Chinook salmon program, as described in Section 1.3. The action area of the Proposed Action includes habitat described as EFH for Chinook and coho salmon (PFMC 2003) within the Hanford Reach area of the Columbia River Basin. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

As described by PFMC (2003), the freshwater EFH for Chinook and coho salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions on natural-origin Chinook and coho salmon in spawning and rearing areas and adult migration corridors and adult holding habitat, and genetic effects on natural-origin Chinook salmon in spawning areas (primarily addressing HAPC 3).

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action has small effects on the major components of EFH. As described in Section 2.5.2, facilities used for hatchery operations can adversely affect salmon by reducing streamflow, or impeding migration. However, water withdrawals are non-consumptive and small enough in scale that changes in flow within spawning habitat would be undetectable.

The PFMC (2003) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts hatchery programs might have on natural salmon and steelhead populations (Section 5). Ecological effects of juvenile and adult hatchery-origin fish on natural-origin Chinook salmon are discussed in Sections 2.5.2.2 and 2.5.2.3.

Hatchery fall Chinook salmon returning to Hanford Reach are not expected to compete for space with spring Chinook or coho salmon because of the usage of different habitats based on species preference and due to differences in run and spawn timing; spring Chinook salmon spawn in the late summer, and coho salmon spawn in the mid-late fall. In contrast, fish produced by the proposed hatchery program typically spawn from late September to early December (Table 39). Because of this small likelihood of overlap in spawn timing and usage of habitat, the spawning habitat HAPC for these species would not be adversely affected by naturally spawning hatchery adults.

Chinook salmon spawning habitat in Hanford Reach will be reduced due to the construction of the new intake structure and the adult fish ladder. The intake structure is estimated to reduce spawning habitat for an area approximately 6.1 meters by 18.3 meters. The impact is expected to be negligible because the width of the mainstem Columbia River at this point is over 750 meters (2,500 ft) and spawning habitat is available from the head of the pool behind McNary Dam up to Priest Rapids Dam, a distance of approximately 41 miles.

EFH for Chinook and coho salmon would likely be affected by the Proposed Action through ecological interactions. Some fall Chinook salmon from the programs may stray into other rivers (Section 2.5.2.2), but not in numbers that would exceed the carrying capacities of natural production areas, or that would result in increased incidence of disease or predators. Predation and competition by juvenile hatchery fall Chinook salmon on juvenile natural-origin Chinook or coho salmon is likely small. Our analysis in Section 2.5.2.3 shows that fewer than 746 Chinook salmon adult equivalents and 0 coho salmon adult equivalents are likely to be lost to predation and competition with hatchery fall Chinook salmon at the juvenile stage within our action area for this consultation. However, some areas within the action area are not included in the EFH designation (e.g., HUC 17020016 for Ringold Springs does not include EFH for coho salmon), so the level of effect is likely to be less than described here.

In Section 2.5.2.2, NMFS evaluated the genetic effects of the RSH program on ESA-listed species and determined that there would be only negligible effect if RSH fall Chinook salmon strayed into the Snake River. EFH does not distinguish between listed and non-listed Chinook and coho salmon when considering genetic effects, and under the Proposed Action the release of hatchery fall Chinook salmon from RSH could have an adverse effect on the natural-spawning population in Hanford Reach. The impact on the naturally spawning population from RSH adults spawning naturally is reduced by incorporating natural-origin fall Chinook salmon into the broodstock and working to control pHOS within the Hanford Reach, as described in the Proposed Action (USACE and WDFW 2019). The goal of these actions is to achieve a PNI 0.67 for the non-listed Hanford Reach, which is expected to mitigate the genetic effects of the RSH program.

NMFS has determined that the Proposed Action is likely to adversely affect EFH for Pacific salmon, specifically through small amounts of competition with hatchery fish produced by the

Proposed Action, the construction associated with the expansion of the RSH, and from naturally spawning RSH adult within Hanford Reach.

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 the HGMP and the ITS (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS has no additional conservation recommendations specifically for Chinook and coho salmon EFH besides fully implementing the Proposed Action and ITS. However, the Reasonable and Prudent Measures and Terms and Conditions included in the ITS, specifically under RPM #1 and RPM #2 and their associated Terms and Conditions, should be complied with to sufficiently address potential EFH effects.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal action agencies 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 Federal action agencies 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

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act") specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, document compliance with the Data Quality Act, 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. NMFS has determined, through this ESA section 7 consultation, that operation of the Ringold Springs fall Chinook salmon hatchery program in the Hanford Reach area of the Columbia River as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are: the NMFS (permitting entity); the WDFW (operating entity); and the Corps (funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of fall Chinook salmon to the Upper Columbia River basin for conservation and harvest, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmonids. This information will improve scientific understanding of hatchery-origin steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. The document will be available within two weeks at the NOAA Library Institutional Repository https://doi.org/10.25923/qwnt-c255. 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 600.920(j).

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

Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. Appendix A-Factors Considered When Analyzing Hatchery Effects

NMFS' analysis of the Proposed Action is in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 51. Generally speaking, effects range from beneficial to negative when programs use local fish[9] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[10]. 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 2005c). 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

---

[9] 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).
[10] Exceptions include restoring extirpated populations and gene banks.

steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

Table 51. 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 2004c).	**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).

5.1. 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.

5.2. Factor 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

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 et al. 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).

5.2.1. 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., (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)[11] 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

[11] 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.

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 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[12]. 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 11).

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)[13]. 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 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent 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.

---

[12] 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.

[13] 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.

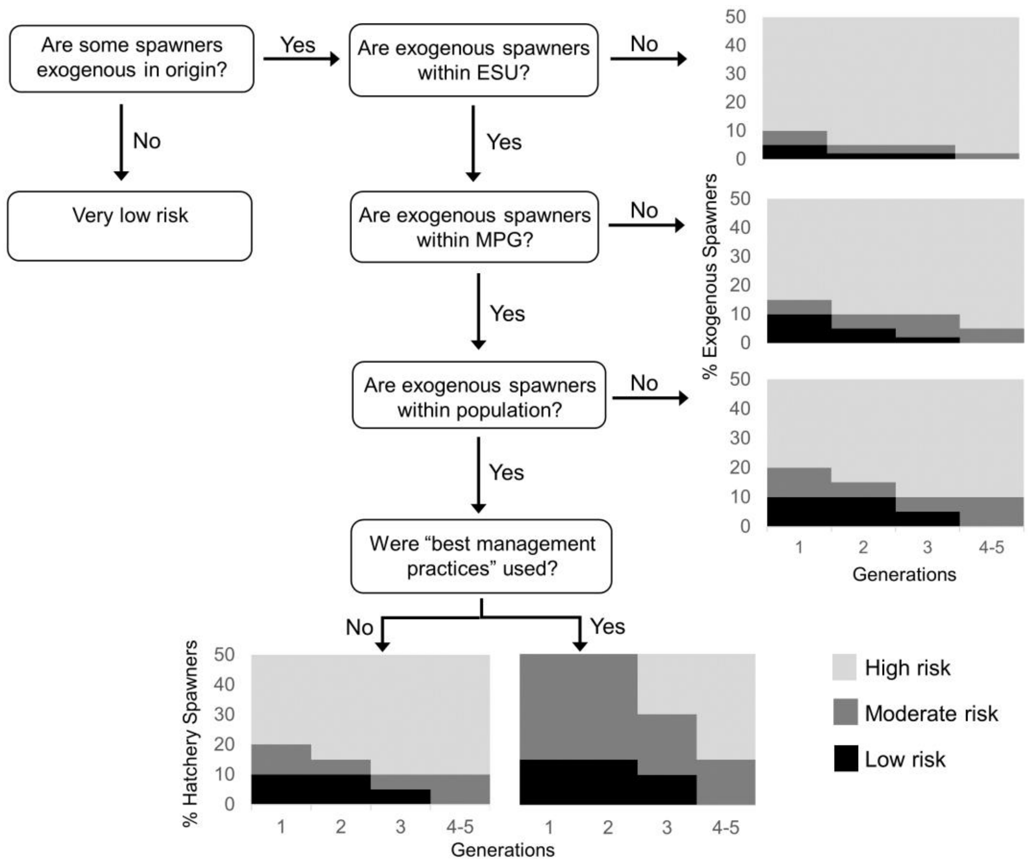

Figure 11. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin.

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 percent. 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 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, 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 12 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[14]. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent 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 percent will have an 81 percent 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.

[14] These computations are purely theoretical, based on a simple mathematical binomial expansion $((a+b)^2=a^2 + 2ab + b^2)$.

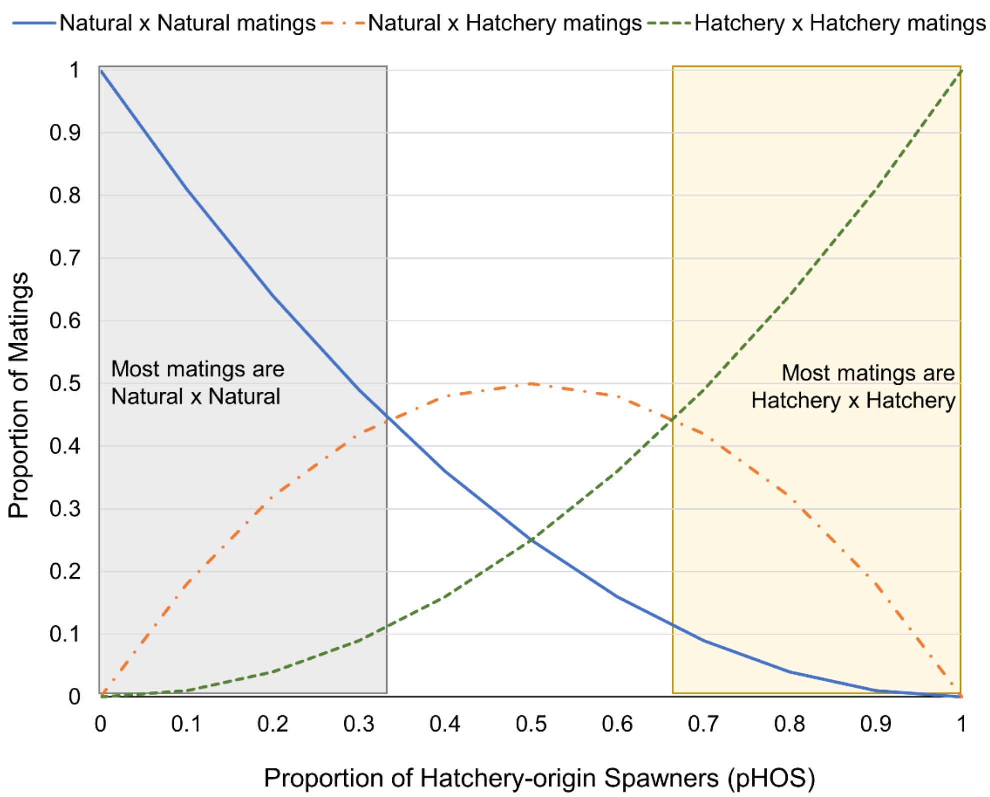

Figure 12. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

5.2.2. 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).

5.2.3. 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.

5.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

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.

5.3.1. 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 out-migration 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 fish (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,[15] 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.

5.3.2. 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 also can prey on fish from a natural population and pose a threat. In general, the threat from

[15] "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.

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.

5.3.3. 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; WWTIT 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.

5.3.4. 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 2014). 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.

5.4. 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)

5.4.1. 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.

5.4.2. 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.

5.4.3. 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 percent (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 percent and was at times as high as 33.3 percent.

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 2000b; 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.

5.5. 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.

5.6. 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 2005c). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

6. REFERENCES:

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(2): 342-355.

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.

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.

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. December 2004. U.S. Dept. Commer., NOAA Technical Memorandum 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.

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.

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.

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.

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.

Bradford, M. J. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences. 52: 1327-1338.

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.

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.

Busack, C. 2007. The impact of repeat spawning of males on effective number of breeders in hatchery operations. Aquaculture. 270: 523-528.

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.

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.

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 R. L. B. Jr. 2019. NOAA Technical Memorandum NMFS. U.S. Pacific Marine Mammal Stock Assessments: 2018. NOAA-TM-NMFS-SWFSC-617. June 2019. 382p.

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.

Cederholm, C. J., D. H. Johnson, R. E. Bilby, L. G. Dominguez, A. M. Garrett, W. H. Graeber, E. L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearch, C. A. Simenstad, and P. C. Trotter. 2000. Pacific Salmon and Wildlife - Ecological Contexts, Relationships, and Implications for Management. Special edition technical report. Prepared for D.H. Johnson and T.A. O'Neil (managing directors), Wildlife-Habitat Relationships, and Implications for Management. WDFW, Olympia, Washington.

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.

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.

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., 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.

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., 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.

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.

Dittmer, K. 2013. Changing streamflow on Columbia basin tribal lands—climate change and salmon. Climatic Change. 120: 627–641.

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.

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.

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.

Flagg, T. A., C. V. W. Mahnken, and R. N. Iwamoto. 2004. Conservation hatchery protocols for Pacific salmon. AFS Symposium. 44: 603-619.

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., 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, and K. C. Balcomb. 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, 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., T. Cooney, P. McElhany, N. J. Sands, L. A. Weitkamp, J. J. Hard, M. M. McClure, R. G. Kope, J. M. Myers, A. Albaugh, K. Barnas, D. Teel, and J. Cowen. 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., 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): 1-14.

Foster, R. W. 2004. Letter to Interested Parties from Robert Foster (NMFS). February 3, 2004. Developing the Hatchery and Genetic Management Plans (HGMPs) for Columbia River Basin Anadromous Fish Propagation Programs. NMFS, Portland, Oregon. 3p.

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.

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.

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.

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.

Grant County PUD, WDFW, Yakama Nation, and USFWS. 2009a. Upper Columbia River Spring-run Chinook Salmon - White River Supplementation Program. September 15, 2009. Spring Chinook Salmon *Oncorhynchus tshawyscha*, Wenatchee Watershed, Upper Columbia Region HGMP.

Grant County PUD, WDFW, and YN. 2009b. Upper Columbia River Spring-run Chinook Salmon, Nason Creek Supplementation Program HGMP. September 15, 2009. 98p.

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.

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. March 2010. 377p.

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.

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 (1): 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, M. J. Ford, M. Everett, K. Parsons, L. Park, J. Hempelmann, D. M. V. Doonik, G. S. Schorr, J. Jacobsen, M. Sears, J. G. Sneva, R. W. Baird, and L. Barre. In prep. Endangered predators and endangered prey: seasonal diet of Southern Resident killer whales. 62p.

Hanson, M. B., C. K. Emmons, E. J. Ward, J. A. Nystuen, and M. O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hanson, M. B., E. J. Ward, C. K. Emmons, and M. M. Holt. 2018. Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-tag locations to improve acoustic detection data. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-17-MP-4C419. 8 January 2018. 41p.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. 2017. Assessing the movements and occurrence of Southern Resident Killer Whales relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-15-MP-4C363. 30 June 2017. 32p.

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.

Hard, J. J., R. P. Jones, M. R. Delarm, and R. S. Waple. 1992. Pacific Salmon and Artificial Propagation under the Endangered Species Act. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-2. October 1992. 64p.

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.

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.

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.

Hay, D. E., P. B. McCarter, R. Joy, M. Thompson, and K. West. 2002. Fraser River Eulachon Biomass Assessments and Spawing Distribution: 1995-2002. 58p.

Healey, M. C. 1991. 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. 89p.

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.

Hillman, T., T. Kahler, G. Mackey, A. Murdoch, K. Murdoch, T. Pearsons, M. Tonseth, and C. Willard. 2017a. Final Monitoring and Evaluation Plan for PUD Hatchery Programs. 2017 update. November 16, 2017. 168p.

Hillman, T., M. Miller, C. Willard, S. Hopkins, M. Johnson, C. Moran, J. Williams, M. Tonseth, B. Ishida, C. Kamphaus, T. Pearsons, and P. Graf. 2017b. Monitoring and Evaluation of the Chelan and Grant County PUDs Hatchery Programs: 2016 Annual Report, September 15, 2017. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, Washington. 834p.

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. D. 2015. Chum Salmon Enhancement in the Lower Columbia River – Development of an Integrated Strategy to Implement Habitat Restoration, Reintroduction and Hatchery Supplementation in the Tributaries below Bonneville Dam. Grays River Chum Salmon Enhancement Program Brood Years 2013 and 2014. Project # 2008-710-00. BPA, Portland, Oregon. 59p.

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.

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. Available at Long Live the Kings. 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, (updated October 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.

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.

IDFG. 2012. Snake River Sockeye Salmon Captive Broodstock, Research and Production HGMP.

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.

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

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.

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, 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.

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 Jr., R. P. 2002. Letter to Interested Parties from Rob Jones (NMFS). Update of Columbia Basin APRE and HGMP Processes. May 31, 2002. NMFS, Portland, Oregon. 4p.

Jones Jr., R. P. 2008. Letter to Jeff Koenings (WDFW) from Rob Jones (NMFS). Review of hatchery programs in the Upper Columbia River. November 13, 2008. NMFS, Portland, Oregon. 11p.

Jones Jr., R. P. 2011. 2010 5-Year Reviews. Updated Evaluation of the Relatedness of Pacific Northwest Hatchery Programs to 18 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments listed under the Endangered Species Act. June 29, 2011 memorandum to Donna Darm, NMFS Northwest Region Protected Resources Division. Salmon Management Division, Northwest Region, Portland, Oregon. 56p.

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, R. P. 2006. Memo to File - Updates to the salmonid hatchery inventory and effects evaluation report: An evaluation of the effects of artificial propagattion on the status and likelihood of extinction of West Coast salmon and steelhead under the Federal Endangered Species Act. January 19, 2006. NMFS, Portland, Oregon.

Jones, R. P. 2009. Letter to Interested Parties from Rob Jones (NMFS). Offer of guidance and assistance to ensure hatchery programs in the Upper Columbia River are in compliance with the ESA. February 6, 2009. NMFS, Portland, Oregon. 3p.

Jones, 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, Portland, Oregon. 54p.

Jonsson, B., N. Jonsson, and L. P. Hansen. 2003. Atlantic salmon straying from the River Imsa. Journal of Fish Biology. 62: 641-657.

Jording, J. 2020. Columbia River Harvest Impacts Table. 1p.

Keefer, M. L., and C. C. Caudill. 2014. 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.

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.

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.

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.

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.

LCFRB. 2010. Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. May 2010. Vol. I. Chapter 2. Listed Species. Pages 2-1 - 2-35.

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.

Lynch, M., and M. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics. 2: 363-378.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. Pages 217 to 253 (Chapter 6) *in*: Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. Climate Impacts Group, University of Washington, Seattle, Washington. 37p.

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

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.

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.

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.

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. 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., 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.

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.

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., and Eric P. Salathé Jr. 2010. Future climate in the Pacific Northwest. Climatic Change. 102(1-2): 29-50.

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.

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.

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.

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.

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.

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. 1994. Biological Opinion for Hatchery Operations in the Columbia River Basin. April 7, 1994. NMFS, Seattle, Washington. 79p.

NMFS. 1995. Proposed Recovery Plan for Snake River Salmon. March 1995. NMFS, Portland, Oregon. 550p.

NMFS. 1999. 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 Species Act Section 7 Consultation Biological Opinion - Reinitiation of Consultation on Operation of the Federal Columbia River Power System, including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. December 21, 2000. NMFS, Seattle, Washington.

NMFS. 2000b. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Northwest Region, Portland, Oregon.

NMFS. 2004a. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery and Conservation Management Act Essential Fish Habitat Consultation on the Effects of the Northeast Oregon Hatchery Project: Imnaha, Upper Grande Ronde, and Wallowa Subbasins, Wallowa and Union Counties, Oregon. October 7, 2004. National Marine Fisheries Service, Habitat Conservation Division. Portland, Oregon. NMFS Consultation No.: NWR-2004-00615. 63p.

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. Appendix A CHART assessment for the Puget Sound salmon evolutionary significant unit from final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 ESUs of West Coast salmon and steelhead. August 2005. 55p.

NMFS. 2005b. 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. 2005c. 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 and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 71: 17757-17766.

NMFS. 2007. 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. 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. 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. 2008c. 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. 2008d. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Seattle, Washington. 251p.

NMFS. 2008e. 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. 2011a. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. January 2011. NMFS, Northwest Region. 260p.

NMFS. 2011b. Evaluation of and recommended determination on a Resource Management Plan (RMP), pursuant to the salmon and steelhead 4(d) Rule comprehensive management plan for Puget Sound Chinook: Harvest management component. Salmon Management Division, Northwest Region, Seattle, Washington.

NMFS. 2012a. Draft Recovery Plan For Oregon Spring/Summer Chinook Salmon and Steelhead Populations in the Snake River Chinook Salmon Evolutionarily Significant Unit and Snake River Steelhead Distinct Population Segment. March 2012. 503p.

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. 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. ESA Recovery Plan for Lower Columbia River coho salmon, Lower Columbia River Chinook salmon, Columbia River chum salmon, and Lower Columbia River steelhead. June 2013. 503p.

NMFS. 2013c. ESA Recovery Plan for the White Salmon River Watershed. June 2013. Prepared by National Marine Fisheries Service Northwest Region.

NMFS. 2015a. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*). June 8, 2015. NMFS, West Coast Region. 431p.

NMFS. 2015b. NMFS Northwest fisheries Science Center Geoviewer. https://www.webapps.nwfsc.noaa.gov/apex/f?p=280:1::::. Accessed November 10, 2015. .

NMFS. 2015c. Proposed ESA Recovery Plan for Snake River Fall Chinook Salmon *(Oncorhynchus tshawytscha*). October 2015. NMFS, West Coast Region, Portland, Oregon. 326p.

NMFS. 2016a. 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. 2016b. 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. 2016c. Proposed ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Steelhead (*Oncorhynchus mykiss*). October 2016. NMFS, Portland, Oregon. 262p.

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. 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.

NMFS. 2017c. 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. 2017d. 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. 2017e. 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. 2017f. 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. 2018. 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. February 23, 2018. NMFS Consultation No.: WCR-2017-7164. 597p.

NMFS, and NOAA. 2006. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 71: 17757-17766.

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.

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.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. NWFSC, Seattle, Washington. 356p.

O'Neill, S. M., G. M. Ylitalo, and J. E. West. 2014. Energy content of Pacific salmon as prey of northern and Southern Resident Killer Whales. Endangered Species Research. 25: 265–281.

ODFW. 2003. Fish Health Management Policy, September 12, 2003. Oregon Department of Fish and Wildlife. 10p.

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. 2011. Sandy River Coho Salmon Program HGMP. Coho Salmon (Stock 11). May 16, 2011. 78p.

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.

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.

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.

PCIC. 2016. Plan 2 Adapt website, available at https://www.pacificclimate.org/analysis-tools/plan2adapt.

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.

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.

PFMC. 2003. 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. 2020. Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales. Risk Assessment. March 2020. SRKW Workgroup Report 1. 164p.

Piorkowski, R. J. 1995. Ecological effects of spawning salmon on several south central Alaskan streams. Ph.D. dissertation, University of Alaska, Fairbanks, Alaska. 191p.

PNFHPC. 1989. Model Comprehensive Fish Health Protection Program. Approved September 1989, revised February 2007. PNFHPC, Olympia, Washington. 22p.

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.

Purcell, A. 2019. Sufficiency letter to Chris Page (COE) from Allyson Purcell (NMFS). Sufficiency of Ringold Springs Upriver Bright Fall Chinook Salmon Program HGMP. December 11, 2019. NMFS, Portland, Oregon. 1p.

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.

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.

Richards, S. P., and T. N. Pearsons. 2015. Final Priest Rapids Hatchery Monitoring and Evaluation Annual Report for 2014-15. September 14, 2015. 113p.

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.

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.

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.

Scheuerell, M. D., P. S. Levin, R. W. Zabel, J. G. Williams, and B. L. Sanderson. 2005. A new perspective on the importance of marine-derived nutrients to threatened stocks of Pacific salmon (*Oncorhynchus* spp.). Canadian Journal of Fisheries and Aquatic Sciences. 62(5): 961-964. http://dx.doi.org/10.1139/f05-113.

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.

Schnorbus, M., A. Werner, and K. Bennett. 2014. Impacts of climate change in three hydrologic regimes in British Columbia, Canada. Hydrological Processes. 28(3): 1170–1189.

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.

Smith, S. 1999. Letter to Bob Austin (BPA) from Stephen Smith (NMFS). Endangered Species Act (ESA) Consultation on Artificial Propagation Programs in the Columbia River Basin. July 27, 1999. NMFS, Portland, Oregon. 4p.

Smith, W. E., and R. W. Saalfeld. 1955. Studies on Columbia River smelt *Thaleichthys pacificus* (Richardson). Washington Dept. Fisheries, Olympia, Washington. Fisheries Research Report. 1(3): 3-27.

Snow, C., C. Frady, D. Grundy, B. Goodman, and A. Murdoch. 2016. Monitoring and Evalutation of the Wells Hatchery and Methow Hatchery Programs. 2015 Annual Report. July 1, 2016. Report to Douglas PUD, Grant PUD, Chelan PUD and the Wells and Rocky Reach HCP Hatchery Committees and the Priest Rapids Hatchery Subcommittees, East Wenatchee, Washington. 210p.

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.

SRSRB. 2011. Snake River salmon recovery plan for SE Washington.

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.

TAC. 2012. 2011 TAC Revised Annual Summary Report. Abundance, Stock Status and ESA Impacts, May 31- June 1, 2012. 18p.

TAC. 2013. 2012 TAC Final Annual Summary Report. Abundance, Stock Status and ESA Impacts, May 30-31, 2013. 23p.

TAC. 2014. 2013 TAC Annual Summary Report. Abundance, Stock Status and ESA Impacts, May 29-30, 2014. May 27, 2014. 29p.

TAC. 2015. 2014 TAC Annual Summary Report. Abundance, Stock Status and ESA Impacts, May 13-14, 2015. May 08, 2015. 28p.

TAC. 2016. 2016 TAC Final Annual Report. Abundance, Stock Status and ESA Impacts. 2015 Summary Fisheries and Fish Runs. May 20, 2016. 29p.

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.

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.

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.

USACE. 2019. Final Biological Assessment John Day Mitigation Ringold Springs Hatchery Expansion. November 2019. 118p.

USACE, and WDFW. 2017. Ringold Springs Hatchery Fall Chinook *Oncorhynchus tshawytscha* (Integrated Program) HGMP. June 19, 2017. USACE, Portland, Oregon. 63p.

USACE, and WDFW. 2019. Final John Day Mitigation Ringold Springs Hatchery Expansion HGMP. November 5, 2019. USACE, Portland, Oregon. 66p.

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. 2015. Mid-Columbia Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*). September 2015. USFWS, Portland, Oregon. 349p.

USFWS. 2020. Concurrence letter to Chris Page (COE), from Brad Thompson (USFWS). Request for ESA Consultation for the John Day Mitigation Program Ringold Springs Hatchery Expansion Biological Assessment. January 16, 2020. 12p.

USFWS, and NMFS. 1998. Endangered Species consultation handbook procedures for conducting consultation and conference activities under section 7 of the Endangered Species Act. U.S. Fish & Wildife Service. National Marine Fisheries Service. 315p.

USGCRP. 2009. Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009. 196p.

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.

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.

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.

Walton, R. G. 2008. Letter to Interested Parties, from Rob Walton. NMFS' Intent to Conduct Consultations Under the ESA. September 12, 2008. NMFS, Portland, Oregon. 2p. with attachments.

Walton, R. G. 2010. Letter to Co-managers, Hatchery Operators, and Hatchery Funding Agencies. Development of Hatchery and Harvest Plans for Submittal under the ESA. April 28. 2010. 6p.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries. 24(2): 12-21.

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., 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.

WDFW. 2002. 2002 Washington State Salmon and Steelhead Stock Inventory (SASSI). Available on-line at: http://wdfw.wa.gov/fish/sasi/index.htm. Washington Department of Fish and Wildlife, Olympia, Washingtion. 724p.

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. 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.

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.

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.

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.

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.

WSDOT. 2014. Biological Assessment Preparation for Transportation Projects, Advanced Training Manual, Version 2014. Chapter 7. Noise Impact Assessment. 94p. Available at: https://wsdot.wa.gov/environment/environment-technical/environment-disciplines/fish-wildlife/BA-preparation-manual.

WWTIT, and WDFW. 2006. The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Revised July 2006. 38p.

YKFP. 2008. Klickitat River Anadromous Fisheries Master Plan. Yakima/Klickitat Fisheries Project 1988-115-35. 188p.

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.