Endangered Species Act (ESA) 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.

NMFS Consultation Number: NWR-2014-697

Action Agency: NOAA's National Marine Fisheries Service (NMFS)

Affected Species and NMFS' Determinations:

ESA-Listed Species	**Status**	**Is Action Likely to Adversely Affect Species?**	**Is Action Likely To Jeopardize the Species?**	**Is Action Likely To Adversely Affect Critical Habitat?**	**Is Action Likely To Destroy or Adversely Modify Critical Habitat?**
Pacific Eulachon/Smelt – Southern Distinct Population Segment (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Lower Columbia River Chinook Salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Upper Columbia River Spring-run Chinook Salmon *(O. tshawytscha)*	Endangered	Yes	No	No	No
Snake River Spring/Summer-run Chinook Salmon *(O. tshawytscha)*	Threatened	Yes	No	No	No
Snake River Fall-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No

Lower Columbia River Coho Salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Columbia River Chum Salmon (*O. keta*)	Threatened	Yes	No	No	No
Snake River Sockeye Salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Upper Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River Basin Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Middle Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Upper Willamette River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	Yes	No	No	No
Sturgeon, green – Southern Distinct Population Segment (*Acipenser medirostris*)	Threatened	No*	NA	NA	NA

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

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

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

Issued By:

Barry A. Thom
Regional Administrator

Date: January 15, 2017

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EXECUTIVE SUMMARY

This Opinion describes and assesses the effects of hatchery programs that were funded through the Mitchell Act in FY 2015 and that are proposed for funding using FY 2016 and future FY 2017 funding. It is also intended to serve as NMFS' consultation through 2025, as NMFS implements its new policy direction for the distribution of Mitchell Act funds.

When NMFS assesses a hatchery program, it does so with the knowledge that hatcheries can have positive and negative effects on salmon and steelhead survival and recovery and that the nature and level of effect is largely dependent on the circumstances and conditions that are unique to every location and every program. NMFS' assessment relies on best available scientific information (see Section 2.4 of the Opinion), and ultimately, the effects of hatchery programs are placed in the context of the numerous threats to the survival and recovery of salmon and steelhead in the Columbia River Basin.

In this case and for the hatchery programs described in the Proposed Action, there is a history of long-standing operations undergoing changes and reforms starting with the first ESA-listings of salmon and steelhead in the Columbia River Basin. NMFS first completed ESA consultation on Mitchell Act funded hatchery programs in 1999 and issued a jeopardy opinion with Reasonable and Prudent Alternatives. Since that time, and through subsequent Opinions, NMFS has called for, and the operators have carried out, important reform actions including: new monitoring of the status of salmon and steelhead populations; changes in hatchery production levels and hatchery fish releases into streams; implementation of weir technology to selectively remove excess hatchery-origin fish; and the use of alternative fish release locations. These measures, evaluated through new monitoring, have reduced the negative effects of these hatchery programs and the risks to natural populations of salmon and steelhead.

But these changes have not sufficiently minimized impacts on the affected ESA-listed salmon and steelhead species' and NMFS has realized through continued monitoring that there is more to do at these hatchery programs. Specifically, continued monitoring is showing that the number of hatchery fish on the spawning grounds is too high and continues to pose a genetic risk to natural populations. In addition, some broodstock practices require further adjustment to improve both fitness and abundance, and the potential of competition for limited food resources and habitat in freshwater, the estuary, and perhaps the Columbia River plume is cause for new scientific investigation and understanding.

NMFS has reviewed the hatchery programs that were funded through the Mitchell Act in FY 2015 and is proposing to fund continued hatchery production contingent on several site-specific measures to implement the preferred policy direction identified in the 2014 Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs (NMFS 2014f). These measures are designed to address new monitoring and evaluation information and to minimize risks to ESA-listed species. NMFS also intends that these measures minimize impacts on Indian and non-Indian fisheries. The proposed measures build on hatchery reform measures implemented by the hatchery operators during the previous 5 to 10 years and are informed by the monitoring of those measures and new scientific information.

The measures or adjustments in hatchery operations, and the criteria for continued hatchery operation included in this Opinion are comprehensive and a sample of those adjustments and criteria are summarized below:

1) Elimination of steelhead broodstocks originating from outside the Columbia River (e.g., Puget Sound)
2) Development of broodstocks that are local to the hatchery and more compatible with local natural populations
3) Reductions in hatchery fish releases from specific hatchery programs that monitoring shows are responsible for hatchery straying
4) Status-quo or increased hatchery fish releases from hatchery programs that monitoring shows are not responsible for significant hatchery fish straying
5) New research and monitoring to determine whether juvenile hatchery fish are using limited food and habitat resources at the expense of or to the disadvantage of fish from natural populations
6) Specific limits on hatchery fish straying
7) New monitoring to better understand the status of Chinook salmon natural populations in the Coastal Stratum of the Lower Columbia River Chinook Salmon Evolutionarily Significant Unit
8) New monitoring to verify hatchery program compliance with the measures and criteria included in this Opinion

The Mitchell Act is one of NMFS' most important means of mitigating for development activities that have reduced the capacity of the Columbia River, and sub-basins of the Columbia River, to produce salmon and steelhead. The evolution of NMFS policy with respect to the distribution of Mitchell Act funds reflects the complexity of the issues and the multitude of stakeholders. NMFS has strived to update its policy for distributing Mitchell Act funds in ways that harmonize salmon and steelhead conservation, Indian reserved fishing rights, and sustainable recreation and non-tribal commercial fisheries. The implications of this update in NMFS policy were thoroughly explored and vetted in the Environmental Impact Statement completed by NMFS in 2014 and the outcome reflects a balancing of these interests in selecting the appropriate policy direction for annually distributing Mitchell Act funds.

It is NMFS' hope that the comprehensive approach to salmon and steelhead recovery in recovery plans is aggressively implemented because by itself these hatchery actions cannot address all of the factors limiting salmon and steelhead survival and recovery. However, the purpose of this action is to address the factors implicated by hatchery practices, and to distribute Mitchell Act funds in a way that minimizes impacts to threatened or endangered species and we ask all parties to keep these factors in mind when reading the following Opinion.

LIST OF ACRONYMS AND ABBREVIATIONS

A/P	Abundance and productivity
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
CCF	Clatsop County Fisheries
CFR	Code of Federal Regulations
CGAAP	Cowlitz Game and Anglers Acclimation Pond
CPS	Coastal pelagic species
CRFMA	*U.S. V. Oregon* Columbia River Fisheries Management Agreement
CSF	Lower Columbia Conservation and Sustainable Fisheries Plan
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWSR	Confederated Tribes of Warm Springs Reservation
CWA	Clean Water Act
CWR	Center for Whale Research
CWT	coded-wire tag (or tagged)
DRNP	Deep River Net Pen
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment model
EFH	essential fish habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
EWEB	Eugene Water and Electric Board
FERC	Federal Energy Regulatory Commission
FCRPS	Federal Columbia River Power System
FR	Federal Register
GBT	gas bubble trauma
GRTS	Generalized Random Tessellation Stratified
HGMP	Hatchery and Genetic Management Plan
HORs	hatchery-origin returns
HMS	highly migratory species
HRPP	Hood River Production Program
HSRG	Hatchery Scientific Review Group
ICTRT	Interior Columbia Technical Recovery Team
IGF-1	Insulin Growth Factor
IHNV	infectious hematopoietic necrosis virus
IMST	Independent Multidisciplinary Science Team
IC	Interior Columbia
IPC	Idaho Power Company
ISAB	Independent Scientific Advisory Board
ITS	incidental take statement
LCFRB	Lower Columbia Fishery Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
LFH	Lyons Ferry Hatchery
LGR	Lower Granite Dam
LSRB	Lower Snake River Recovery Board
M/A/G	Mill/Abernathy/Germany
MATs	minimum abundance threshold
MCR	Middle Columbia River
MDN	marine derived nutrients
MF	Middle Fork
MPG	major population group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	maximum sustainable yield
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NORs	natural-origin returns
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NPMP	Northern Pikeminnow Management Program
NPT	Nez Perce Tribe

NTTOC	non-target taxa of concern
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
OMV	*Onchorhynchus masou virus*
PAH	polycyclic aromatic hydrocarbons
PBF	physical or biological features
PBT	Parental Based Genetic Tagging
PCB	Polychlorinated biphenyl
PCEs	primary constituent elements
PCSRF	Pacific Coastal Salmon Recovery Fund
PFMC	Pacific Fisheries Management Council
PGE	Portland General Electric
PIT	passive integrated transponder
PUD	public utility district
RM	river mile
RM&E	research, monitoring, and evaluation
RPA	Reasonable and Prudent Alternative
R/S	recruits per spawner
SAR	smolt-to-adult returns
SBT	Shoshone-Bannock Tribe
SCA	Supplemental Comprehensive Analysis
SCORE	Salmon Conservation and Reporting Engine
SEWMU	Washington portion of the Snake River Basins
SFD	Sustainable Fisheries Division
SRFB	Salmon Recovery Funding Board
SRS	sediment retention structure
SS/D	composite spatial structure/diversity
STEP	Salmon and Trout Enhancement Program
TAC	Technical Advisory Committee
TDG	total dissolved gas
TRT	Technical Recovery Team
UCR	Upper Columbia River
UCSRB	Upper Columbia River Recovery Board
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VHSV	Viral hemorrhagic septicemia virus
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WLC TRT	Willamette Lower Columbia

1. INTRODUCTION

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

1.1 Background

This document constitutes National Marine Fisheries Service (NMFS)' opinion under Section 7 of the Endangered Species Act (ESA) and under essential fish habitat EFH consultation requirements in accordance with the MSA for the following federal action: NMFS application of a policy direction for the distribution of Mitchell Act funding starting in Fiscal Year (FY) 2016 based on the preferred alternative from the Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs (NMFS 2014f), hereafter referred to as "the Mitchell Act EIS".

The 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 (16 USC 1531 et seq.), and implementing regulations at 50 CFR[1] 402.

We also completed an 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 through NMFS' Public Consultation Tracking System https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Lacey, Washington.

Artificial propagation has occurred in the Columbia River Basin since 1876 (Wahle and Smith 1979). Congress enacted the Mitchell Act (16 United States Code [USC]755-757) in 1938 for the conservation of anadromous (salmon and steelhead) fishery resources in the Columbia River Basin (defined as all tributaries of the Columbia River in the United States [U.S.] and the Snake River Basin). Since 1946, Congress has continued to appropriate Mitchell Act funds on an annual basis, and it is one of several Federal acts passed in the 1930s and 1940s, that led to the Federal government's development of Columbia River water resources for major irrigation, flood retention, and hydroelectric projects (Section 1.5.1, Hatchery Facilities in the Columbia River Basin) (http://www.nwcouncil.org/history/DamsHistory).

The Mitchell Act authorized the establishment, operation, and maintenance of one or more hatchery facilities in the states of Oregon, Washington, and Idaho, scientific investigations to facilitate the conservation of the fishery resource, and "all other activities necessary for the

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[1] Code of Federal Regulations

conservation of fish in the Columbia River Basin in accordance with law." While the Mitchell Act provided the authority for the conservation of fishery resources in the Columbia River Basin, Congress must annually appropriate funds to implement it. In 1970, administration of the Mitchell Act was transferred from the Department of the Interior to the Department of Commerce (DOC) and the NMFS. Each year, after funding is appropriated by Congress, NMFS must decide which programs, existing or new, will receive Mitchell Act funding.

This Opinion describes and assesses the past, present and future role of Mitchell Act funding of hatchery operations in the Columbia River basin, placed in the context of the numerous threats to survival and recovery of threatened and endangered species, including salmon and steelhead. Mitchell Act funds serve significant purposes, including supplementing salmon populations in order to support fishing by Indian tribes under applicable treaties.

The evolution of NMFS' policies with respect to distributing Mitchell Act funds, described below, reflects the complexity of the issues and the multitude of stakeholders. NMFS has strived to change its policy for Mitchell Act funds in ways that will help bring about the reform of hatchery practices and, over time, reduce the extent to which hatcheries represent a limiting factor in salmon recovery. The implications of these changes were thoroughly explored in the Environmental Impact Statement completed by NMFS in 2010, which enabled all stakeholders to participate in the development of this policy, as did NMFS' regular interactions with state and tribal co-managers.

The outcome reflects a balancing of these interests in selecting the appropriate policy for distributing Mitchell Act funds, with an emphasis on hatchery reform and recovery of ESA-listed fish. NMFS has spent the past several years working with hatchery operators to make significant changes to ongoing programs, including large reductions of hatchery smolt releases, as described below. These are arduous decisions for stakeholders, particularly state and tribal co-managers, to make, and the Proposed Action may have effects on harvest in the short term that would not lessen until recovery of natural-origin populations advances. Additionally, by itself the reform of hatchery practices cannot achieve the recovery of salmon and steelhead, or address all of the limiting factors. However, the purpose of this action is to address the factors implicated by hatchery practices, and to distribute Mitchell Act funds in a way that will not jeopardize threatened or endangered species. NMFS believes that the co-managers and hatchery operators fully support the goal of recovering listed salmon and steelhead, and are committed to making changes that reflect this. We ask all parties to keep these factors in mind when reading the following Opinion.

1.2 Consultation History

1.2.1 ESA Listing and Consultation History in the Columbia River Basin

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, Snake River spring/summer Chinook and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994; 2008h). 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 et al. 1995). This Opinion determined that hatchery actions jeopardized 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 Upper Columbia River (UCR) steelhead were listed (62 FR 43937, August 18, 1997) and following the expiration of the previous Opinion on December 31, 1998 (NMFS 1999a). This Opinion concluded that Federal and non-Federal hatchery programs jeopardized Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. 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." Opinions would be issued for hatchery programs in the, (1) Upper Willamette, (2) MCR, (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS's 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 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, which are detailed below in Section 1.2.3.

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 2000b). The Northwest Power and Conservation Council (NPCC) 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., Hatchery Genetic Management Plans (HGMPs)). 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 (Brown 2001). Also at this time, a *U.S. v. Oregon* Columbia River Fisheries Management Agreement (CRFMA), 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 was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMA 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 found to be sufficient[2] 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 USFWS and by the WDFW. NMFS's Opinion (NMFS 2007b) 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 2008h) and an Opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008d). Since the Proposed Action did not encompass hatchery operations per se, no incidental take coverage was offered through the FCRPS biological Opinion for hatcheries operating in the region. Instead, NMFS advised that the operators of each hatchery program should address its obligations under the ESA in separate consultations, as required" (see NMFS 2008h, p. 5-40).

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 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…."

Many, but not all, of the hatchery programs funded with Mitchell Act dollars are included in the *U.S. v. Oregon* agreement.

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

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[2] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful.

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 Jr. 2008). While NMFS was conducting ESA hatchery consultations in the upper Columbia River and elsewhere, in 2013 it reinitiated section 7 consultation for hatchery programs funded under the Mitchell Act, starting with steelhead HGMPs in the LCR. This first stage in the consultation prompted changes and improvements in the HGMPs, some that were implemented immediately, including the termination of several hatchery programs and the creation of wild steelhead refuges.

Overall and since 2009, NMFS has completed ESA consultations for 101 of the 159 HGMPs in the Columbia River basin, including many HGMPs funded under the Mitchell Act.

1.2.2 NMFS' Mitchell Act Action under National Environmental Policy Act (NEPA)

NMFS' annual funding of hatchery programs and facilities, in the Columbia River basin constitutes a major federal action, and as such, requires a review under the NEPA, of the impacts of the action on the human environment (NMFS 2014f). NMFS published a Federal Register notice of its intent to prepare an Environmental Impact Statement (EIS) on September 3, 2004 (69 Fed. Reg. 53892), opening a 90-day public comment period to gather information on the scope of issues and range of alternatives to be analyzed in the draft EIS. In addition, NMFS held a series of external meetings to seek input on potential EIS alternatives for continuing to fund hatchery production with Mitchell Act appropriated funds. External meetings were attended by representatives from the Washington Department of Fish and Wildlife (WDFW), the Oregon Department of Fish and Wildlife (ODFW), the USFWS, the Nez Perce Tribe, the Pacific Fishery Management Council (PFMC), the Northwest Indian Fisheries Commission (NWIFC), the Confederated Tribes of the Colville Reservation, the Columbia River Inter-tribal Fish Commission (CRITFC), the Institute for Tribal Government, and various fishing and environmental groups. A second notice, published on March 12, 2009 (74 Fed. Reg. 10724), notified the public of NMFS' intent to expand the project scope to include all Columbia River hatchery programs, regardless of funding source.

NMFS published its draft EIS in August 2010 for a 90-day public review period. The comment period was announced in newspapers, through correspondence with tribes and other interested parties, and by publication in the Federal Register (75 Fed. Reg. 47591, August 6, 2010). This period was extended for an additional 30 days (75 Fed. Reg. 54146, September 3, 2010) for a total of 120 days for public comment. Additionally, NMFS held a series of public meetings where public testimony was taken. These meetings were held in Vancouver, Washington; Kennewick, Washington; Astoria, Oregon; and Lewiston, Idaho, between September 20, 2010 and October 13, 2010. NMFS received more than 1,100 comments on the draft EIS.

NMFS published its final EIS in the Federal Register on September 12, 2014 and made it available for a 60-day public review period. The final EIS described NMFS' preferred Alternative for the policy direction used to guide NMFS' future funding of Mitchell Act hatcheries in the Columbia River basin.

1.2.3 Consultation History for Hatchery Programs Funded by the Mitchell Act

As described above in Section 1.2.1, there have been a series of ESA consultations on the various federal and non-federally-funded hatchery programs throughout the Columbia River basin, since the first ESA-listings of salmon and steelhead in the early 1990s. Several of these consultations have included many or all of the hatchery programs funded by the Mitchell Act.

In 1994, 1995 and 1999 NMFS consulted on all the hatchery production funded by the Mitchell Act (NMFS 1994; NMFS et al. 1995; NMFS 1999a). Subsequent site specific reinitiated consultations, based on the geographic areas within the Columbia Basin, also contained many of the Mitchell Act-funded programs.

NMFS completed consultation on the USFWS-operated hatchery programs in the Lower Columbia and Middle Columbia River in 2007 (NMFS 2007b). This action contained nine Mitchell Act-funded programs. This consultation found that the USFWS's operations of the facilities, hatchery programs and associated monitoring and evaluation would not jeopardize the LCR Chinook Salmon ESU, UWR Chinook Salmon ESU, Columbia River Chum Salmon ESU, LCR Steelhead DPS, MCR Steelhead DPS, and LCR Coho Salmon ESU or destroy or adversely modify their respective designated critical habitats. This consultation was subsequently re-authorized in 2016 (NMFS 2016i) to cover NMFS' funding action of USFWS Mitchell Act programs, for federal fiscal year 2016.

In 2011, NMFS completed a consultation on the Bonneville Power Administration (BPA)funded hatchery programs operated in the Umatilla River basin by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the state of Oregon (ODFW) (NMFS 2011e). This included one program that is supported by the Mitchell Act (Umatilla coho salmon). NMFS found that the operation of these programs would not jeopardize MCR steelhead, Snake River Spring/summer Chinook salmon, or Snake River fall-run Chinook salmon. Nor would it destroy or adversely modify any of their designated critical habitat.

NMFS completed a consultation on the operation of hatchery programs in the Yakima River basin in 2013 (NMFS 2013c). These hatchery programs are operated by the Yakama Nation and the state of Washington (WDFW). This consultation included programs that are partially funded by the Mitchell Act (Prosser Hatchery coho and Chinook salmon), as well as other programs which are interrelated and/or interdependent with the annual Mitchell Act hatchery funding action. Here NMFS found that the Yakama Nation's and WDFW's operations of the hatchery programs and associated monitoring and evaluation would not jeopardize the MCR Steelhead DPS or destroy or adversely modify its designated critical habitats.

In 2014, NMFS completed a consultation on the BPA Mid-Columbia River Coho Salmon Restoration Program including operation and construction activities in the Yakima, Wenatchee and Methow river subbasins. The consultation was completed in June of 2014 (NMFS 2014c) and authorizes these programs which are operated in conjunction with annual Mitchell Act-funded hatchery programs and facilities in the LCR. This consultation determined that the Proposed Action would not jeopardize the ESA-listed UCR Steelhead DPS, UCR Spring

Chinook Salmon ESU, LCR Steelhead DPS, or the LCR Chinook Salmon ESU. Nor would it destroy or adversely modify critical habitat associated with any of these ESA-listed fish.

Also in 2014, NMFS completed a consultation on five hatchery programs operated by the ODFW in the Sandy River (OR) (NMFS 2014e), issuing an ESA Section 4(d) Rule (Limit 5) exemption to the State of Oregon. This initial authorization for ODFW to operate the Sandy River hatcheries was subsequently replaced by a new authorization and 4(d) determination on June 17, 2016 (Turner 2016). NMFS found that ODFW's operations of the hatchery programs in the Sandy River (OR) would not jeopardize the LCR Steelhead DPS, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, Columbia River Chum Salmon ESU, or the Southern Pacific Eulachon DPS. Nor would it destroy or adversely modify their designated critical habitat.

1.2.4 Current NMFS Actions Under Consideration

The Proposed Action continued to take shape as NMFS considered potential Mitchell Act funding consultation that were smaller in scope. NMFS initially requested formal consultation on several hatchery programs, included in the current Proposed Action, on December 24, 2013. NMFS's requested concurrence, under Section 7(a)(2) of the ESA, with their internal determination of the effects of four hatchery programs operated in the Klickitat River basin by the Yakama Nation and the WDFW and funded, annually, by the Mitchell Act (Dixon 2013) . NMFS completed its review of the 4 Klickitat HGMPs cited in the assessment on February 14, 2014, determining them to be sufficient for formal consultation (Jones 2014).

Additionally, on April 8, 2014, NMFS requested written concurrence with the internal determination that NMFS' annual Mitchell Act funding of 18 WDFW-operated hatchery programs would likely adversely affect (LAA) ESA-listed Columbia River salmon, steelhead, and Eulachon and Green Sturgeon, but would not jeopardize the continued existence of these ESA-listed species, or destroy or adversely modify designated critical habitat (Dixon 2014). NMFS completed its initial review of the 18 HGMPs (WDFW 2012a-p) cited in the assessment on April 17, 2014, determining them to be sufficient for formal consultation (Jones Jr. 2014). This initial, formal consultation (PCTS 2014-697), ultimately grew to encompass the entirety of the Proposed Action that this Opinion is evaluating.

As described earlier, in Section 1.2.2, NMFS published its final EIS on Mitchell Act hatchery funding in September of 2014 (79 FR 54707, September 12, 2014) and, after the public review period (60 day), began working on its ROD. During the next several months (during 2015) internal discussions between NMFS West Coast Regional staff, the NMFS West Coast Regional NEPA coordination team, and the National Oceanic and Atmospheric Administration (NOAA) Northwest General Council, that the eventual issuance of the ROD, outlining NMFS' intent to issue future Mitchell Act funding, guided by the EIS preferred Alternative, would necessitate an evaluation of its effects under the ESA. Additional discussion regarding the scope of the "action", to be considered, also took place. By the late summer of 2015, it was decided that in order to understand the likely effects of the continued funding of Mitchell Act hatcheries, under the implementation of the EIS preferred alternative, a consultation on the full effects of the operations of all of the Mitchell Act-funded hatchery programs was necessary. In late 2015

NMFS prepared, and in January of 2016, published a Federal Register update on the MA EIS process and its intent to (81 FR 2196, January 15, 2016). At this time, and in an effort to effectively and efficiently manage its resources, NMFS looked to utilize an already existing, in-progress consultation process on Mitchell Act-funded hatchery programs (PCTS 2014-697 from above), in order to build this larger, more comprehensive evaluation of the current Proposed Action.

NMFS began discussion with all current Mitchell Act-recipient agencies—States, Tribes, and Federal—to coordinate submission of all relevant and recent information on the operations and effects of current Mitchell Act-funded hatchery programs. Final and draft HGMPs, as well as supplemental information, requested during this period, were submitted and used to develop and assess the Proposed Action.

1.3 Proposed Action

“Action” means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). “Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

NMFS proposes to implement its preferred policy direction (EIS Preferred Alt) for the distribution of Mitchell Act funds as described in the Final EIS to Inform Columbia Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs (NMFS 2014f). NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008d). 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).

This Opinion is intended to apply to distributions of Mitchell Act funds from 2016 through 2025. It may require amendments in that time as programs included in the Opinion make significant changes to their operations, or as programs are discontinued, or as the availability of Mitchell Act funds changes. Additionally, there are requirements included in the proposed action or terms and conditions which could lead to new information that would necessitate program changes. Finally, as with all biological opinions, changes in the extent of effects or take of ESA-listed species may also lead to reinitiation of consultation and a new Opinion. Therefore, this Opinion will remain in effect through the action to distribute Mitchell Act funds in FY 2025, unless superceded or withdrawn before that time.

In addition to potential changes to the Opinion over time, new circumstances could lead to funding changes as well. Because the underlying action concerns a series of year-to-year funding actions, any changes to the action or the expected effects from what is described in this opinion would likely cause NMFS to reconsider if a program can still be funded in the next cycle of Mitchell Act grants. For example, if NMFS received indication that applicable pHOS goals were not likely to be met, possibly due to changing circumstances or the failure to take an action such as installing a weir, NMFS may be unable to issue Mitchell Act funds for programs responsible for those missed goals, unless changes could be made (e.g. reductions in program size) that would restore the program's ability to meet pHOS goals before the next distribution of Mitchell Act funds takes place. Each year's continued funding is contingent on NMFS judgment that the actions and analysis of effects described in this Opinion remain in force. At this time, this Opinion is sufficient to support distributing FY 2016 funds (Phase 1, as described below).

In addition to covering specific distributions of Mitchell Act grants, the Proposed Action includes the policy direction NMFS intends to adopt to guide these and all future distributions of Mitchell Act funds. In the final EIS, NMFS identified a preferred policy direction that would be used to guide decisions about the distribution of funds for hatchery production under the Mitchell Act. The preferred policy direction is defined by the following goals and/or principles:

- The stronger performance goal would be applied to Mitchell Act-funded hatchery programs that affect ESA-listed primary and contributing (or equivalent) salmon and steelhead populations in the Columbia River Basin. These stronger performance goals would minimize the risks of, or accentuate the benefits of, hatchery programs on ESA-listed natural-origin salmon and steelhead populations.
    - Integrated Mitchell Act hatchery programs would be better integrated, where necessary, than under baseline conditions.
    - Isolated Mitchell Act hatchery programs would be better isolated, where necessary, than under baseline conditions.
- Conservation hatchery programs funded under the Mitchell Act would be operated at a level determined by conservation need.
- Best Management Practices (BMPs) for Mitchell Act-funded facilities would be applied.
- New Mitchell Act-funded programs (for conservation, harvest, or both purposes) could be initiated throughout the Columbia River Basin, where appropriate.
- Monitoring, evaluation, and reform (MER) for Mitchell Act funded hatchery programs would occur under the selected alternative. NMFS would continue to work with Mitchell Act-funded hatchery operators, basinwide, to develop priorities and strategies for Mitchell Act MER.
- Adaptive management planning, related to risk minimization, would be required for Mitchell Act-funded programs that affect ESA-listed primary and contributing (or equivalent) salmon and steelhead populations in the Columbia River Basin. Annual review of hatchery program goals and objectives, related to biological risk/benefit management, as well as cultural and economic benefits of the hatchery programs will occur. Mitigation measures, when necessary, would be implemented to address concerns.
- Mitchell Act hatchery funds would be disbursed, annually, in support of the above goals and/or principles.

The goals and/or principles outlined in the preferred policy direction are meant as indicators of the direction that NMFS intends to move hatchery programs that receive Mitchell Act funding.

The preferred policy direction does not identify specific actions that would be taken consistent with its preferred policy direction because specific hatchery actions are best identified on a hatchery program-by-hatchery programs basis. At this time, NMFS has reviewed the hatchery programs that were funded through the Mitchell Act in Fiscal Year (FY) 2015 and developed a strategy for implementing its preferred policy direction, which is broken into three phases:

- Phase 1 includes measures that will be applied to the distribution of FY 2016 funds.

- Phase 2 includes measures that will be applied to the distribution of FY 2017 through FY 2022.

- Phase 3 includes measures that will be applied to the distribution of FY 2023 through FY 2025.

1.3.1 Implementation of Preferred Alternative in Phase 1 (FY 2016)

Phase 1 includes the distribution of FY 2016 funds to the hatchery programs identified below summarized in NMFS (2017) and Table 1.

Prior to 2016, the allocation of Mitchell Act Funds has been an annual process involving NMFS and the following hatchery operators: the U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, the Yakama Nation, and the Nez Perce Tribe (as described above in Section 1.2.2).

The allocation of funds for hatchery operations has been determined with the goal of maintaining production to meet levels identified in the 2008-2017 *U.S. v. Oregon* Management Agreement and to meet other important mitigation needs. Reductions in production due to reduced funding or increased costs to the operators were negotiated by the hatchery operators and where applicable by parties to the *U.S. v. Oregon* Management Agreement. Monitoring, evaluation, and reform projects were reviewed annually by NMFS, the hatchery operators, and tribes to identify projects that would be continued based on the expected level of funding. If additional funds became available for reform actions, the hatchery operators and NMFS evaluated the proposals and agreed on the allocation of funds for specific projects.

In FY 2016, NMFS used the same process for determining the initial allocation of Mitchell Act funds. However, because NMFS was still in the process of determining its policy direction for disbursement of Mitchell Act funds for hatchery production, each new grant or grant modification for FY 2016 funds contains a special condition that prohibits hatchery operators from accessing FY 2016 funds until all applicable environmental reviews have been completed and NMFS' new policy direction for the funding of Mitchell Act hatchery programs has been finalized.

A summary of the hatchery programs that would be funded under Phase 1 are found in NMFS (2017), including information on the following:

- Watershed where fish are released
- Program operator
- Funding agency

- Operational strategy (i.e., isolated or integrated)
- Broodstock origin and listing status
- Relationship of broodstock to listed salmon and steelhead in watershed of release
- Number of broodstock collected
- Mating protocols
- Incidental handling of ESA-listed natural-origin fish during broodstock collection
- Number of fish released
- Size of fish released
- Marking protocols for released fish
- Months of acclimation prior to release
- River mile where fish are released
- Whether the fish are volitionally released
- Month of release
- Facilities used by Mitchell Act funded programs
- Source of water for each facility used
- Amount of withdrawn water
- Water diversion distance, if applicable, between water intake and discharge structures
- Whether the water intake structures are screened according to NMFS criteria
- Whether the hatchery facilities have National Pollution and Discharge Elimination System (NPDES) permits

Additionally, NMFS (2017) outlines the ongoing Mitchell Act Hatchery Monitoring, Evaluation, and Reform Activities that would be funded in Phase 1. MER, which is a categorical component of the annual Mitchell Act hatchery funding, stands for monitoring, evaluation, and reform. For the purposes of this Opinion, activities and measures in the MER category are considered as Research, Monitoring and Evaluation (RM&E) activities.

1.3.2 Implementation of Preferred Alternative in Phase 2 (FY 2017 through FY 2022[3])

In Phase 2, NMFS would prioritize funding for hatchery programs that received FY 2016 funding as long as they meet all applicable measures included in Phase 1 plus the following measures, if applicable to their hatchery program, to ensure they are operated consistent with the goals and principles of the preferred policy direction. In order to ensure compliance with these measures, hatchery operators would need to include in a letter to NMFS sufficient commitments to implement the measures below, according to the identified schedule, before a hatchery operator could access their Mitchell Act funds for that fiscal year. Additional measures may be required based on the annual funding review process, new science, or ESA consultations.

- No hatchery programs funded through the Mitchell Act may rear or release, into any watershed where steelhead are ESA-listed, Chambers Creek steelhead, a hatchery stock

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[3] FY 2017 through FY 2022 would start October 1, 2016 and end September 30, 2022.

that does not originate from within the Columbia River basin after broodyear 2016 fish are released.

- Mitchell Act-funded LCR Chinook and coho salmon hatchery programs that release fish from broodstocks originating from outside of the MPG where they are released will begin transitioning to broodstocks originating from within-MPG, beginning in broodyear 2016 and have fully transitioned to the within-MPG stock by broodyear 2019.
- All hatchery programs funded through the Mitchell Act must comply with all terms and conditions identified in any applicable NMFS and/or FWS Opinions.
- WDFW will preserve its Wild Steelhead Gene Bank in the East Fork Lewis River, Wind River, and NF Toutle River, so that at least one primary steelhead population[4] in each LCR steelhead MPG is protected from the genetic influence of hatchery programs.
- To minimize genetic risks from the hatchery programs funded through the Mitchell Act, to primary and contributing populations of Chinook and coho salmon, and steelhead, hatchery production in the following hatchery programs cannot exceed production levels identified in Table 1 based on release year. The production level changes will reduce the proportion of hatchery-origin fish on the spawning grounds (pHOS) as described in Table 3 and Table 4 based on analyses described in (NMFS 2017). Hatchery operators may not use other funds (i.e., non-Mitchell Act) to "backfill" the reductions in tule fall Chinook or coho salmon production at the facilities in Table 1 because backfilling this production would pose an unacceptable genetic risk to ESA-listed LCR coho and Chinook salmon ESUs.

Table 1. Production levels by hatchery programs and year.

Mitchell Act Hatchery Program	**Hatchery Program Operator**	**Integrated or Isolated**	**Recent Average (2015-2016) Release Number**	**Maximum Number of Fish that Can Be Released by end Phase 2 (i.e., Spring of 2022)**
Bonneville coho salmon	ODFW	Isolated	323,000	250,000
Bonneville fall Chinook salmon (tule)	ODFW	Isolated	2,519,000	5,000,000
Big Creek Chinook salmon (tule)	ODFW	Isolated	3,106,000	1,400,000
Big Creek coho salmon	ODFW	Isolated	543,000	735,000
Big Creek chum salmon	ODFW	Integrated	154,000[1]	300,000
Big Creek winter steelhead	ODFW	Isolated	55,900	60,000

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[4] Population designations (i.e., primary and contributing) are identified in the Lower Columbia River Recovery Plan (ODFW 2005a).

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Isolated	Recent Average (2015-2016) Release Number	Maximum Number of Fish that Can Be Released by end Phase 2 (i.e., Spring of 2022)
Gnat Creek winter steelhead	ODFW	Isolated	37,500	40,000
Klaskanine winter steelhead	ODFW	Isolated	38,900[2]	40,000
Klaskanine fall Chinook salmon (tule)	ODFW	Isolated	2,425,000	2,475,000
Clackamas summer steelhead	ODFW	Isolated	144,000[2]	125,000
Clackamas winter steelhead	ODFW	Integrated	106,000[2]	165,000
Clackamas spring Chinook salmon	ODFW	Integrated	636,000[2]	1,050,000
Grays River coho salmon	WDFW	Integrated	161,000	75,000
North Fork Toutle fall Chinook salmon (tule)	WDFW	Integrated	1,394,000	1,100,000
North Fork Toutle coho salmon	WDFW	Integrated	163,000[1]	90,000
Kalama fall Chinook salmon (tule)	WDFW	Integrated to Isolated	5,801,000	2,600,000
Kalama coho salmon - Type N	WDFW	Integrated to Isolated	459,000[1]	300,000
Kalama summer steelhead (integrated)	WDFW	Integrated	83,000	90,000 (Int/Iso)
Kalama winter steelhead (integrated)	WDFW	Integrated	56,000	135,000 (Int/Iso)
Washougal fall Chinook salmon (tule)	WDFW	Integrated	1,976,000	1,200,000
Washougal coho salmon	WDFW	Integrated	154,000	108,000
Walla Walla spring Chinook salmon	CTUIR/ USFWS	Isolated	250,000[3]	
Ringold Springs steelhead	WDFW	Isolated	183,000	180,000
Ringold Springs coho salmon	WDFW	Isolated	0	750,000
Clearwater River coho restoration project	NPT/USFWS	Isolated	517,000[1]	550,000
Lostine River coho restoration project	NPT/ODFW	Isolated	0	500,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Isolated	Recent Average (2015-2016) Release Number	Maximum Number of Fish that Can Be Released by end Phase 2 (i.e., Spring of 2022)
Deep River coho salmon (MA/SAFE)	WDFW	Isolated	787,000	700,000
Klickitat coho salmon	YN/WDFW	Isolated	3,607,000	3,500,000
Klickitat upriver bright fall Chinook salmon	YN	Isolated	2,742,000	4,000,000
Klickitat spring Chinook salmon	YN	Isolated	521,000	800,000
Klickitat Skamania summer steelhead	YN/WDFW	Isolated	92,000	90,000
Deep River fall Chinook salmon	WDFW	Isolated	903,000	0
Beaver Creek summer steelhead	WDFW	Isolated	31,000	30,000
Beaver Creek winter steelhead	WDFW	Isolated	66,000	130,000
Beaver Creek (Elochoman R) coho salmon	WDFW	Integrated	0	150,000
South Toutle summer steelhead	WDFW	Isolated	20,000	20,000
Coweeman winter steelhead	WDFW	Isolated	11,000	12,000
Cathlamet Channel Net-pen spring Chinook salmon	WDFW	Isolated	124,000	250,000
Klineline winter steelhead (Salmon Creek)	WDFW	Isolated	35,000	40,000
Washougal summer steelhead (Skamania Hatchery)	WDFW	Isolated	62,900	70,000
Washougal winter steelhead (Skamania Hatchery)	WDFW	Isolated	64,200	85,000
Kalama River early winter steelhead (Chambers)	WDFW	Isolated	58,100	0
Kalama River Skamania summer steelhead	WDFW	Isolated	30,000	0
Rock Creek winter steelhead	WDFW	Isolated	18,000	20,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Isolated	Recent Average (2015-2016) Release Number	Maximum Number of Fish that Can Be Released by end Phase 2 (i.e., Spring of 2022)
Kalama Spring Chinook salmon	WDFW	Isolated	515,591	500,000
Umatilla River coho salmon	CTUIR/ODFW	Isolated	500,000[3]	
Sandy River spring Chinook salmon	ODFW	Integrated	132,000[3]	
Sandy River winter steelhead	ODFW	Integrated	170,000[3]	
Sandy River summer steelhead	ODFW	Isolated	80,000[3]	
Sandy River coho salmon	ODFW	Isolated	300,000[3]	
Carson National Fish Hatchery spring Chinook salmon	USFWS	Isolated	1,170,000[3]	
Little White Salmon National Fish Hatchery upriver bright fall Chinook salmon	USFWS	Isolated	4,500,000[3]	
Little White Salmon National Fish Hatchery Spring Chinook salmon	USFWS	Isolated	1,000,000[3]	
Eagle Creek National Fish Hatchery winter steelhead	USFWS	Integrated	100,000[3]	
Eagle Creek National Fish Hatchery coho salmon	USFWS	Isolated	350,000[3]	
Yakima River - Prosser upriver bright fall Chinook salmon	YN	Isolated	1,700,000[3]	

[1]Avg of 2014 and 2015 releases; [2]2015 only; [3]Release goal for program operations with existing ESA-authorization (See Consultation History, Section 1.2.2).

Table 2. Hatchery programs and release sizes which are interrelated to and/or interdependent with Mitchell Act hatchery programs.

Hatchery Programs which are Interrelated or Interdependent to Mitchell Act hatchery funding	Hatchery Program Operator	Integrated or Isolated	Release Level Considered in this Assessment

SAFE coho salmon (Youngs Bay, Tongue Point, Blind Slough, Klaskanine, and SF Klaskanine)	ODFW/CCP	Isolated	3,745,000
Astoria High School STEP[5] coho salmon	ODFW	Isolated	4,000
Astoria High School STEP fall Chinook salmon (tule)	ODFW	Isolated	25,000
Warrenton High School STEP coho salmon	ODFW	Isolated	5,000
Warrenton High School STEP fall Chinook salmon (tule)	ODFW	Isolated	16,500
Methow and Wenatchee River coho salmon- Reintroduction Program	YN	Isolated	1,500,000[1]
Yakima River coho salmon	YN	Isolated	1,000,000[1]

[1] Release goal for program operations with existing ESA-authorization (See Consultation History, Section 1.2.2).

Hatchery program production levels, proposed in Table 1 above, not including programs were authorizations for the operations exist (indicated by the table footnote), are expected to result in the following levels of genetic effects (Table 3, Table 4, Table 5).

Table 3. Expected genetic effect levels on ESA-listed Chinook salmon populations potentially affected by Mitchell Act-funded hatchery programs.

Chinook Salmon ESU	**Major Population Group (MPG)**	**Population**	**Recovery Designation**	**Recent Avg pHOS (2010-2015)**	**Expected pHOS levels* once fully Implemented**
LCR	Coast	Elochoman/Skamokawa	Primary	79%	≤50.0%
		Mill/Germany/Abernathy	Primary	89%	≤50.0%
		Grays/Chinook	Contributing	73%	≤50.0%
	Cascade	Coweeman	Primary	15%	≤10.0%
		Lower Cowlitz	Contributing	27%	≤30.0%
		Toutle	Primary	64%	≤30.0%
		Kalama (fall)	Contributing	84%	≤10.0%
		Kalama (spring)	Contributing	~0%	≤10.0%
		Lewis	Primary	34%	≤10.0%
		Washougal	Primary	65%	≤30.0%
UWR	Western Cascade	Clackamas	Primary	<10%	≤10.0%

*Expected pHOS levels are based on a 4-year average

Table 4. Expected genetic effect levels on ESA-listed LCR coho salmon populations potentially affected by Mitchell Act-funded hatchery programs.

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[5] Salmon and Trout Enhancement Program (STEP)

LCR Major Population Group (MPG)	Population	Recovery Designation	Recent Avg. pHOS (2011-2015)	Expected pHOS levels* once fully Implemented
Coast	Grays/Chinook	Primary	59%	≤30.0%
	Elochoman/Skamokawa	Primary	42%	≤30.0%
	Clatskanie	Primary	6%	≤10.0%
	Scappoose	Primary	0%	≤10.0%
Cascade	Lower Cowlitz	Primary	7%	≤30.0%
	Coweeman	Primary	13%	≤10.0%
	SF Toutle	Primary	25%	≤10.0%
	NF Toutle	Primary	33%	≤30.0%
	EF Lewis	Primary	12%	≤10.0%
	Washougal	Contributing	37%	≤30.0%
	Sandy	Primary	6%	≤10.0%
	Clackamas	Primary	9%	≤10.0%

*Expected pHOS levels are based on a 4-year average

Table 5. Expected genetic effect levels on ESA-listed steelhead populations potentially affected by Mitchel Act-funded hatchery programs.

Steelhead DPS	Major Population Group (MPG)	Population	Recovery Designation	Expected Maximum Gene flow level from MA programs once fully Implemented	Expected Census pHOS levels* from MA programs once fully Implemented
LCR DPS	Cascade (W)	Coweeman	Primary	≤2.0%	≤5.0%
		SF Toutle	Primary	≤2.0%	≤5.0%
		Kalama	Primary	≤2.0%*	≤5.0%**
		Salmon Cr	Stabilizing	≤2.0%	≤5.0%
		Clackamas	Primary	N/A	Winter program: ≤10.0%; Summer program: ≤5.0%
		Washougal	Contributing	≤2.0%	≤5.0%
		Sandy	Primary	N/A	Winter program: ≤10.0%; Summer program: ≤5.0%
	Cascade (S)	Kalama	Primary	≤2.0%*	≤5.0%**
		Washougal	Primary	≤2.0%	≤5.0%
	Gorge (W)	Upper Gorge	Stabilizing	≤2.0%	≤5.0%
Mid-C DPS	Cascade East Slop Tribs.	Klickitat (S/W)	Viable	N/A	≤5.0%
UCR DPS	East Slope Cascades	All UCR Pops (Wenatchee, Methow, Entiat, Okanogan)	Viable	N/A	≤5.0%

* Expected pHOS levels are based on a 3-year average

**Expected outcome from the isolated component of the Kalama steelhead programs.

- In addition to reducing production levels, the hatchery operators will also need to operate weirs in the following tributaries. All weirs must be operating before the end of Phase 2. All hatchery-origin fall Chinook salmon encountered at the weirs will be removed to better isolate hatchery programs that are not designed to supplement natural-spawning populations. Appendix D (Weirs) includes additional information on new proposed weirs (*).
    - Grays River
    - Skamokawa River*
    - Elochoman River
    - Mill Creek*
    - Abernathy Creek*
    - Germany River*
    - South Fork Toutle River*
    - Coweeman River
    - Cedar Creek
    - Washougal River
    - Kalama River

- By September 30, 2017, NMFS will work with the hatchery operators, and others as appropriate, to develop priorities and strategies for Mitchell Act MER

- In addition, NMFS will continue to fund or support the following MER projects (RM&E) [details can be found in Appendix B of (NMFS 2017)]:
    - Spawning ground surveys and other methods, in the LCR tributaries, to determine the abundance of natural-origin fish and hatchery-origin fish on the spawning grounds
    - A genetic monitoring project to determine the efficacy of isolated steelhead programs
    - LCR and tributary fishery monitoring
    - Operation of the North Fork Toutle River Fish Collection Facility
    - Kalama River Research Program
        - Annual adult and juvenile steelhead monitoring activities in the Kalama, including adult trapping, marking, smolt trapping, and adult abundance surveys
    - Evaluation of the benefits and risks of juvenile wild fish rescue programs
    - Klickitat River fishway and RM&E programs (I&I, BPA)

- By January 1, 2019, NMFS and the operators of the following hatchery facilities, will develop a plan to address the needs listed in Table 6, including a timeframe for completion and a plan to secure funding, through Mitchell Act or other sources.

Table 6. Hatchery facilities that need improvement.

Hatchery Facility	Improvement Needed

Grays River Hatchery	Primary intake does not meet criteria and dewaters section of stream between intake and hatchery outfall.
Fallert Creek Hatchery	Fallert Creek intake lost in 2016 flood will need to be updated to meet current criteria and to provide passage for NOR adults. Mainstem Kalama River pump screens have been updated but may not meet 2011 criteria
Clackamas Hatchery	Mainstem Clackamas River intake does not meet criteria – new intake in River Mill Dam reservoir expected to be completed in 2017
Klaskanine Hatchery	Mainstem Intake #1 does not meet current criteria, provide adult passage and Intakes #2 and #3.
NF Toutle Hatchery	Surface intake – feasibility study completed in 2012, awaiting funding.
Beaver Creek Hatchery	Elochoman River intake being upgraded, expected to be completed in 2017.
Kalama Falls Hatchery	Intake screens updated in 2006, may not meet 2001 criteria – considered low priority.
Washougal Hatchery	Intake screens do not meet current criteria
Klickitat Hatchery	Surface intake structure does not meet current criteria – currently under negotiations on remodel of intake

- The Grays River Hatchery intake has been identified as likely having adverse effects on ESA-listed fish and designated critical habitat within the West Fork Grays River due to the general condition of the structure, out-of-criteria screens, and the annual reduction of flow in the river reach between the intake structure and the hatchery outfall. Due to these adverse effects, NMFS will direct WDFW to develop a plan to address these effects by January 1, 2019, and will require that the plan be fully implemented by January 1, 2022 or the operation of the facility will no longer be funded through the Mitchell Act.

- NMFS will consider new proposals for hatchery programs if there are available funds. However, all newly funded hatchery programs will need to be reviewed for ESA and NEPA compliance prior to receiving funding. If insufficient funds are available to fund all hatchery programs identified in Table 1, NMFS will consult with the Tribes and States to review and revise the Mitchell Act program in light of the actual Fiscal Year appropriation. NMFS will give good faith consideration to all *U.S. v. Oregon* parties' recommendations, the United States trust responsibility to the tribes, and Mitchell Act history before deciding which Mitchell Act program actions will be funded.

- Monitoring, evaluation, and reform (RM&E) for Mitchell Act funded hatchery programs would occur under the selected alternative. NMFS would continue to work with its regional partners to develop priorities and strategies for Mitchell Act MER (RM&E).

1.3.3 Implementation of Preferred Alternative in Phase 3 (FY 2023 through FY 2025)

Phase 3 constitutes an adaptive management phase. In Phase 3 NMFS will utilize information gathered from MER activities that occur in Phase 2 to inform any additional, necessary modifications to Mitchell Act-funded hatchery programs to ensure they are operated consistent with the goals and principles of the preferred policy direction. If any of these modifications result in effects to ESA-listed species, beyond what is considered in this Opinion, NMFS will review the modifications for ESA compliance before implementing them.

In Phase 3, NMFS will prioritize FY 2021 through FY 2025 funding for hatchery programs that received FY 2020 funding as long as they meet all applicable measures included in Phase 1 and Phase 2, plus the following measures, if applicable to their hatchery program Compliance with these measures must be demonstrated in a funding proposal submitted to NMFS before a hatchery operator can receive funds. Additional measures may be required based on the annual funding review process, new science, or ESA consultations.

- All hatchery programs funded through the Mitchell Act will continue to comply with all terms and conditions identified in any applicable NMFS and/or FWS Opinions.
- To minimize genetic risks from the hatchery programs funded through the Mitchell Act, to primary and contributing populations of Chinook and coho salmon, and steelhead, hatchery programs, identified in Table 1, above, may need further modification to size or operation, based MER (RM&E) results. NMFS will work with the hatchery operators to further modify the hatchery program operations, as necessary.
- Based on the results of reductions in pHOS in various LCR tributaries, i.e., the response of the extant natural-origin populations of fall Chinook in the Coast MPG, NMFS will determine and implement further, necessary changes to the contributing programs, including:
    - Further Program reductions
    - Program discontinuation
    - Implementing new conservation programs to supplement populations
    - Further use of pHOS control measures, such as weirs.
- In addition to maintaining or modifying, where necessary, production levels, the hatchery operators will also need to continue to operate weirs in the following tributaries, unless additional program changes or results of monitoring have eliminated the need for the weir to operate.
    - Grays River
    - Skamokawa River
    - Elochoman River
    - Mill Creek
    - Abernathy Creek
    - Germany River
    - South Fork Toutle River
    - Coweeman River
    - Cedar Creek
    - Washougal River
    - Kalama River

- NMFS will continue to fund or support the MER (RM&E) projects identified in Phase 1 and Phase 2, as well as any new MER (RM&E) activities developed during Phase 2, which become essential for effects monitoring.

- NMFS will continue to implement its plan to address the facility upgrades needed (Table 6). Having developed and started a plan (Phase 2) to address the necessary facility improvements and repairs, to ensure they are operated consistent with the goals and principles of the preferred policy direction, NMFS and the operators of the hatchery facilities, will develop a plan to address the needs listed in Table 6, including a timeframe for completion and a plan to secure funding, through Mitchell Act or other sources.

- NMFS will consider new proposals for hatchery programs if there are available funds. However, all newly funded hatchery programs will need to be reviewed for ESA compliance prior to receiving funding. If insufficient funds are available to fund all hatchery programs identified in Table 1, NMFS will consult with the Tribes and States to review and revise the Mitchell Act program in light of the actual Fiscal Year appropriation. NMFS will give good faith consideration to all *United States v. Oregon* parties' recommendations, the United States trust responsibility to the tribes, and Mitchell Act history before deciding which Mitchell Act program actions will be funded.

1.4 Action Area

"Action Area" means all areas to be affected directly or indirectly by the Federal Action and not merely the immediate area involved in the action (50 CFR 402.02). Therefore the Action Area, in this case, consists of all the areas where biological and or environmental effects resulting from NMFS' administration of Mitchell Act hatchery funding may occur. This includes rivers, streams, and hatchery facilities where hatchery-origin salmon and steelhead occur or are anticipated to occur in the Columbia River Basin, including the Snake River and all other tributaries of the Columbia River in the United States (U.S.). This area also includes the Columbia River estuary[6] and plume[7].

The Action Area comprises two salmon recovery domains (the Willamette/Lower Columbia and the Interior Columbia (IC)) as established by NMFS under its ESA recovery planning

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[6] The estuary is broadly defined to include the entire continuum where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This geographic scope encompasses areas from Bonneville Dam (River Mile [RM] 146; River Kilometer [RKm] 235) to the mouth of the Columbia River. The scope includes the lower portion of the Willamette River (from Willamette Falls, at RM 26.6 [RKm 42.6], to the Willamette's confluence with the Columbia River), along with the tidally influenced portions of other tributaries below Bonneville Dam. This region is that which experiences ocean tides, extending up the Columbia River to Bonneville Dam and up the Willamette River to Willamette Falls (south of Portland at Oregon City, Oregon) from the mouth of the Columbia River.

[7] The plume is generally defined by a reduced-salinity contour of approximately 31 parts per thousand near the ocean surface. The plume varies seasonally with discharge, prevailing near-shore winds, and ocean currents. For purposes of this opinion, the plume is considered to be off the immediate coast of both Oregon and Washington and to extend outward to the continental shelf. This definition is consistent with the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (Appendix D in NMFS 2013e).

responsibilities (Figure 1). This area contains seven ecological provinces and more than 37 subbasins (i.e., tributaries to the Columbia or Snake Rivers) (NMFS 2014f).

The Willamette/Lower Columbia Recovery Domain includes the Willamette River Basin and all Columbia River tributaries from the mouth of the Columbia River to the confluence of Hood River in Oregon and the confluence of White Salmon River in Washington. The domain contains four ESA-listed ESUs of salmon and two ESA-listed DPSs of steelhead: LCR Chinook Salmon ESU, Columbia River Chum Salmon ESU, Upper Willamette River (UWR) Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, and UWR Steelhead DPS.

The IC Recovery Domain covers all of the Columbia River Basin accessible to anadromous salmon and steelhead above Bonneville Dam. The IC Recovery Domain contains four ESA-listed ESUs of salmon and three ESA-listed DPSs of steelhead: Snake River Sockeye Salmon ESU, Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River Steelhead DPS, MCR Steelhead DPS, and UCR Steelhead DPS.

Prepared by Parametrix, Inc. December 16, 2014 (ROD_AppBFig1_20141216).

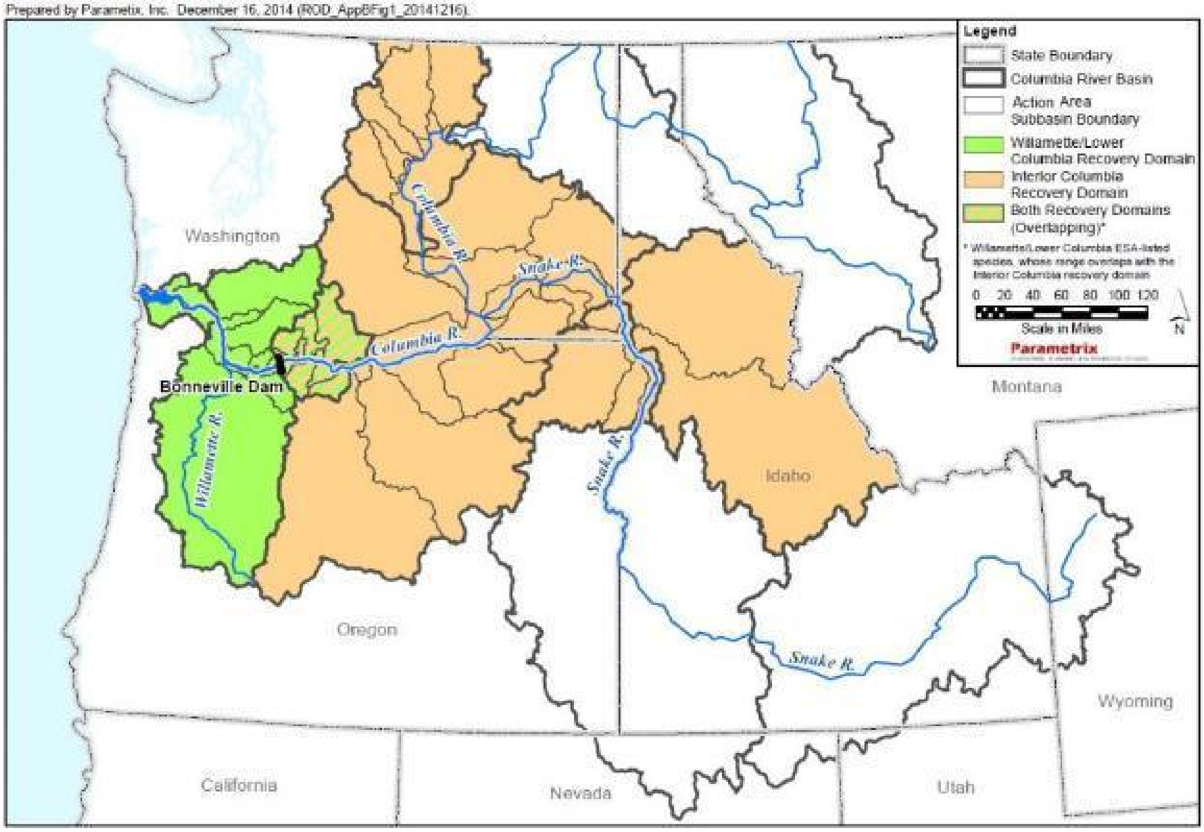

Figure 1. Action Area inside the Columbia River Basin (NMFS 2014f).

Each recovery domain consists of several ecological provinces, as identified by the NPCC (see www.nwcouncil.org for more information). Ecological provinces encompass subbasins with similar climates and geography (NMFS 2014f). This Action Area encompasses only 7 of the 11

Columbia River Basin ecological provinces because anadromous salmon and steelhead do not currently have access to the other 4 ecological provinces (the Middle Snake, Upper Snake, Intermountain, and Mountain Columbia Ecological Provinces). A sample of the location of these respective domains and associated subbasins are captured in Table 7.

Table 7. Action Area by recovery domain, ecological province (with subbasin examples).

Recovery Domain	Ecological Province	Subbasin[1]
Willamette/ Lower Columbia	Columbia Estuary	Grays River (WA)
		Elochoman River (WA)
		Youngs River (OR)
		Klaskanine River (OR)
	Lower Columbia	Cowlitz River (WA)
		North Fork Toutle River (WA)
		South Fork Toutle River (WA)
		Coweeman River (WA)
		Kalama River (WA)
		Lewis River (WA)
		Salmon Creek (WA)
		Washougal River (WA)
		Willamette River (OR)
		Sandy River (OR)
Overlap of Willamette/ Lower Columbia and Interior Columbia[2]	Columbia Gorge	Wind River (WA)
		Little White Salmon River (WA)
		Klickitat River (WA)
		Hood River (OR)
		Fifteen Mile Creek (OR)
Interior Columbia	Columbia Plateau	Yakima River (WA)
		Walla Walla River (WA/OR)
		Umatilla River (OR)
		Lower Middle Columbia River (WA/OR)
		Lower Snake River (WA)
	Columbia Cascade	Wenatchee River (WA)
		Entiat River (WA)
		Methow River (WA)
		Okanogan River (WA/BC)
		Upper Middle Columbia River (WA)
	Blue Mountain	Asotin Creek (WA)
		Grande Ronde River (WA/OR)
		Imnaha River (OR)
		Snake Hell’s Canyon (OR/ID)

	Mountain Snake	Clearwater River (ID)
		Salmon River (ID)

[1] Not all subbasins are included in this table, instead these were chosen simply to represent the geographic range that the Action Area encompasses given these subbasins are thought to be more commonly known.
[2] The Willamette/Lower Columbia Recovery Domain and the IC Recovery Domain overlap within the Columbia Gorge Ecological Province (see Figure 1).

The hatchery facilities and programs that are proposed to receive Mitchell Act funding are located in three regions: the LCR, MCR, and Snake River (Figure 2). Facilities in the LCR are displayed in Figure 3, those in the LCR, Bonneville, and Columbia River Gorge area are displayed in Figure 4, those in the MCR are displayed in Figure 5, and those in the Snake River are in Figure 6.

NMFS considered whether the ocean should be included in the Action Area but the effects analysis was unable to detect or measure effects of the Proposed Action beyond the area described above (i.e., outside of the Columbia River plume), based on best available scientific information (NMFS 2009a). Available knowledge and techniques are insufficient to discern the role and contribution of the Proposed Action to density dependent interactions affecting salmon and steelhead growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. While there is evidence that hatchery production can impact salmon survival at sea, the degree of impact or level of influence is not yet understood or predictable. NMFS will monitor emerging science and information and will reinitiate Section 7 consultation in the event that new information reveals effects of the action to ESA- listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

The Action Area does not include the entire range of SRKW and is defined by the extent of indirect effects on SRKW, which encompasses the whales' entire coastal range from California to Vancouver, British Columbia where the marine range of SRKW could overlap with the range of Chinook salmon produced at hatchery programs proposed for funding under the Mitchell Act.

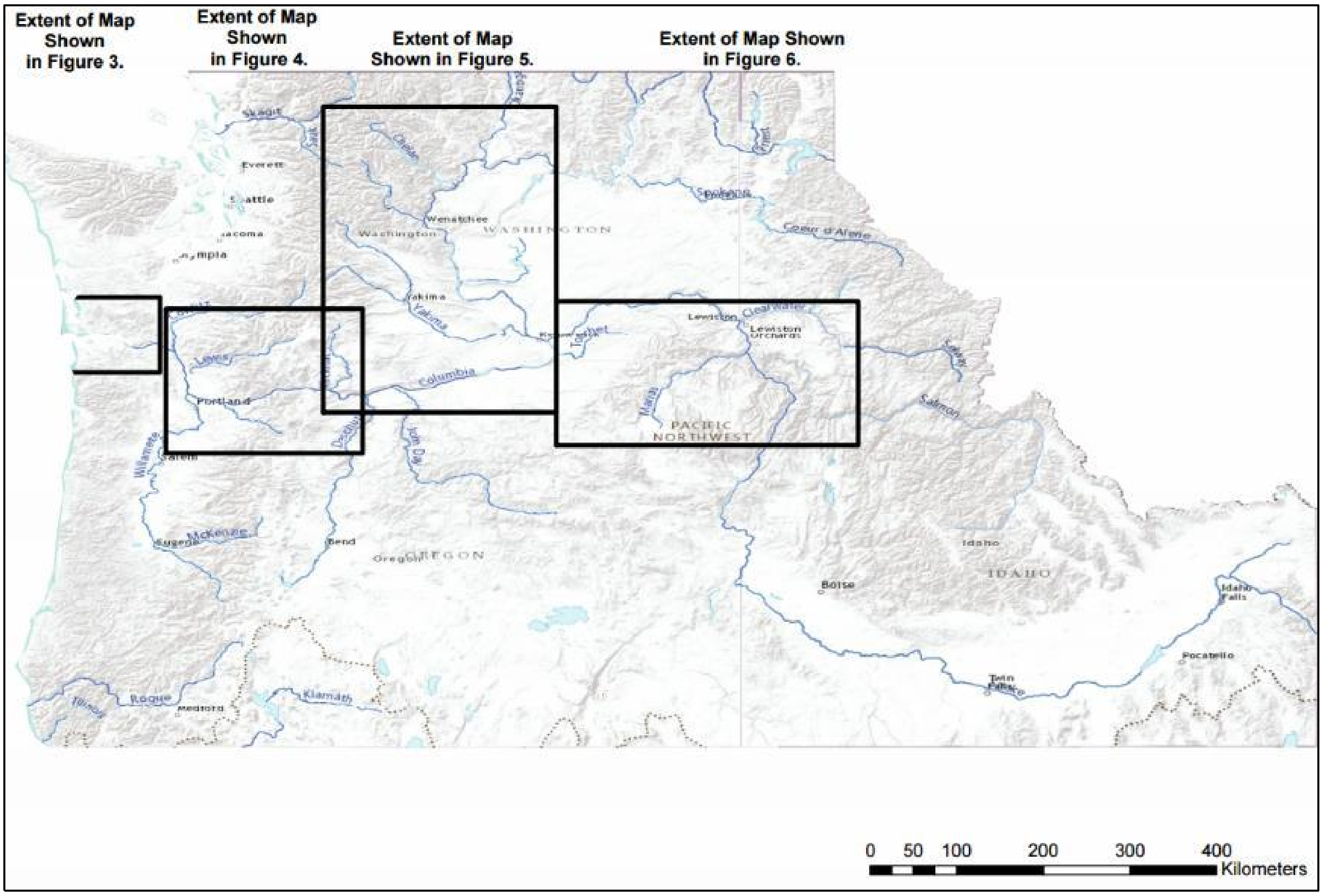

Figure 2. General hatchery facility and release site locations within the Action Area with sub-figure areas identified.

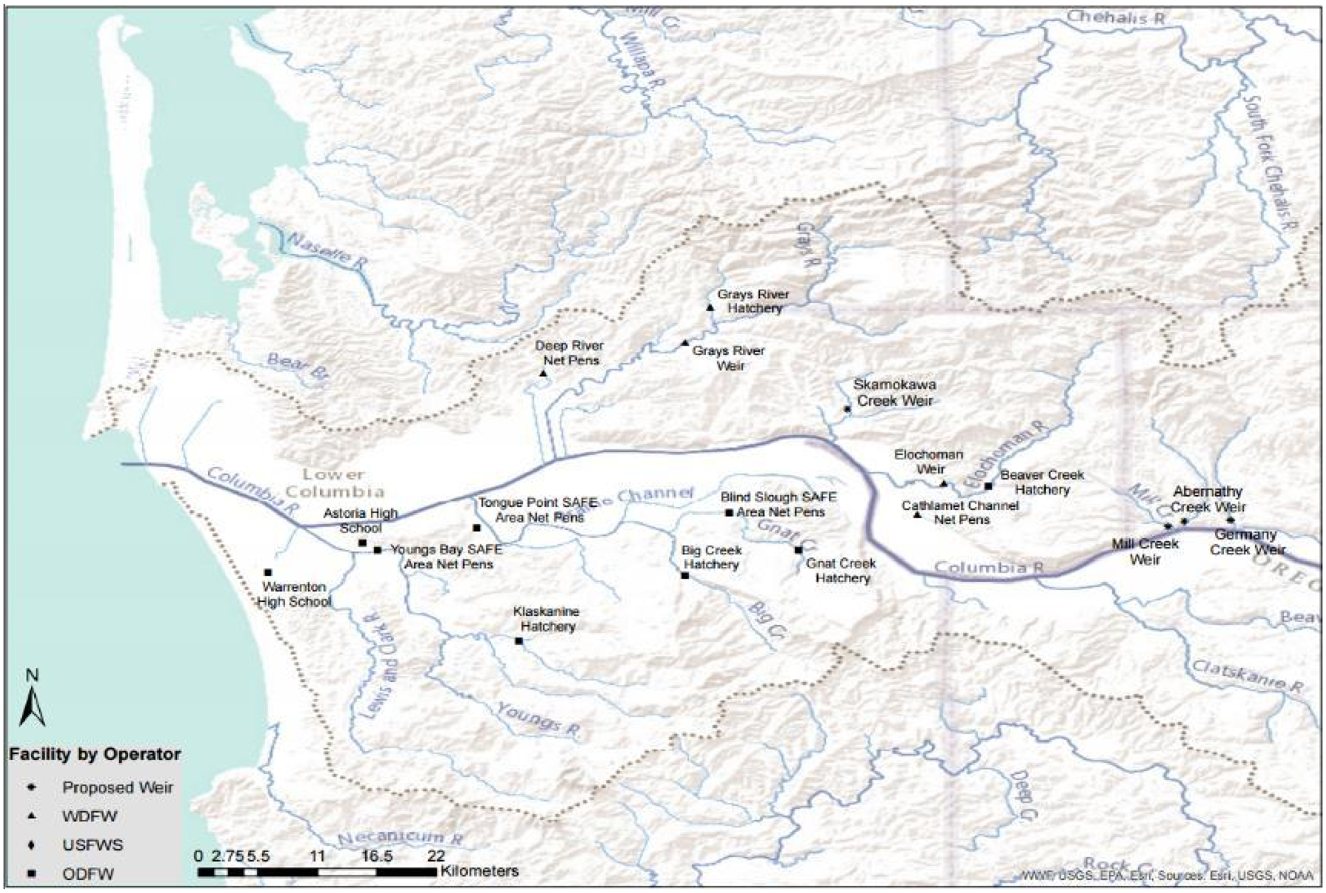

Figure 3. Hatchery and release site locations in the LCR.

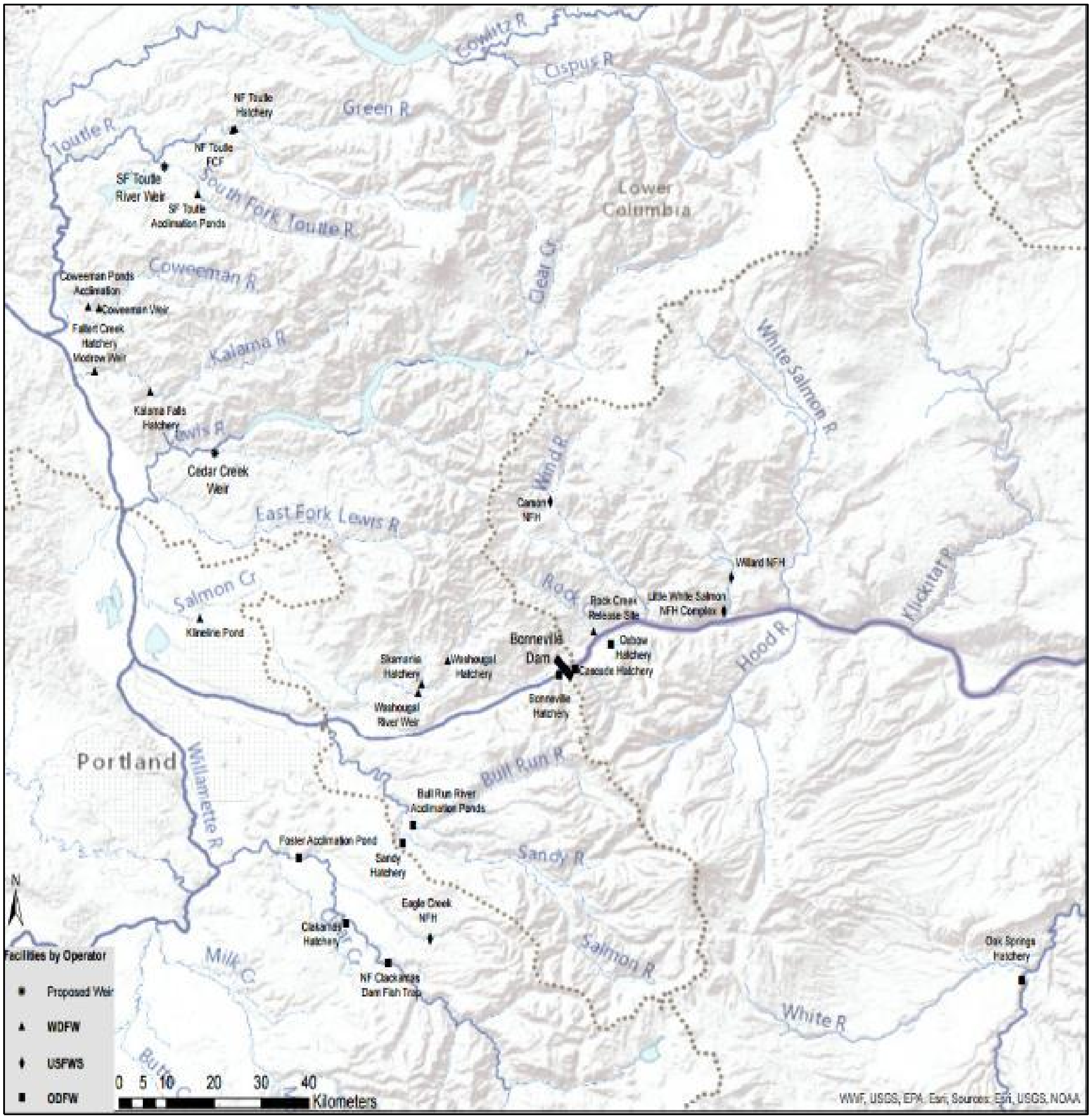

Figure 4. Hatchery and release site locations in the LCR, Bonneville, and Columbia River Gorge Area.

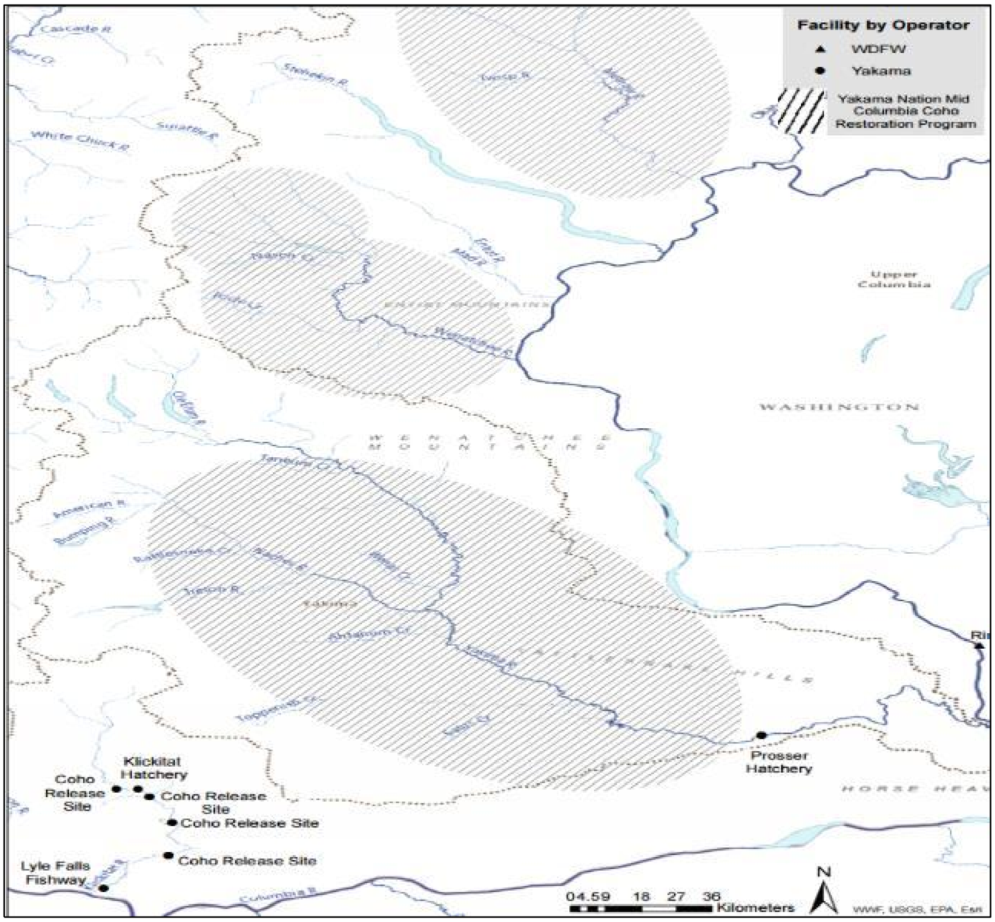

Figure 5. Hatchery and release site locations in the MCR.

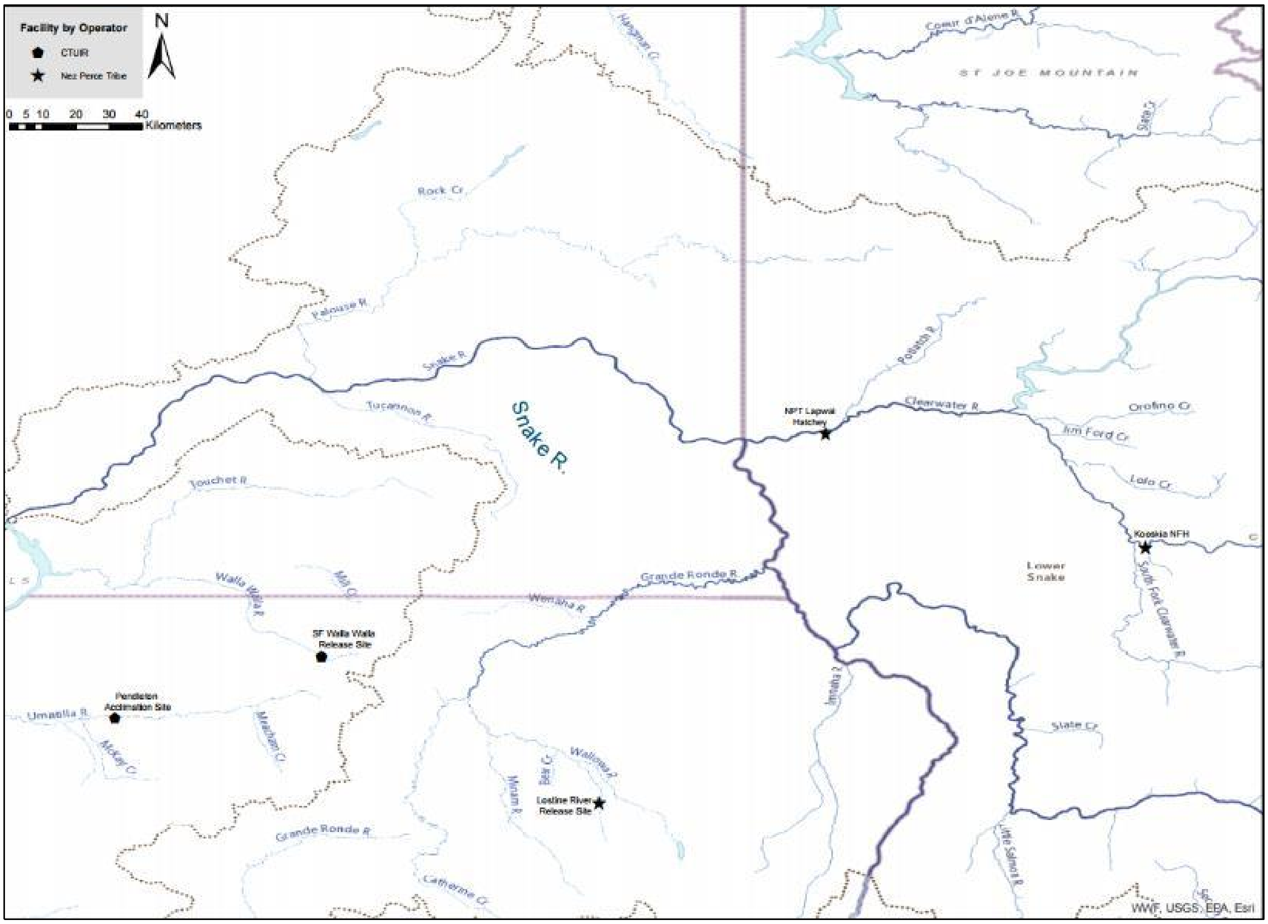

Figure 6. Hatchery and release site locations in the Snake River.

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, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal Action Agencies consult with NMFS and Section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an Opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, Section 7(b)(4) requires NMFS to provide an Incidental Take Statement that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

NMFS has determined that the Proposed Action is not likely to adversely affect species in Table 8 or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations Section (2.11).

Table 8. Species not likely adversely affected by the Proposed Action described in Section 1.3.

Species	**Listing Status**	**Critical Habitat**	**Protective Regulations**
Green Sturgeon (*Acipenser medirostris*)			
Southern DPS	Threatened, 71 FR 17757; April 7, 2006	74 FR 52300; October 9, 2009	75 FR 30714; June 2, 2010

2.1 Analytical Approach

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

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

The designation(s) of critical habitat for species listed in Table 9 use the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR

7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified in primary constituent elements (PCEs), PBFs, or essential features. In this Opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

- First, the current status of listed species and designated critical habitat, relative to the conditions needed for recovery, are described in Section 2.2.
- Next, the environmental baseline in the Action Area is described in Section 2.3.
- In Section 2.4, we consider how the Proposed Action would affect the species’ abundance, productivity, spatial structure, and diversity and the Proposed Action’s effects on critical habitat features.
- Section 2.5 describes the cumulative effects in the Action Area, as defined in our implementing regulations at 50 CFR 402.02
- In Section 2.6, the status of the species and critical habitat (Section 2.2), the environmental baseline (Section 2.3), the effects of the Proposed Action (Section 2.4), and cumulative effects (Section 2.5) are integrated and synthesized to assess the effects of the Proposed Action on the survival and recovery of the species in the wild and on the conservation value of designated or proposed critical habitat.
- Our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7.
- If our conclusion in Section 2.7 is that the Proposed Action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify designated critical habitat, we must identify a RPA to the action in Section 2.8.
- In addition, NMFS has determined that the Proposed Action is likely to affect, but not likely to adversely affect

2.2 Rangewide Status of the Species and Critical Habitat

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

Table 9. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to a listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Pacific Eulachon *(Thaleichthys pacificus)*			
Southern DPS	Threatened, 79 FR 20802, April 14, 2014	76 FR 65324, October 20, 2011	Not yet developed
Chinook salmon *(Oncorhynchus tshawytscha)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52706, September 2, 2005	70 FR 37160, June 28, 2005
Upper Columbia River spring-run	Endangered, 70 FR 20816, April 14, 2014	70 FR 52732, September 2, 2005	Issued under ESA Section 9
Snake River spring/summer-run	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005
Snake River fall-run	Threatened, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Upper Willamette River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52720, September 2, 2005	70 FR 37160, June 28, 2005
Coho salmon *(O. kisutch)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	81 FR 9252, February 24, 2016	70 FR 37160, June 28, 2005
Chum salmon *(O. keta)*			
Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52746, September 2, 2005	70 FR 37160, June 28, 2005
Sockeye salmon *(O. nerka)*			
Snake River	Endangered, 79 FR 20802, April 14, 2014	70 FR 52630, September 2, 2005	Issued under ESA Section 9
Steelhead *(O. mykiss)*			
Lower Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52833, September 2, 2005	70 FR 37160, June 28, 2005
Upper Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52630, September 2, 2005	71 FR 5178, February 1, 2006
Snake River Basin	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 37160, June 28, 2005
Middle Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52808, September 2, 2005	70 FR 47160, June 28, 2005
Upper Willamette River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52848, September 2, 2005	70 FR 37160, June 28, 2005
Killer Whales (*Orcinus orca*)			
Southern Resident DPS	Endangered, 79 FR 20802; April 14, 2014	71 FR 69054; November 29, 2006	Issued under ESA Section 9

"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 distinct population, and hence a "species" under the ESA if it represents an 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 USFWS-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. Pacific eulachon found in the Columbia River are part of the southern DPS of the taxonomic species *Thaleichthys pacificus*; The five Chinook salmon species listed in Table 9 each constitute an ESU (a salmon DPS) of the taxonomic species *Oncorhynchus tshawytscha*; LCR coho salmon constitute an ESU of the taxonomic species *Oncorhynchus kisutch*; Columbia River chum salmon constitute an ESU of the taxonomic species *Oncorhynchus keta*; Snake River Sockeye salmon constitute an ESU of the taxonomic species *Oncorhynchus nerka;* and the five steelhead listed each constitute a DPS of the taxonomic species *Oncorhynchus mykiss* and as such each ESU or DPS is considered a "species" under the ESA.

2.2.1 Status of Listed Species

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

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

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

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

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

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe how VSP criteria at the population, major population group (MPG), and species scales (i.e., salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species' populations and MPGs has been determined, NMFS assesses the status of the entire species. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as meta-populations (McElhany et al. 2000).

In order to describe a species' status, it is first necessary to define what the term "species" means in this context. In addition to defining "species" as including an entire taxonomic species or subspecies of animals or plants, the ESA also recognizes listing units that are a subset of the species as a whole. As described above, the ESA allows a DPS (or in the case of salmon, an ESU) of a species to be listed as threatened or endangered. In terms determining the status of a species, the Willamette Lower Columbia TRT (WLC TRT) developed a hierarchical approach for determining ESU-level viability criteria (Figure 7) that represents best available science and is used for the purposes of this Opinion.

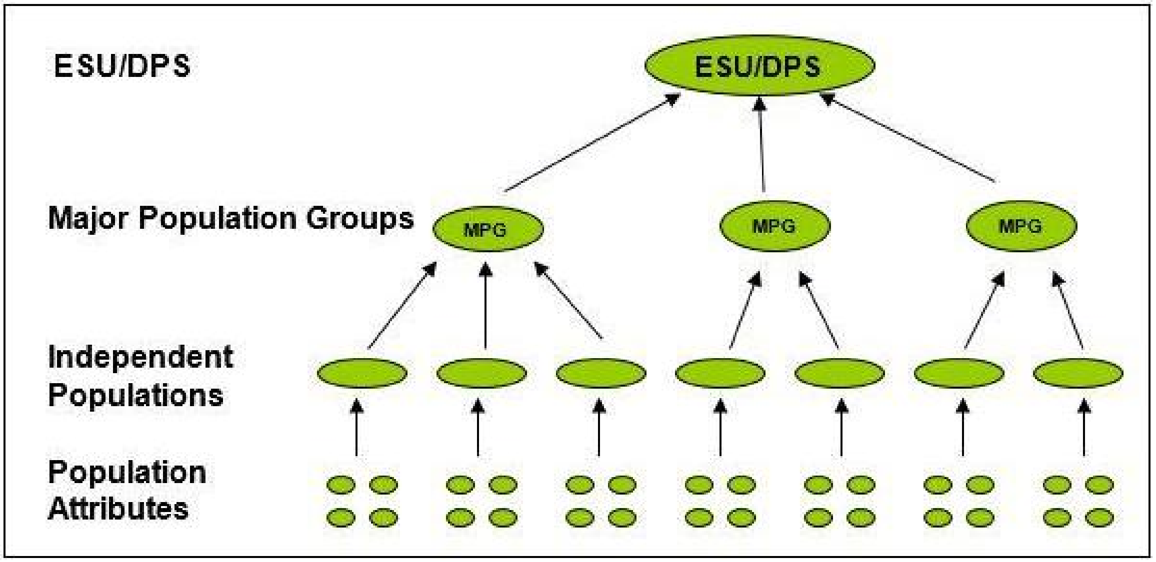

Figure 7. Hierarchical approach to ESU viability criteria.

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

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

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

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

2.2.1.1 Life-History and Status of the Pacific Eulachon Southern DPS

On March 18, 2010, NMFS listed the Southern DPS Pacific Eulachon (*Thaleichthys pacificus*; hereafter referred to as "eulachon") as a threatened species (75 FR 13012). The threatened status was reaffirmed on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat was designated for the southern DPS on October 20, 2011 (76 FR 65324) (Table 9), while protective regulations via Section 4(d) of the ESA have not yet been promulgated.

The eulachon, also known as Columbia River smelt, candlefish, or hooligan, are anadromous species that are endemic to the northeastern Pacific Ocean; they range from northern California to southwest Alaska and into the southeastern Bering Sea (Figure 8). Within the conterminous U.S., most eulachon production originates in the Columbia River Basin with the major and most consistent spawning runs returning to the Columbia River main stem and Cowlitz River. Spawning also occurs in the Grays, Elochoman, Kalama, Lewis, and Sandy Rivers. Adult eulachon have been recorded at several locations on the Washington and Oregon coasts, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams, although these tend to be erratic, appearing in some years but not others (Hay and McCarter 2000; Willson et al. 2006; Gustafson et al. 2010).

Eulachon typically enter the Columbia River between December and May with peak entry and spawning during February and March (Gustafson et al. 2010). They generally spawn in rivers that are fed by either glaciers or snowpack and that experience spring freshets. Normally, eulachon broadcast eggs “where the substrate consists of coarse sand/fine gravel, and where water flows are ‘moderate’ in velocity” (ODFW and WDFW 2000). Eggs sink, are demersal, and usually adhere to the substrate; therefore, sites with stable substrate for eggs to adhere to is important. Eulachon eggs, averaging 1 mm in size, are commonly found attached to sand or pea-sized gravel, though eggs have been found on a variety of other substrates, including silt, gravel to cobble sized rock, and organic detritus (Moody 2008). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel. Eggs become adhesive after fertilization and hatch in 3 to 8 weeks depending on temperature (Gustafson 2016). Fecundity estimates range from 7,000 to 60,000 eggs per female, and egg to larva survival may be less than 1% (Gustafson et al. 2010).

It has been suggested that because freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). Upon hatching, stream currents rapidly carry the newly hatched larvae, 4-8 mm in length, to the sea. While larvae do develop during their time in freshwater, they largely drift with the current and rapidly emigrate to the ocean (ODFW and WDFW 2000; NMFS 2016j). Newly hatched young are largely transparent, and are first found in the estuaries of known spawning rivers and then disperse along the coast (COSEWIC 2011) and rear in the pelagic zone experiencing high mortality rates during their transition to the juvenile phase. Sampling in the LCR (1996-2009) has found larval densities ranging from 0.3 to 42.1 larvae per cubic meter.

After the yolk sac is depleted, eulachon feed on pelagic plankton. After three to five years at sea, they return as adults to spawn. Among such anadromous species, high fecundity and mortality conditions may lead to random “sweepstake recruitment” events where only a small minority of spawning individuals contribute to subsequent generations (Hedgecock 1994). Adult eulachon weigh an average of 0.1 pounds each and are 15 to 20 cm long with a maximum recorded length of 30 cm. They are an important link in the food chain between zooplankton and larger organisms. Small salmon, lingcod and other fish feed on eulachon larvae and eulachon juveniles and adults are an important food source for a variety of species, including Pacific salmon (Gustafson et al. 2010)

Since freshets rapidly move eulachon eggs and larvae to estuaries, it is believed that eulachon imprint and home to an estuary into which several rivers drain rather than individual spawning rivers (Hay and McCarter 2000). After yolk sac depletion, eulachon larvae acquire characteristics to survive in oceanic conditions and move off into open marine environments as juveniles (COSEWIC 2011). From December to May, eulachon typically enter the Columbia River system with peak entry and spawning during February and March (Gustafson et al. 2010).

Eulachon movements in the ocean are poorly known, although the amount of eulachon bycatch in the pink shrimp fishery seems to indicate that the distribution of these organisms overlap in the ocean (NMFS 2016j). Prior to entering their spawning rivers, eulachon hold in brackish waters while their bodies undergo physiological changes in preparation for freshwater and to synchronize their runs. Eulachon then enter the rivers, move upstream, spawn, and die to complete their semelparous (spawn once and die) life cycle. Eulachon return to their spawning river at ages ranging from two to five years (COSEWIC 2011).

Adult eulachon weigh an average of 50 g each and are 15 to 20 cm long with a maximum recorded length of 30 cm. They are an important link in the food chain between zooplankton and larger organisms. Small salmon, lingcod, white sturgeon, and other fish feed on small larvae near river mouths. As eulachon mature, a wide variety of predators consume them (Gustafson et al. 2010).

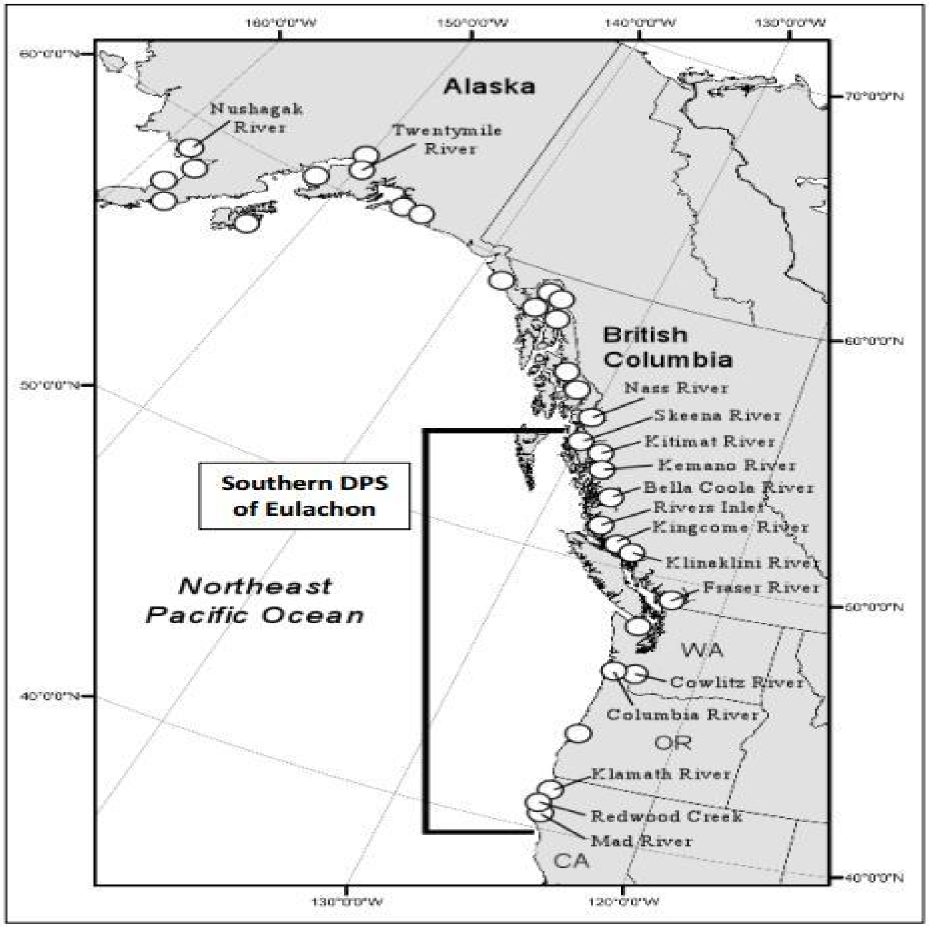

Figure 8. Distribution of the Southern DPS of Pacific Eulachon (*Thaleichthys pacificus*) (Gustafson 2016).

On June 21, 2013, NMFS announced a Federal recovery plan outline that serves as interim guidance for recovery efforts (NMFS 2013a). The major threats to eulachon are impacts of climate change on oceanic and freshwater habitats (species-wide), fishery bycatch (species-wide), dams and water diversions (Klamath and Columbia subpopulations), and predation (Fraser River and British Columbia sub-populations) (NMFS 2013g). Preliminary key recovery actions in the recovery outline include maintaining conservative harvest rates, reducing the bycatch of smelt, restoring more natural flows and water quality in the Columbia River, removing Klamath River dams, and completing research on life history and genetics, climate effects, and habitat effects (NMFS 2013g; Personal comm., R. Anderson 2016; Gustafson 2016).

Abundance, Productivity, Spatial Structure and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Southern DPS of Pacific Eulachon, is at high risk and remains at threatened status. They are a short-lived, high-fecundity, high-mortality forage fish; and such species typically have extremely large population sizes.

There are few direct estimates of eulachon abundance. In most areas where the southern DPS exists, escapement counts or estimates of spawning-stock biomass are unavailable. When available, catch statistics from commercial or recreational eulachon fisheries have been used to as proxies of relative abundance. However, inferring population status or trends from yearly catch statistics requires seldom verified assumptions such as similar fishing effort and efficiency, a consistent relationship among the harvested and total stock portion, and certain statistical assumptions (e.g., random sampling). There are few fishery-independent sources of abundance data available for eulachon, and eulachon monitoring programs do not exist in the U.S. However, the combination of catch records and anecdotal information indicates that eulachon were present in large annual runs in the past, and that substantial declines in abundance have occurred. Eulachon numbers are at, or near, historically low levels throughout the range of the southern DPS (Gustafson et al. 2010).

The Biological Review Team (BRT) separated the DPS into four subpopulations (Gustafson et al. 2010): the Klamath River (including the Mad River and Redwood Creek), the Columbia River (including all of its tributaries upstream to RM 180), the Fraser River, and the British Columbia coastal rivers (north of the Fraser River up to, and including, the Skeena River). The Elwha is the only river in the United States' portion of Puget Sound and the Strait of Juan de Fuca that supports a consistent eulachon run (Personal comm. R. Anderson 2016).

Microsatellite genetic work, in addition to other biological data including the number of vertebrae size at maturity, fecundity, river-specific spawning times, and population dynamics (Gustafson et al. 2010) appears to confirm the existence of significant differentiation among populations in the Southern DPS of Pacific Eulachon. The BRT was concerned about risks to eulachon diversity because of data suggesting that Columbia River and Fraser River spawning stocks may be limited to a single age class. This combined with the species' semelparous life history (individuals spawn once and die), likely increases the species' vulnerability to environmental catastrophes and perturbations and provide less of a buffer against year-class failure than species such as herring that spawn repeatedly and have variable ages at maturity (Gustafson et al. 2010; Personal comm. Anderson 2016).

In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River (Biological Review Team (BRT) 2008). Persistent low returns and landings of eulachon in the Columbia River from 1993-2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan in 2001 that provides for restricted harvest management when parental run strength, juvenile production, and ocean productivity forecast a poor return (WDFW and ODFW 2001). Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings evenually declined to the low levels observed in the mid-1990s (ODFW and WDFW 2009). Starting in 2005, the fishery has operated at the most conservative level allowed in the management plan (ODFW and WDFW 2009). Large commercial and recreational fisheries have occurred in the Sandy River in the past. The most recent commercial harvest in the Sandy River was in 2003. No commercial harvest has been recorded for the Grays River from 1990 to the present, but larval sampling has confirmed successful spawning in recent years (NMFS and NOAA 2011). Starting in 2011, returns in the Columbia River have rebounded by up to two orders of magnitude (Table 10). Spawning stock biomass estimations for the Fraser River 2002-2016 are reported in Table 10 (Personal comm. Anderson 2016).

Table 10. Annual Columbia and Fraser Rivers eulachon run size from 2000-2016.

	Columbia River[1,2]	**Fraser River[1]**		
Year	**Mean Estimates**	**Number of Fish at 9.9 Fish/Pound**	**Number of Fish at 13.3 Fish/Pound**	**Combined Biomass/Pounds**
1995	--	6,591,381	8,855,087	665,796
1996	--	41,709,035	56,033,350	4,213,034
1997	--	1,615,107	2,169,790	163,142
1998	--	2,968,304	3,987,721	299,829
1999	--	9,123,169	12,256,379	921,532
2000	5,421,500	2,837,349	3,811,793	286,601
2001	77,512,900	13,291,890	17,856,782	1,342,615
2002	59,114,500	10,781,927	14,484,812	1,089,084
2003	64,670,000	5,805,653	7,799,514	586,430
2004	--	720,250	967,609	72,753
2005	783,400	349,212	469,144	35,274
2006	1,233,200	632,947	850,323	63,934
2007	1,605,900	894,856	1,202,181	90,390
2008	2,418,400	218,258	293,215	22,046
2009	4,873,600	305,561	410,501	30,865
2010	1,759,900	109,129	146,607	11,023
2011	36,775,900	676,599	908,966	68,343
2012	35,722,100	2,619,092	3,518,578	264,555
2013	107,794,900	2,182,576	2,932,148	220,462
2014	185,965,200	1,440,500	1,935,218	145,505
2015	123,582,000	6,918,767	9,294,909	698,865
2016	54,556,500	960,330	1,290,140	97,003

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[1] All estimates were calculated based on methods developed by Parker (1985), Jackson and Cheng (2001), and Hay et al. (2002) to estimate spawning biomass of pelagic fishes.

[2] For the Columbia River data from 2000-2010, estimates were back-calculated using historical larval density data and pounds were converted to numbers of fish at 11.6 fish pound (WDFW 2015b).

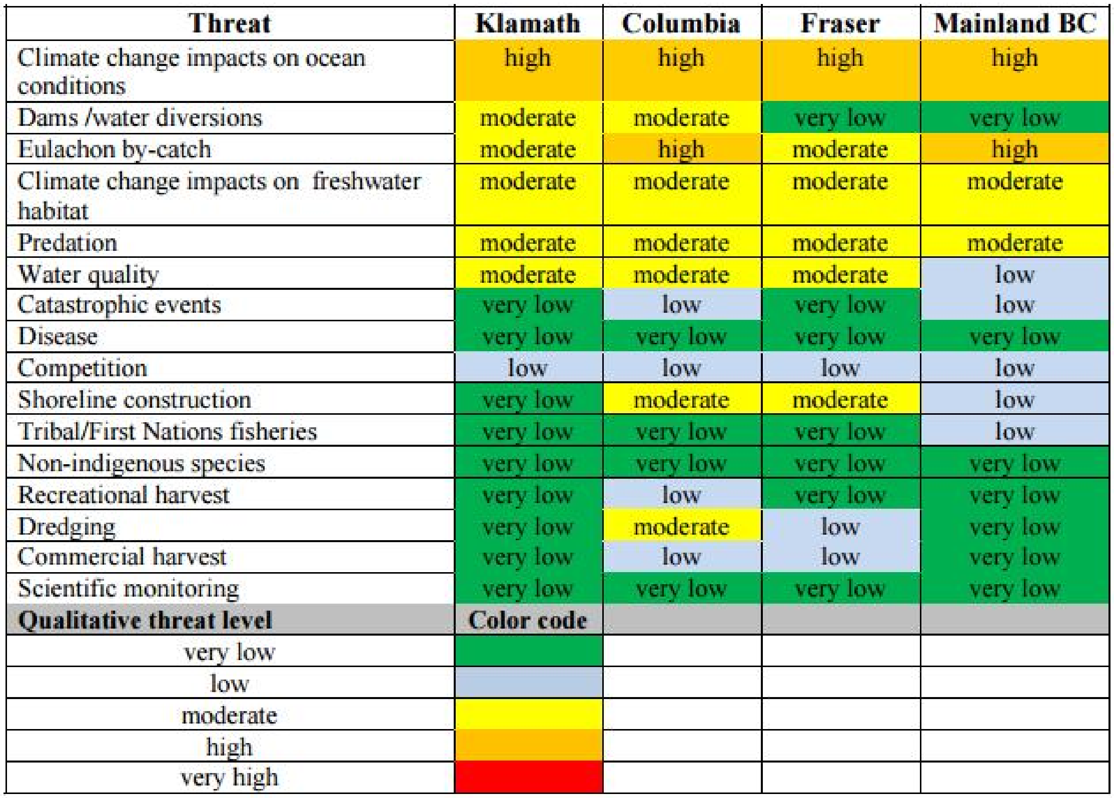
Limiting Factors

Understanding the limiting factors and threats that affect the Southern DPS of Pacific Eulachon provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Southern DPS of Pacific Eulachon. Factors that limit the DPS's survival and recovery include climate change impacts on ocean habitat as the most serious threat to persistence (Gustafson et al. 2010). Other threats to the species include habitat alteration and degradation from a variety of activities and climate change impacts on freshwater habitat. All other factors limiting the southern DPS, such as bycatch in shrimp trawl fisheries, occur outside the Action Area or would not be affected by the proposed hatchery programs. The 2013 recovery outline plan (NMFS 2013g) describes threats and limiting factors in detail. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.

The release of hatchery juvenile salmonids was not identified as a limiting factor, but eulachon may be impacted by hatchery fish through competition for space, and possibly predation on eulachon by salmon and steelhead juveniles. Predation by hatchery salmon and steelhead juveniles on newly hatched juvenile eulachon is assumed to occur if hatchery salmonid juveniles overlap with juvenile eulachon emigrating from areas within the Action Area, as described in Section 1.4 including the Cowlitz, Grays, Elochoman, Kalama, and Lewis Rivers. The actual level of predation and the effects of that predation on eulachon in these river basins are unknown but they were considered and determined not substantive compared to other factors identified as limiting the recovery of eulachon in the Columbia River (Gustafson et al. 2010).

The 2010 expert BRT examined the potential roles that 16 identified threats may have played in the decline of the Southern DPS of Pacific Eulachon and scored the severity of these threats from 1 to 5 in corresponding areas where each of the four southern DPS subpopulations exist (i.e., the Klamath, Columbia, and Frasier Rivers and in that portion of the DPS along the mainland coast of British Columbia). The severity of each threat was qualitatively scores as: 1-very low, 2-low, 3-moderate, 4-high, and 5-very high. The result of the 2010 BRT's expert analysis were presented in the 2010 status review report (Gustafson et al. 2010) by rank order from most severe to least severe for each geographical subset as determined by the mean 2010 BRT threat scores. Table 11 shows the modal scores of the 2010 BRT's qualitative threats analysis.

Table 11. Qualitative threat level and numerical and color coding for identified threats[1] in the decline of the Southern DPS of Pacific Eulachon.



Threat	Klamath	Columbia	Fraser	Mainland BC
Climate change impacts on ocean conditions	high	high	high	high
Dams /water diversions	moderate	moderate	very low	very low
Eulachon by-catch	moderate	high	moderate	high
Climate change impacts on freshwater habitat	moderate	moderate	moderate	moderate
Predation	moderate	moderate	moderate	moderate
Water quality	moderate	moderate	moderate	low
Catastrophic events	very low	low	very low	low
Disease	very low	very low	very low	very low
Competition	low	low	low	low
Shoreline construction	very low	moderate	moderate	low
Tribal/First Nations fisheries	very low	very low	very low	low
Non-indigenous species	very low	very low	very low	very low
Recreational harvest	very low	low	very low	very low
Dredging	very low	moderate	low	very low
Commercial harvest	very low	low	low	very low
Scientific monitoring	very low	very low	very low	very low
Qualitative threat level	**Color code**			
very low	🟩			
low	🟦			
moderate	🟨			
high	🟧			
very high	🟥			

[1] The level of threat severity is based on the 2010 BRT's modal score for each threat in each subpopulation (Gustafson 2016).

The BRT categorized climate change impacts on ocean conditions as the most serious threat to the persistence of eulachon in all four subpopulations of the DPS: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River. Climate change impacts on freshwater habitat and eulachon bycatch in offshore shrimp fisheries were also identified as significant threats in all subpopulations of the DPS. Dams and water diversions in the Klamath and Columbia rivers and predation in the Fraser and British Columbia coastal rivers filled out the last of the top four threats (Gustafson et al. 2010). These threats, together with large declines in abundance, indicated to the BRT that eulachon were at moderate risk of extinction throughout all of its range (Gustafson et al. 2010). Based on the BRT's qualitative threats assessment in Table 11, priority threats (those threats with a qualitative threats level of high) facing eulachon are climate change impacts on ocean conditions and bycatch in the offshore shrimp trawl fisheries (Personal comm. Anderson 2016).

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

On March 24, 1999, NMFS listed the LCR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on April 14, 2014 (Table 9). Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706) (Table 9).

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 12), 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 2005c).

Table 12. LCR Chinook Salmon ESU description and MPGs (NMFS 2013e; Jones Jr. 2015; NWFSC 2015).

ESU Description[1]	
Threatened	Listed under ESA in 1999; updated in 2014 (Table 9)
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 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.[8]

Thirty two historical populations within six MPGs comprise the LCR Chinook Salmon ESU. These are distributed through three ecological zones[9], whereby through a combination of life history types based on run timing and ecological zones result in the six MPGs, some of which are considered extirpated or nearly so (Table 13). The run timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Figure 9).

Table 13. Current status for LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013e).

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

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[8] 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 (WLC-TRT 2003).

[9] 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)

	Lewis (WA)	VL	Primary	H+	1,500
	Salmon (WA)	VL	Stabilizing	VL	--
	Clackamas (OR)	VL	Contributing	M	1,551
	Sandy (OR)	VL	Contributing	M	1,031
	Washougal (WA)	VL	Primary	H+	1,200
Gorge Fall	Lower Gorge (WA/OR)	VL	Contributing	M	1,200
	Upper Gorge (WA/OR)	VL	Contributing	M	1,200
	White Salmon (WA)	VL	Contributing	M	500
	Hood (OR)	VL	Primary[4]	H[4]	1,245
Cascade Late Fall	North Fork Lewis (WA)	VH	Primary	VH	7,300
	Sandy (OR)	H	Primary	VH	3,561

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

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

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

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

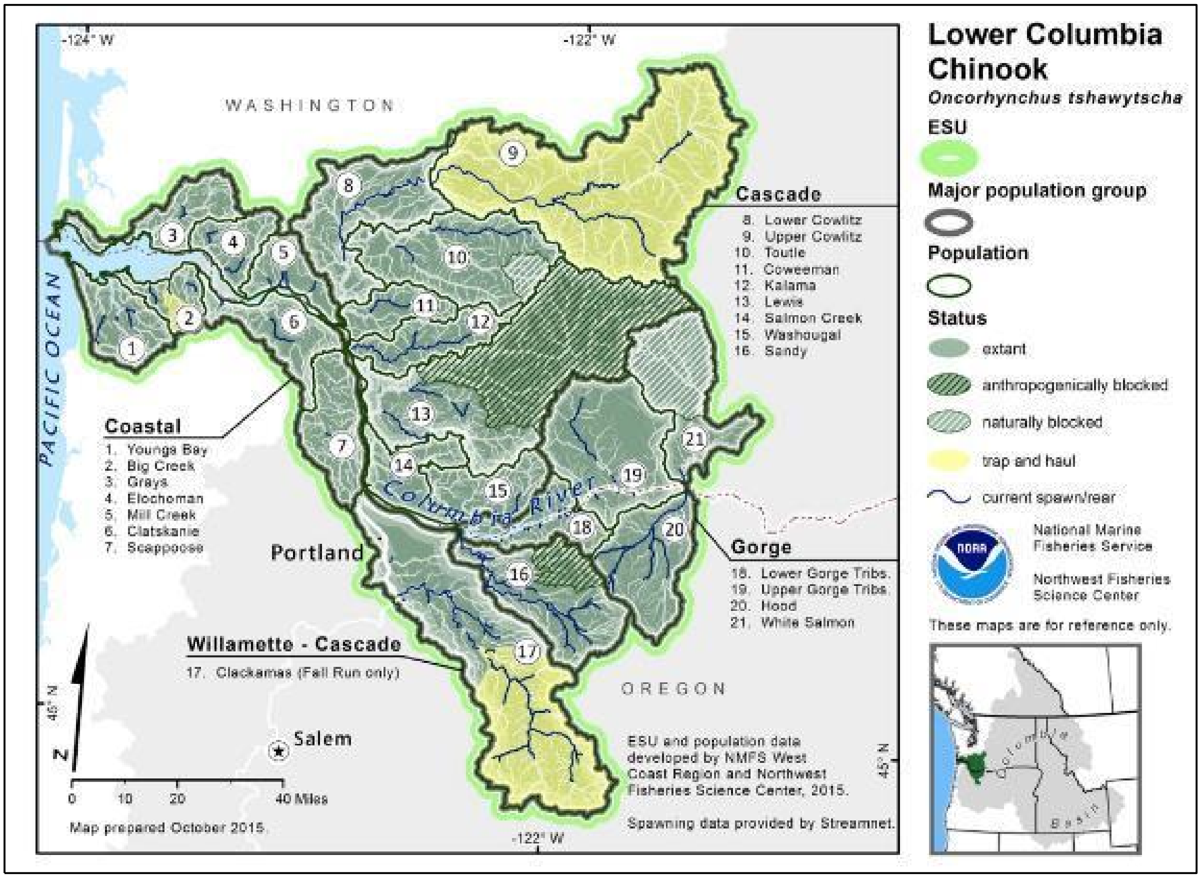

Figure 9. Map of the LCR Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs. Several watersheds contain or historically contained both fall and spring runs; only the fall-run populations are illustrated here (NWFSC 2015).

Chinook salmon have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: "stream-type" and "ocean-type" (Healey 1991; Myers et al. 1998). The Proposed Action produces both types of Chinook salmon. Ocean-type Chinook salmon reside in coastal ocean waters for 3 to 4 years before returning to freshwater and exhibit extensive offshore ocean migrations, compared to stream-type Chinook salmon that spend 2 to 3 years in coastal ocean waters. The ocean-type also enter freshwater to return for spawning later (May and June) than the stream-type (February through April). Ocean-type Chinook salmon use different areas in the river – they spawn and rear in lower elevation main stem rivers, and they typically reside in fresh water for no more than 3 months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

LCR Chinook salmon are classified into three life history types including spring runs, early-fall runs ("tules", pronounced (too-lees)), and late-fall runs ("brights") based on when adults return to freshwater (Table 14). 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 2013e). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, Chinook salmon may rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the north Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. The spawning run typically includes three or more age classes. Adult Chinook salmon are the largest of the salmon species, and LCR fish occasionally reach sizes up to 25 kilograms (55 lbs). Chinook salmon require clean gravels for spawning and pool and side-channel habitats for rearing. All Chinook salmon die after spawning once (NMFS 2013e).

Table 14. Life-history and population characteristics of LCR Chinook salmon.

	Life-History Features		
Characteristic	**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 2010b). Bright Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, bright Chinook salmon mature at an older average age than either LCR spring or tule Chinook salmon, and have a more northerly oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (NWFSC 2015).

Abundance, Productivity, Spatial Structure and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Chinook Salmon ESU, is at high risk and remains at threatened status. Each LCR Chinook salmon natural population baseline and target persistence probability level is summarized in Table 13, 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 13 were achieved, it would exceed the WLC TRT's MPG-level viability criteria for the Coast and Cascade fall MPGs, the Cascade spring MPG, and the Cascade late-fall MPG. However, the recovery scenario for Gorge spring and Gorge fall Chinook salmon does not meet WLC TRT criteria because, within each MPG, the scenario targets only one population (the Hood) for high persistence probability. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook salmon MPG, was intentional on the part of local recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring MPGs. In addition, multiple spring Chinook salmon natural populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems.

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

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 13 represents one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade MPG, coupled with compensation in the other strata for not meeting TRT criteria in the Gorge stratum would provide an ESU no longer likely to become endangered.

Cascade Spring MPG

LCR spring Chinook salmon natural populations occur in both the Gorge and Cascade MPGs (Table 12). There are seven LCR spring Chinook salmon populations in the Cascade MPG. The most recent estimates of minimum inriver run size, catch, and escapement totals for LCR spring Chinook salmon is provided in Table 15. The combined hatchery-origin and natural-origin LCR spring Chinook salmon run sizes for the Cowlitz, Kalama, and Lewis river populations in Washington have all numbered in the thousands in recent years (Table 15). Estimated total spawner abundances for Washington populations are provided in Table 16. The Cowlitz and Lewis populations are currently managed for hatchery production since most of the historical spawning habitat has been inaccessible due to hydro development in the upper basin (LCFRB 2010). The hatcheries' escapement objectives have been met in recent years with few exceptions (Table 17).

Table 15. Estimates of minimum inriver run size (including both catch and escapement totals) for LCR spring Chinook salmon populations (PFMC 2016b, Table B-12).

Year	Cowlitz River[1]	Kalama River	Lewis River[1]	Sandy River
1997	1,877	505	2,196	4,410
1998	1,055	407	1,611	3,577
1999	2,069	977	1,753	3,585
2000	2,199	1,418	2,515	3,641
2001	1,609	1,796	3,777	5,329
2002	5,215	2,912	3,514	5,905
2003	15,954	4,556	5,040	5,615
2004	16,511	4,286	7,475	12,680
2005	9,379	3,367	3,512	7,668
2006	6,963	5,458	7,301	4,382
2007	3,975	8,030	7,596	2,813

2008	2,986	1,623	2,215	5,994
2009	5,977	404	1,493	2,429
2010	8,830	918	2,337	7,652
2011	5,834	778	1,311	5,721
2012	12,617	862	1,895	5,038
2013	9,536	1,014	1,597	5,700
2014	10,461	1,013	1,482	5,971
2015	23,931	3,149	1,006	4,000

[1] Includes hatchery escapement, tributary recreational catch, and natural spawning escapement from 1975-present.

Table 16. Spring Chinook salmon total natural spawner abundance estimates (natural and hatchery spawners combined) in LCR tributaries, 1997-2015 (from WDFW Salmon Conservation and Reporting Engine (SCORE)[1])*.

Year	**Cowlitz**[2]	**Kalama**	**North Fork Lewis**
1997	437	39	410
1998	262	42	211
1999	235	215	241
2000	264	33	473
2001	315	555	678
2002	781	886	493
2003	2,485	766	679
2004	2,048	352	494
2005	539	380	116
2006	816	292	847
2007	144	2,146	264
2008	484	362	25
2009	819	26	58
2010	286	0	157
2011	191	200	90
2012	321	28	190
2013	409	158	60
2014	227	187	403
2015	n/a	n/a	147

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

*Date Accessed: November 8, 2016.

[2] Cowlitz River numbers include both the Lower, Upper, and Cispus portions of the Cowlitz River. Only natural spawner abundance estimates are shown.

Table 17. Cowlitz, Lewis River, and Kalama Falls Hatchery rack escapements for LCR spring Chinook salmon (From WDFW Final Hatchery Escapement Reports, 1996-1997 through 2009-2010). These are numbers of fish returning to the hatchery, with each hatchery's goal.

Year	Cowlitz Salmon Hatchery[1]	Lewis River Hatchery[2]	Kalama Falls Hatchery[3]
	Goal: 1,337	**Goal: 1,380**	**Goal: 300**
1997	1,298	2,245	576
1998	812	1,148	408
1999	1,321	845	794
2000	1,408	776	1,256
2001	1,306	1,193	952
2002	2,713	1,865	1,374
2003	10,481	3,056	3,802
2004	12,596	4,235	3,421
2005	7,503	2,219	2,825
2006	5,379	4,130	4,313
2007	3,089	3,897	4,748
2008	1,895	1,386	940
2009	3,604	1,068	170
2010	5,920	1,896	467
2011	1,992	1,101	275
2012	5,589	1,294	285
2013	3,762	1,785	732
2014	4,591	1,009	709
2015	17,600	908	2,642

[1] Cowlitz River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Cowlitz Salmon Hatchery. Goal is from Cowlitz River Spring Chinook HGMP online at: http://wdfw.wa.gov/hatcheries/hgmp/pdf/lower_columbia/cowlitz_sping_chinook_2014.pdf last accessed June 18, 2016.

[2] Lewis River Spring Chinook salmon brood origin hatchery returns are collected at the Merwin Dam Fish Collection Facility, and on-station at the Lewis River Hatchery. Goal is from Lewis River Spring Chinook HGMP online at: http://wdfw.wa.gov/hatcheries/hgmp/pdf/lower_columbia/lewisr_sp_chin_2014_draft.pdf last accessed June 18, 2016.

[3] Kalama River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Kalama Falls Hatchery.

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

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

The Cowlitz, Lewis, and Kalama river systems have all met their hatcheries escapement objectives in recent years, with few exceptions based on the goals established in their respective HGMPs (Table 17). This at least ensures that what remains of the genetic legacy of these natural populations is preserved and can be used to advance recovery. The existence of these hatchery programs reduces extinction risk, in the short-term.

The historical significance of the Kalama population to the overall LCR Chinook Salmon ESU was likely limited because habitat there was probably not as productive for spring Chinook salmon compared to the other spring Chinook salmon populations in the ESU (NMFS 2013e). In the recovery scenario, the Kalama spring Chinook salmon population is designated as a contributing population targeted for a relatively lower persistence probability because habitat there was not as productive historically for spring Chinook salmon (Table 13) (NMFS 2013e).

Legacy effects of the 1980 Mount St. Helens eruption are still a fundamental limiting factor for the Toutle spring Chinook salmon natural population (NMFS 2013e). The North Fork Toutle was the area most affected by the blast and resulting sedimentation from the eruption. Because of the eruption, a sediment retention structure (SRS) was constructed to manage the ongoing input of fine sediments into the lower river. Nonetheless, the SRS is a continuing source of fine sediments and blocks passage to the upper river. A trap and haul system was implemented and operates annually from September to May to transport adult fish above the SRS. The transport program provides access to 50 miles of anadromous fish habitat located above the structure (NMFS 2013e) but that habitat is still in very poor condition. There is relatively little known about current natural spring Chinook salmon production in this basin. The Toutle population has been designated a contributing population targeted for medium persistence probability under the recovery scenario (Table 13).

The baseline persistence probability of the Sandy River spring natural population is currently medium. This population is designated as a primary population targeted for high persistence probability and thus is likely to be important to the overall recovery of the ESU (Table 13). Marmot Dam in the upper Sandy watershed was used as a counting and sorting site in prior years, but the Dam was removed in October 2007. The abundance component of the persistence probability goal for Sandy River spring Chinook salmon is 1,230 natural-origin fish (Table 13), and the return of natural-origin fish has exceeded this goal in recent years. The total return of spring Chinook salmon to the Sandy River, including ESA-listed hatchery fish, has averaged more than 5,500 since 2000 (Table 15). Although the abundance criterion has been exceeded in recent years, other aspects of the VSP criteria would have to improve for the population to achieve the higher persistence probability level that is targeted.

Gorge Spring MPG

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

Most of the habitat that was historically available to spring Chinook salmon in the Hood River is still accessible. Because of the apparent extirpation of the population, Oregon initiated a reintroduction program using spring Chinook salmon from the Deschutes River. The nearest natural population of spring Chinook salmon is the Deschutes River population, but the population is part of a different ESU, the MCR Chinook Salmon ESU. Although the reintroduction program has been underway since the mid-90s, it has not met its original goals for smolt-to-adult survival rates. Deficiencies are attributed to production practices (ISRP 2008; CTWSR 2009; NMFS 2013e). The Confederated Tribes of Warm Springs Reservation (CTWSR) conducted a Hood River Production Program (HRPP) monitoring and evaluation project through 2010, and their estimates of natural spring Chinook salmon returning to the Hood River Powerdale trap prior to removal of the Powerdale Dam in 2010 are in Table 18. The delisting persistence probability target is listed as very high, but NMFS (2013e) believes that the prospects for meeting that target are uncertain.

Table 18. Hood River spring Chinook salmon actual returns to the Powerdale adult trap generated by CTWSR for the HRPP (from ODFW Salmon & Steelhead Recovery Tracker)[1]*).

Year	Hatchery Origin Returns	Natural Origin Returns
1997	280	68
1998	18	77
1999	88	23
2000	20	64
2001	597	45
2002	1,304	70
2003	344	101
2004	148	137
2005	633	112
2006	920	298
2007	401	142
2008	974	56
2009	1,395	72
2010	850	125

[1] Online at: http://www.odfwrecoverytracker.org/explorer/species/Chinook/run/spring/esu/257/262/
* Date Accessed: April 12, 2016.

The White Salmon River natural population is also considered extirpated. Condit Dam was completed in 1913 with no juvenile or adult fish passage, thus precluding access to all essential habitat. The breaching of Condit Dam in 2011 provided an option for recovery planning in the White Salmon River. The recovery plan calls for monitoring escapement into the basin for four to five years to see if natural recolonization occurs (abundance estimates prior to 2012 reflected fish spawning below Condit Dam during the spring run temporal spawning window) (NWFSC 2015). Sometime during or at the end of the interim monitoring program, a decision will be made about whether to proceed with a reintroduction program using hatchery fish; however, there is not enough data available yet to evaluate that action. The recovery scenario described in the recovery plan identifies the White Salmon spring population as a contributing population with a low plus persistence probability target (Table 13).

Coast Fall MPG

There are seven natural populations in the Coast Fall Chinook salmon MPG. None are considered genetic legacy populations. The baseline persistence probability of five of the seven populations in this MPG is listed as very low, whereas the remaining two populations are listed as low (Youngs Bay and Scappoose) (Table 13). All of the populations are targeted for improved persistence probability in the recovery scenario. The Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany (M/A/G), and Scappoose populations are targeted for high persistence, while the Grays River is targeted for medium plus persistence probability. The Big Creek and Youngs Bay populations are targeted for low persistence probability (Table 13).

Populations in this MPG are subject to significant levels of hatchery straying (Beamesderfer et al. 2011). There was a Chinook salmon hatchery on the Grays River, but that program was closed in 1997 with the last hatchery returns to the river in 2002. A temporary weir was installed for the first time on the Grays River in 2008 to quantify escapement and to help control the number of hatchery strays, from hatchery programs outside the Grays River. As it turns -out, a large number of out-of-ESU Rogue River “brights” from the Youngs Bay net pen programs were observed at the weir, and by 2010 the weir was functionally able to begin removing hatchery strays. It is worth noting that the escapement data reported in Table 19 have been updated through 2015 relative to those reported in the 2010 status review (Ford 2011). More recent information is reported in WDFW’s SCORE online system (see Table 19 citations).

The Elochoman had an in-basin fall Chinook salmon hatchery production program that released 2,000,000 fingerlings annually. That program was closed in 2009 (NMFS 2013e). The last returns of these hatchery fish were probably in 2014. Closure of the hatchery program is consistent with the overall transition and hatchery reform strategy for tule Chinook salmon. The number of spawners in the Elochoman has ranged from several hundred to several thousand in recent years (Table 19) with most being hatchery-origin (Beamesderfer et al. 2011). The M/A/G population does not have an in-basin hatchery program, but still has several hundred hatchery spawners each year; however, numbers have decreased slightly in the most recent years (Table 19).

Table 19. Early-fall (tule) Chinook salmon (in Coast MPG) total natural spawner abundance estimates (natural- and hatchery-origin fish combined) and the proportion of hatchery-origin fish (pHOS[1]) on the spawning grounds for the Coast Fall MPG populations, 1997-2015 (from WDFW SCORE[2]).

Year	Clatskanie[3]	pHOS	Grays	pHOS	Elochoman[4]	pHOS	M/A/G[4]	pHOS	Youngs Bay[3]	pHOS
1997	7	na	12	na	2,137	na	595	na	na	na
1998	9	na	93	na	358	na	353	na	na	na
1999	10	na	303	na	957	na	575	na	na	na
2000	26	90%	89	na	146	na	370	na	na	na
2001	26	90%	241	na	2,806	na	3,860	na	na	na
2002	39	90%	78	na	7,893	na	3,299	na	na	na
2003	48	90%	373	na	7,384	na	3,792	na	na	na
2004	11	90%	726	na	6,880	na	4,611	na	na	na
2005	10	90%	122	na	2,699	na	2,066	na	na	na
2006	4	90%	383	na	324	na	622	na	na	na
2007	9	90%	96	na	168	na	335	na	na	na
2008	9	90%	33	65%	1,320	na	780	na	na	na
2009	94	44%	210	62%	1,467	na	604	na	na	na
2010	12	88%	70	55%	154	88%	194	93%	1,152	0%
2011	12	100%	70	83%	59	95%	111	93%	1,584	61%
2012	6	92%	43	79%	64	73%	23	88%	170	97%
2013	3	92%	189	91%	187	71%	207	80%	409	95%
2014	7	91%	322	56%	192	78%	65	90%	119	95%
2015	6	91%	156	85%	313	68%	92	91%	382	81%

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

[2] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score Date Accessed: April 15, 2016

[3] Clatskanie and Youngs Bay estimates are from.http://odfwrecoverytracker.org/explorer/species/Chinook/run/fall/esu/241/244/, 2012 Youngs Bay estimate is from http://odfw.forestry.oregonstate.edu/spawn/pdf%20files/reports/2012-13LCTuleSummary%20.pdf Date accessed: May 19, 2016

[4] Elochoman and Ge/Ab/Mi estimates from 1997-2009 are considered a proportion on the WDFW SCORE website. Elochoman estimates include the Skamokawa Creek Fall Chinook Spawners (proportion).

ODFW reported that hatchery strays contributed approximately 90% of the fall Chinook salmon spawners in both the Clatskanie River and Scappoose Creek over the last 30 years (ODFW 2010a). New information was considered when developing the status of the Clatskanie and Scappoose natural populations. Problems with the previous Clatskanie estimates are summarized in Dygert (2011). Escapement estimates for Clatskanie from 1974 to 2006 were based on expanded index counts, meaning if index counts were less than five, they were replaced with values based on averages of neighboring years. This occurred for 11 of the 33 years in the data set. From 2004 to 2006, there was also computational error in the data reported, resulting in estimates that were approximately twice as high as they should have been. Index counts in the Clatskanie since 2006 (i.e., not using the expanded index counts) continue to show few natural spawners.

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

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

The Big Creek and Youngs Bay natural populations are both proximate to large net pen rearing and release programs designed to provide for a localized, terminal fishery in Youngs Bay. ODFW estimates that 90% of the fish that spawn in these areas are hatchery strays (Table 19). The number of fish released at the Big Creek hatchery has been reduced with additional changes in hatchery practices to help reduce straying into the Clatskanie and other neighboring systems. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries. The nature and scale of the reform actions were described in more detail in Frazier (2011) and Stahl (2011).

Cascade Fall MPG

There are ten natural populations of fall Chinook salmon in the Cascade MPG. Of these, only the Coweeman and East Fork Lewis are considered genetic legacy populations. The baseline persistence probability of all of these populations is very low (Table 13). These determinations were generally based on assessments of status at the time of listing. The Lower Cowlitz, Kalama, Clackamas, and Sandy populations are targeted for medium persistence probability and Toutle, Coweeman, Lewis, and Washougal populations are targeted for high-plus persistence probability in the ESA recovery plan. The target persistence probability for the other two populations is very low: Salmon Creek, a population within a highly urbanized subbasin with limited habitat recovery potential, and Upper Cowlitz, a population with reintroduction of spring Chinook salmon as the main recovery effort (NMFS 2013e) (Table 13).

Total escapements (natural-origin and hatchery fish combined) to the Coweeman and East Fork Lewis have averaged 735 and 612, respectively, over the last eighteen years (Table 20) The recovery abundance target for the Coweeman is 900 natural-origin fish and 1,500 natural-origin fish for the East Fork Lewis (Table 13). The historical contribution of hatchery spawners to the Coweeman and East Fork Lewis populations is relatively low compared to that of other populations (Beamesderfer et al. 2011). The Kalama, Washougal, Toutle, and Lower Cowlitz natural populations are all associated with significant in-basin hatchery production and are subject to large numbers of hatchery strays (Beamesderfer et al. 2011). We have less information on returns to the Clackamas and Sandy Rivers, but ODFW indicated for both that 90% of the spawners are likely hatchery strays from as many as three adjacent hatchery programs (NMFS 2013e, Appendix A).

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

Table 20. LCR tule Chinook salmon total natural spawner escapement (natural-origin and hatchery fish combined) and the proportion of hatchery-origin fish (pHOS[1]) on the spawning grounds for Cascade Fall MPG populations, 1997-2015 (from WDFW SCORE[2])*.

Year	**Coweeman**	**pHOS**	**Washougal**	**pHOS**	**Kalama**	**pHOS**	**EF Lewis**	**pHOS**	**Upper Cowlitz[3]**	**pHOS**	**Lower Cowlitz**	**pHOS**	**Toutle[4]**	**pHOS**
1997	689	na	4,529	na	3,539	na	307	na	27	na	2,710	na	na	na
1998	491	na	2,971	na	4,318	na	104	na	257	na	2,108	na	1,353	na
1999	299	na	3,105	na	2,617	na	217	na	1	na	997	na	720	na
2000	290	na	2,088	na	1,420	na	304	na	1	na	2,363	na	879	na
2001	802	na	3,836	na	3,613	na	526	na	3,646	na	4,652	na	4,971	na
2002	877	na	5,725	na	18,809	na	1,296	na	6,113	na	13,514	na	7,896	na
2003	1,106	na	3,440	na	24,710	na	714	na	4,165	na	10,048	na	13,943	na
2004	1,503	na	10,404	na	6,612	na	886	na	2,145	na	4,466	na	4,711	na
2005	853	na	2,671	na	9,168	na	598	na	2,901	na	2,870	na	3,303	na
2006	566	na	2,600	na	10,386	na	427	na	1,782	na	2,944	na	5,752	na
2007	251	na	1,528	na	3,296	na	237	na	1,325	na	1,847	na	1,149	na
2008	424	na	2,491	na	3,734	na	379	na	1,845	na	1,828	na	1,725	na
2009	783	na	2,741	na	7,546	na	596	na	7,491	na	2,602	na	539	na
2010	446	30%	833	86%	832	88%	378	64%	3,700	62%	3,169	29%	275	87%
2011	500	12%	842	82%	599	93%	827	71%	5,029	62%	2,782	25%	338	79%
2012	412	11%	305	72%	517	93%	601	52%	1,951	68%	1,946	29%	259	73%
2013	1,398	31%	3,018	58%	1,037	91%	1,441	85%	3,287	55%	3,593	19%	950	58%
2014	857	4%	1,362	33%	1,029	91%	856	57%	na	na	na	na	371	50%
2015	1,430	1%	1,703	57%	3,598	50%	947	50%	na	na	na	na	440	39%

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

[2] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

* Date Accessed: April 18, 2016

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

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

Gorge Fall MPG

There are four natural populations of tule Chinook salmon in the Gorge Fall Chinook salmon MPG: Lower Gorge, Upper Gorge, White Salmon, and Hood. The baseline persistence probability for all of these populations is very low (Table 13). The recovery plan targets the White Salmon and Lower and Upper Gorge populations for medium persistence probability, and the Hood River population for high persistence although, as discussed earlier in this subsection, it is unlikely that the high viability objective can be met (Table 13). There is some uncertainty regarding the historical role of the Gorge populations in the ESU and whether they truly functioned historically as demographically independent populations (NMFS 2013e). This is accounted for in the recovery scenario presented in the recovery plan.

Natural populations in the Gorge Fall MPG have been subject to the effects of a high incidence of hatchery fish straying and spawning naturally. The White Salmon population, for example, was limited by Condit Dam, as discussed above regarding Gorge Spring MPG, and natural spawning occurred in the river below the dam (NMFS 2013e, Appendix C). The number of fall Chinook salmon spawners in the White Salmon increased from low levels in the early 2000s to an average of 1,086 for the period from 2010 to 2015 (Table 21), but spawning is dominated by tule Chinook salmon strays from the neighboring Spring Creek Hatchery and upriver bright Chinook salmon from the production program in the adjoining Little White Salmon River[10]. The Spring Creek Hatchery, which is located immediately downstream from the Little White Salmon River mouth, is the largest tule Chinook salmon production program in the Columbia basin, releasing approximately 10 million smolts annually. The White Salmon River was the original source for the hatchery brood stock, so whatever remains of the genetic heritage of the population is contained in the mix of hatchery and natural spawners. There is relatively little known about current natural-origin fall Chinook salmon production in this basin, but it is presumed to be low.

The breaching of Condit Dam is likely to add silt to the lower reaches of the White Salmon utilized for spawning. The White Salmon Working Group (WSWG), comprised of staff from the USFWS, Yakama Nation, WDFW, NMFS, PacifiCorp, and U.S. Geological Survey, out-planted adult fall Chinook salmon upstream of Condit Dam in 2011 prior to the breaching, in lieu of adult collection and subsequent propagation. This was a one-time conservation measure to mitigate for the impacts of the expected sediment released downstream. As part of this measure, the WSWG collected 552 natural-origin and 127 hatchery-origin returning Chinook salmon (of which 299 were females) at the White Salmon weir located adjacent to the White Salmon hatchery ponds at RM 1.4 and transported them upstream of Northwestern Lake reservoir (NMFS 2012d). No additional trap and haul operations are planned at this time. Natural escapement and production will be monitored for the next four to five years. Thereafter, a decision will be made about the role of hatchery propagation in future plans for recovery (NMFS 2013e).

There is relatively little specific or recent information on the abundance of tule Chinook salmon for the other natural populations in the Gorge Fall MPG (Table 21). Stray hatchery fish are

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

presumed to be decreasing contributors towards the spawning populations in these tributaries due to recent reductions in overall Gorge MPG hatchery releases, including the recent discontinuation of tule Chinook salmon releases from the Little White Salmon Hatchery. Hatchery strays still contribute to the escapement to the Lower Gorge, Upper Gorge, and Hood River populations on the Oregon side of the river (NMFS 2013e, Appendix A). These populations are mostly influenced by hatchery strays from the Bonneville Hatchery located immediately below Bonneville Dam, and the Spring Creek Hatchery located just above Bonneville Dam. The natural-origin abundance of returning Chinook salmon on the Washington side of the Lower and Upper Gorge populations has been steadily increasing in recent years (Table 21). The tributaries in the Gorge on the Washington side of the river are similarly affected by hatchery strays, which the recent past five years of monitoring show stable pHOS levels (Table 21). As a consequence, hatchery-origin fish contribute at varying degrees to spawning levels in all of the Gorge area tributaries, but actual estimates are unknown for areas like Eagle Creek, Tanner Creek and Herman Creek.

Table 21. LCR tule Chinook salmon total natural-origin spawner abundance estimates in Gorge Fall Strata populations, 2005-2015 (from WDFW SCORE[1])*.

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

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

* Date Accessed: April 18, 2016

[2] For example, Hood River in 2005 had 42 natural-origin spawners and 14 % hatchery spawners. To calculate hatchery-origin numbers multiply (42/ (1-.14))-42 = ~7 hatchery-origin spawners.

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

Cascade Late Fall MPG

There are two late fall, "bright," Chinook salmon natural populations in the LCR Chinook Salmon ESU in the Sandy and Lewis Rivers. Both populations are in the Cascade MPG (Table 12). The baseline persistence probability of the Lewis and Sandy populations are very high and high, respectively; both populations are targeted for very high persistence probability under the recovery scenario (Table 13).

The Technical Advisory Committee (TAC) designated for the 2008-2017 *United States v. Oregon* Management Agreement provides estimates of the escapement of bright Chinook salmon to the Sandy River (Table 22); these are estimates of spawning escapement are estimates of peak redd counts obtained from direct surveys in a 16 km index area that is expanded to estimates of spawning escapement by multiplying by a factor of 2.5 (TAC 2008). The recovery plan includes an appendix that describes how index counts are expanded to estimates of total abundance (ODFW 2010a, Appendix C). There are some minor differences between the values reported in Appendix C and those shown in Table 22 that reflect updates or revisions in prior index area estimates. The abundance target for delisting is 3,747 natural-origin fish (Table 13) and escapements have averaged about 3,000 natural-origin fish since 1995 (Table 22).

The Lewis River population is the principal indicator stock for management within the Cascade Late Fall MPG. It is a natural-origin population with little or no hatchery influence. The escapement goal, based on estimates of maximum sustained yield (MSY), is 5,700. The escapement has averaged 9,000 over the last ten years and has generally exceeded the goal by a wide margin since at least 1980. Escapement was below goal from 2006 through 2008 (Table 22). The shortfall is consistent with a pattern of low escapements for other far-north migrating stocks in the region and can likely be attributed to poor ocean conditions. Escapement improved in 2009 and has been well above goal since (Table 22). NMFS (2013e) identifies an abundance target under the recovery scenario of 7,300 natural-origin fish (Table 13), which is 1,600 more fish than the currently managed for escapement goal. The recovery target abundance is estimated from population viability simulations and is assessed as a median abundance over any successive 12 year period. The median escapement over the last 12 years is 8,750, therefore exceeding the abundance objective (Table 22). Escapement to the Lewis River is expected to vary from year-to-year as it has in the past, but generally remain high relative to the population's escapement objectives, which suggests that the population is near capacity (NWFSC 2015).

Table 22. Annual escapement of natural-origin LCR bright Chinook salmon from 1995-2015.

Year	Lewis River[1, 2]	Sandy River[3]
1995	9,715	4,338
1996	13,077	2,115
1997	8,168	8,379
1998	5,173	3,237
1999	2,417	1,872
2000	8,741	352
2001	11,274	3,451
2002	13,293	5,339
2003	12,912	2,592
2004	12,928	2,517
2005	9,775	3,224
2006	5,066	4,732
2007	3,708	745
2008	5,485	2,521
2009	6,283	3,128
2010	9,294	1,713
2011	8,205	1,635

2012	8,143	568
2013	15,197	2,489
2014	20,809	565
2015	23,614	2,006

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

* Date Accessed: May 23, 2016

[2] Data are total spawner estimates of wild late fall (bright) Chinook

[3] Data from 1995-2008 are index area counts are expanded to spawning escapement by multiplying by 4.2 based on method described in ODFW (2010a, Appendix C). Data from 2009-2015 are total fall Chinook, and may include components of both the bright and tule stocks, estimated by GRTS (Generalized Random Tessellation Stratified) based monitoring (tule is believed to be majority) (Personal comm., E. Brown 2016).

Summary

Spatial structure and diversity are VSP attributes that are evaluated for the LCR Chinook Salmon ESU using a mix of qualitative and quantitative metrics. Spatial structure has been substantially reduced in many populations within the ESU (NMFS 2013e). The estimated changes in VSP status for LCR Chinook salmon populations in Table 23 indicate that a total of 7 of 32 populations are at or near their recovery viability goals, although under the recovery plan scenario only two of these populations had scores above 3.0, indicating these two are at a moderate level of viability. The remaining 25 populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals (NWFSC 2015). The natural populations that did meet their recovery goals were able to do so because the goals were set at status quo levels.

Table 23. Summary of VSP scores and recovery goals for LCR Chinook salmon populations (NWFSC 2015).

MPG	State	Population	Total VSP Score	Recovery Goal
Cascade Spring	WA	Upper Cowlitz	0.5	3.5
	WA	Cispus	0.5	0.5
	WA	Tilton	0.5	2.0
	WA	Toutle	0.5	3.5
	WA	Kalama	0.5	1.0
	WA	NF Lewis	0.5	3.0
	OR	Sandy	2.0	3.0
Gorge Spring	WA	White Salmon	0.5	1.5
	OR	Hood	0	4.0
Coast Fall	OR	Youngs Bay	1.0	1.0
	WA	Grays/Chinook	0.5	2.5
	OR	Big Creek	0	1.0
	WA	Elochoman/Skamokawa	0.5	3.0
	OR	Clatskanie	0	3.0
	WA	Mill/Aber/Ger	0.5	3.0
	OR	Scappoose	1.0	3.0
Cascade Fall	WA	Lower Cowlitz	0.5	2.5
	WA	Upper Cowlitz	0.5	1.0

	WA	Toutle	0.5	3.5
	WA	Coweeman	0.5	3.5
	WA	Kalama	0.5	2.0
	WA	Lewis	4.0	4.0
	WA	Salmon	0.5	0.5
	OR	Clackamas	0	2.0
	OR	Sandy	0	2.0
	WA	Washougal	0.5	3.5
Gorge Fall	WA/OR	Lower Gorge	0.5	2.0
	WA/OR	Upper Gorge	0.5	2.0
	WA	White Salmon	0.5	2.0
	OR	Hood	0	3.0
Cascade Late Fall	WA	NF Lewis	0.5	3.5
	OR	Sandy	3.0	4.0

Notes: Summaries taken directly from Figures 60 and 61, 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.

Table 24 provides recently updated information about the abundance and productivity, spatial structure, diversity, and overall persistence probability for each population within the LCR Chinook Salmon ESU. Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (NMFS 2016j).

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

Abundance and productivity (A/P) ratings for LCR Chinook salmon populations are currently low to very low for most populations, except for spring Chinook salmon in the Sandy River (moderate) and late-fall Chinook salmon in North Fork Lewis River and Sandy Rivers (very high for both) (Table 24) (NMFS 2016j). For some of these populations with low or very low A/P ratings, low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. For tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (NMFS 2016j).

Table 24. LCR Chinook Salmon ESU MPG, ecological sub-regions, run timing, populations, and scores for the key elements (A/P, spatial structure, and diversity) used to determine overall net persistence probability of the population (NMFS 2013e).[1]

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

[1] Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016j).

Figure 10 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for natural populations of LCR Chinook salmon in Oregon

(Ford 2011). The results indicate low to moderate spatial structure risk for most populations, but high diversity risk for all but two populations; the Sandy River bright and spring Chinook salmon populations. The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR Chinook salmon natural populations in Oregon. Risk is characterized as high or very high for all populations except the Sandy River late fall and spring populations (Figure 10). Relative to baseline VSP levels identified in the recovery plan (NMFS 2013e) there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals (NWFSC 2015).

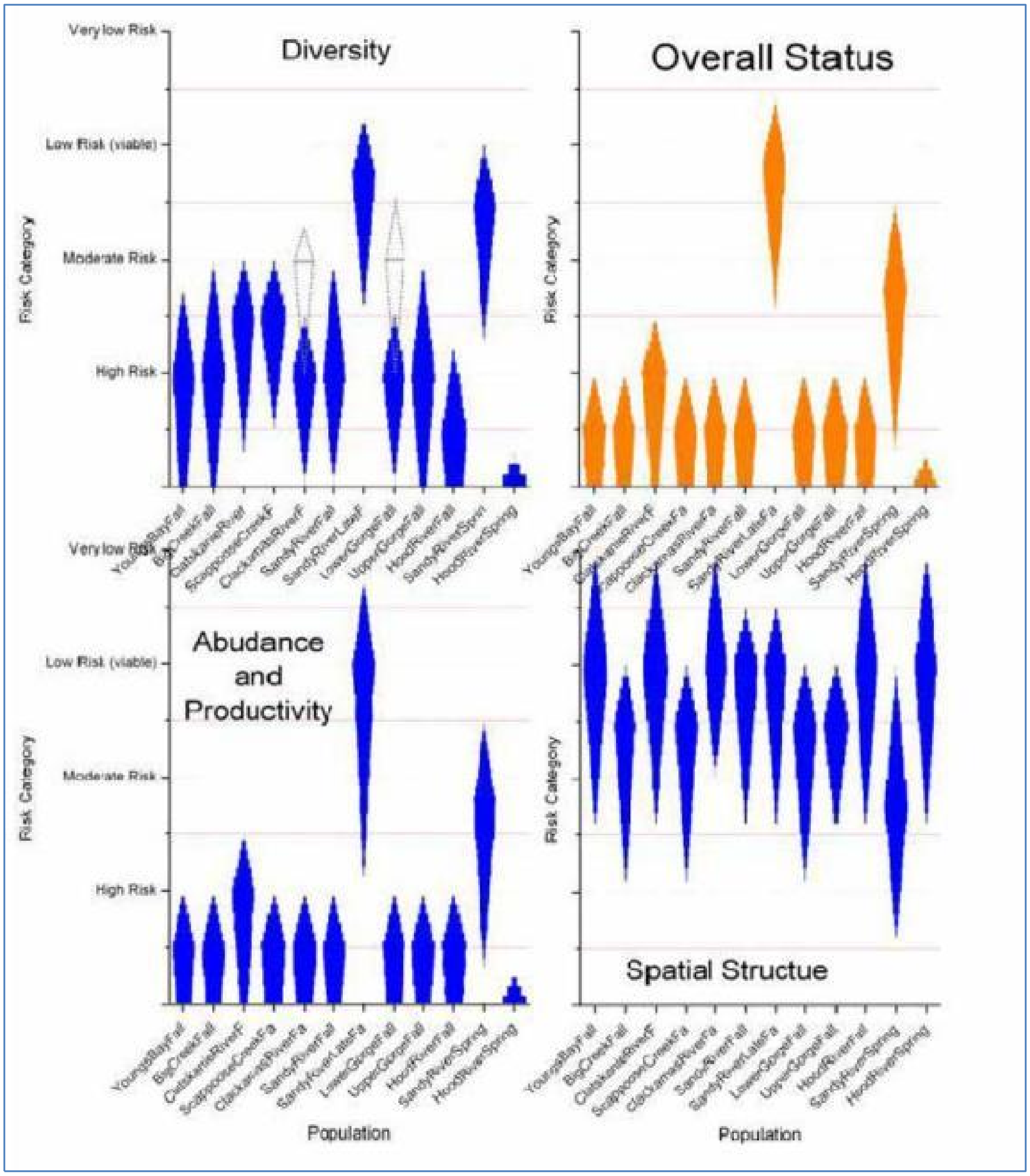


Figure 10. Extinction risk ratings for LCR Chinook salmon natural populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combine the three attributes (Ford 2011).

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

Limiting Factors

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

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

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

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

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

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

Naturally spawning spring Chinook salmon are made up of anywhere from 34% to 90% hatchery-origin fish, depending on the population (LCFRB 2010a, Table 3-8; ODFW 2010a, Table 4-8). Hatchery straying, combined with past stock transfers, has likely altered the genetics of LCR spring Chinook salmon population structure and diversity, and reduced the productivity as a result of this influence. However, high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g. for reintroduction purposes in the Hood, Cowlitz, and Lewis subbasins.

Most fall Chinook salmon currently returning to Lower Columbia tributaries are produced in hatcheries operated to produce fish for harvest. The fish from these programs are not intended to spawn naturally. Hatchery production has been reduced from its peak in the late 1980s but continues to threaten the productivity of LCR fall Chinook salmon natural populations (NMFS 2013e). Out-of-ESU Rogue River bright fall Chinook salmon released into Youngs Bay to support terminal harvest have been recovered in the Grays River, potentially affecting genetics and diversity within the Grays River population. Similar to spring Chinook populations, genetic stock integrity and productivity for fall Chinook salmon in the LCR Chinook Salmon ESU has likely declined as a result of the influence of hatchery-origin fish contributing to natural spawning.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2006a) and the Lower Columbia Fishery Recovery Board (LCFRB 2010a) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty for which not much information currently existed on which to draw conclusions from. ODFW (2010a) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS West Coast Region and Northwest and Southwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

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

On March 24, 1999, NMFS listed the UCR spring-run Chinook Salmon ESU as an endangered species (64 FR 14308). The endangered status was reaffirmed on June 28, 2005 (70 FR 37160) and most recently on April 14, 2014 (70 FR 20816) (Table 9). Critical habitat for the UCR spring-run Chinook salmon was designated on September 2, 2005 (70 FR 2732) (Table 9).

Inside the geographic range of this ESU, eight natural populations within three MPGS have historically comprised the UCR spring-run Chinook Salmon ESU, but the ESU is currently limited to one MPG (North Cascades MPG) and three extant populations (Wenatchee, Entiat, and Methow populations). Six hatchery spring Chinook salmon programs are currently operational, but only four are included in the ESU (Jones Jr. 2015). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c). Table 25 lists the hatchery and natural populations included (or excluded) in the ESU.

Table 25. UCR spring-run Chinook Salmon ESU description and MPG (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Endangered	Listed under ESA in 1999; updated in 2014 (see Table 9)
3 major population groups	8 historical populations
Major Population Group	***Populations***
North Cascades	Wenatchee River, Entiat River, Methow River.
Artificial production	
Hatchery programs included in ESU (4)	Methow, Winthrop NFH, Chiwawa River, White River
Hatchery programs not included in ESU (2)	Nason Creek, Leavenworth NFH

Approximately half of the area that originally produced spring Chinook salmon in this ESU is now blocked by dams. What remains of the ESU includes all naturally spawned fish upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State, excluding the Okanogan River (64 FR 14208, March 24, 1999). Figure 11 shows the map of and specific basins within the current ESU.

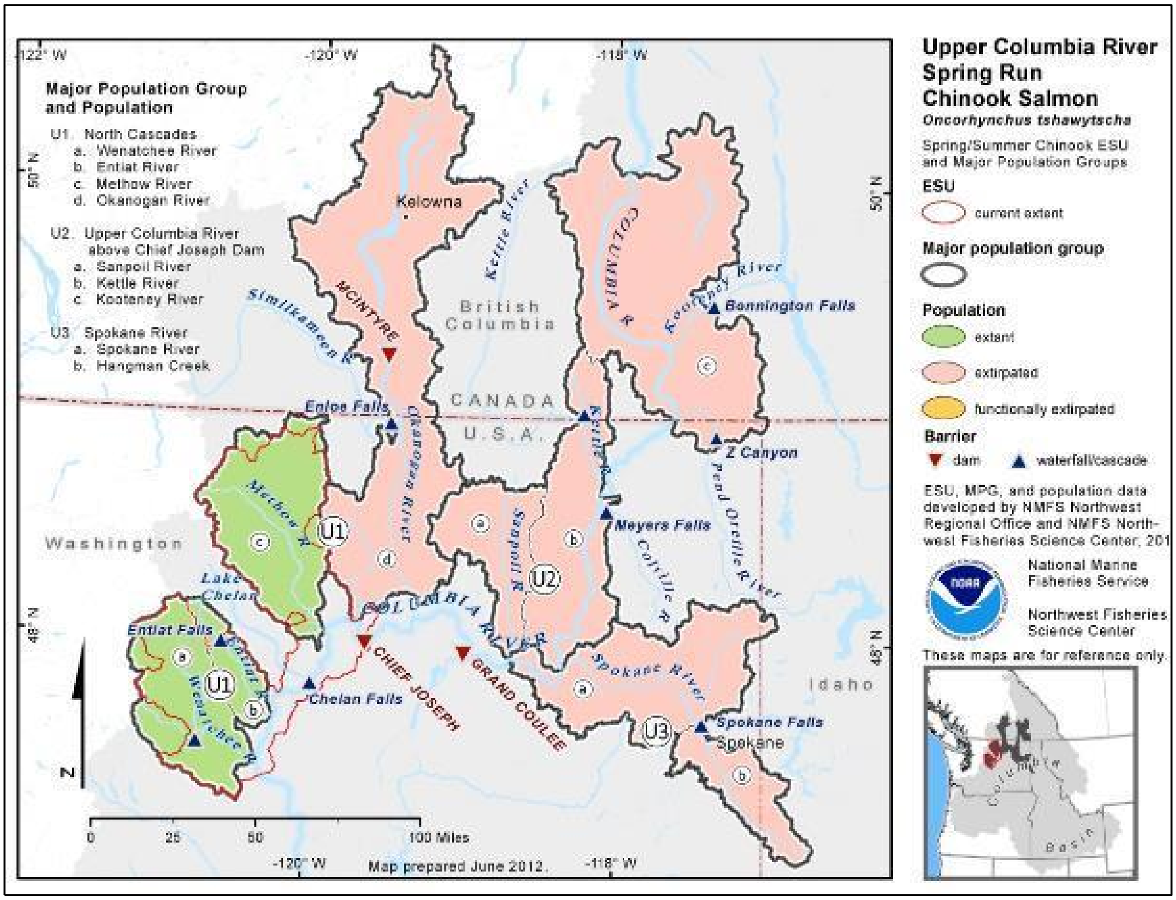


Figure 11. Map of the UCR spring-run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR spring-run Chinook Salmon ESU, is at high risk and remains at endangered status (NWFSC 2015). The ESA Recovery Plan (UCSRB 2007) calls for improvement in each of the three extant spring-run Chinook salmon populations (no more than 5% risk of extinction in 100 years) and for a level of spatial structure and diversity that restores the distribution of natural populations to previously occupied areas and that allows natural patterns of genetic and phenotypic diversity to be expressed. This corresponds to a threshold of at least "viable" status for each of the three natural populations. None of the three populations are viable with respect to abundance and productivity, and they all have a greater than 25 % chance of extinction in 100 years (Figure 12) (UCSRB 2007).

Risk Rating for Spatial Structure/Diversity				
Risk Rating for Abundance/Productivity	Very Low	Low	Moderate	High
Very Low (<1%)	Highly Viable	Highly Viable	Viable	Maintained
Low (1-5%)	Viable	Viable	Viable	Maintained
Moderate (6-25%)	Maintained	Maintained	Maintained	High Risk
High (>25%)	High Risk	High Risk	High Risk	High Risk Wenatchee R. Entiat R. Methow R.

Figure 12. Matrix used to assess natural population status across VSP parameters or attributes for the UCR Spring-Run Chinook Salmon ESU. Percentages for abundance and productivity scores represent the probability of extinction in a 100-year time period (ICTRT 2007; Ford 2011; NMFS 2014c).

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

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

Achieving recovery (i.e., delisting the species) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the Upper Columbia Salmon Recovery Board (UCSRB) Plan. The plan calls for meeting or exceeding the same basic spatial structure and diversity criteria adopted from the ICTRT viability report for recovery (NWFSC 2015).

Table 26. UCR spring-run Chinook Salmon ESU population viability status summary.

Population	**Abundance and productivity metrics**[1]				**Spatial structure and diversity metrics**			**Overall viability rating**
	ICTRT minimum threshold	**Natural Spawning Abundance**	**ICTRT Productivity**	**Integrated A/P Risk**	**Natural Processes Risk**	**Diversity Risk**	**Integrated SS/D Risk**	
Wenatchee River 2005-2014	2,000	545 ⬆ (311-1,030)	0.60 ⬆ (0.27,15/20)	High	Low	High	High	High Risk
Entiat River 2005-2014	500	166 ⬆ (78-354)	0.94 ⬆ (0.18, 12/20)	High	Moderate	High	High	High Risk
Methow River 2005-2014	2,000	379 ⬆ (189-929)	0.46 ○ (0.31, 16/20)	High	Low	High	High	High Risk

[1] Current abundance and productivity estimates are geometric means. The range in annual abundance, standard error, and number of qualifying estimates for production are in parentheses. Upward arrows = current estimates increased from prior review. Oval = no change since prior review (NWFSC 2015).

Overall A/P remains rated at high risk for each of the three extant populations in this MPG/ESU (Table 26) (NWFSC 2015). The 10-year geometric mean abundance of adult natural-origin spawners has increased for each population relative to the levels reported in the 2011 status review, but natural origin escapements remain below the corresponding ICTRT thresholds. The combinations of current abundance and productivity for each population result in a high risk rating when compared to the ICTRT viability curves (NWFSC 2015).

The composite SS/D risks for all three of the extant natural populations in this MPG are rated at high (Table 26). The natural processes component of the SS/D risk is low for the Wenatchee and Methow River populations and moderate for the Entiat River population. All three of the extant populations in this MPG are rated at high risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and a lack of genetic diversity among the natural-origin spawners (ICTRT 2008; NWFSC 2015).

Based on the combined ratings for A/P and SS/D, all three of the extant natural populations of UCR spring-run Chinook salmon remain rated at high overall risk (Table 26, Table 27).

Table 27. Scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for spring-run UCR Chinook salmon (NWFSC 2015)[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) and extirpated (E). Extirpated populations were not evaluated as indicated by the blank cells (NMFS 2016j).

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

The most recent total natural spawner abundance information for UCR spring-run Chinook salmon is provided in Table 28. The proportions of natural-origin contributions to spawning in the Wenatchee and Methow populations have trended downward since 1990, reflecting the large increase in hatchery production and releases and subsequent returns from the directed supplementation program in those two drainages. There is no direct hatchery supplementation program in the Entiat River. The Entiat NFH spring-run Chinook salmon release program was discontinued in 2007, and the upward trend in proportional natural-origin spawners since then can be attributed to that closure. Hatchery supplementation returns from the adjacent Wenatchee River program stray into the Entiat (Ford et al. 2015). The nearby Eastbank Hatchery facility is used for rearing the Wenatchee River supplementation stock prior to transfer to the Chiwawa acclimation pond. It is possible that some of the returns from that program are homing on the Eastbank facility and then straying into the Entiat River, the nearest spawning area (NWFSC 2015).

Table 28. UCR spring-run Chinook salmon total natural spawner (natural- and hatchery-origin fish combined) abundance estimates in UCR tributaries, 1997-2015 (from WDFW SCORE[1])*.

Year	Entiat River	Methow River[2]	Wenatchee River[3]
1997	68	269	189
1998	42	20	140
1999	29	45	121
2000	73	117	489
2001	226	1,832	973
2002	152	345	724
2003	199	58	38
2004	142	488	1,015
2005	129	527	316
2006	79	328	314
2007	206	266	376
2008	95	298	366
2009	180	564	594
2010	334	601	536
2011	381	971	1,152
2012	254	200	935
2013	152	241	692
2014	160	506	978
2015	165	392	686

[1] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook
*Date Accessed: April 19, 2016
[2] Data from 1997-2004 was calculated using different method than data from 2005-2015.
[3] Data from 1997-1999 was calculated using different method than data from 2000-2015.

Limiting Factors

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

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

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

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

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

On June 3, 1992, NMFS listed the Snake River spring/summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399) (Table 9).

The Snake River spring/summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 11 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (Jones Jr. 2015). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c). Table 29 lists the natural and hatchery populations included (or excluded) in the ESU.

Table 29. Snake River Spring/Summer-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014 (see Table 9)
5 major population groups	28 historical populations (4 extant)

Major Population Group	***Populations***
Lower Snake River	Tucannon River
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha
South Fork Salmon River	Secesh, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River
Middle Fork	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon
Artificial production	
Hatchery programs included in ESU (11)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Looking glass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum, Big Sheep Creek-Adult Spr/Sum out planting from Imnaha program, McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring.
Hatchery programs not included in ESU (8)	Dollar Creek Shoshone-Bannock Tribe (SBT) spring, Panther Creek summer, Yankee Fork SBT spring, Rapid River Hatchery spring, Dworshak NFH spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring.

Twenty eight historical populations (4 extirpated) within five MPGs comprise the Snake River spring/summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life history characteristics. Figure 13 shows a map of the current ESU and the MPGs within the ESU.

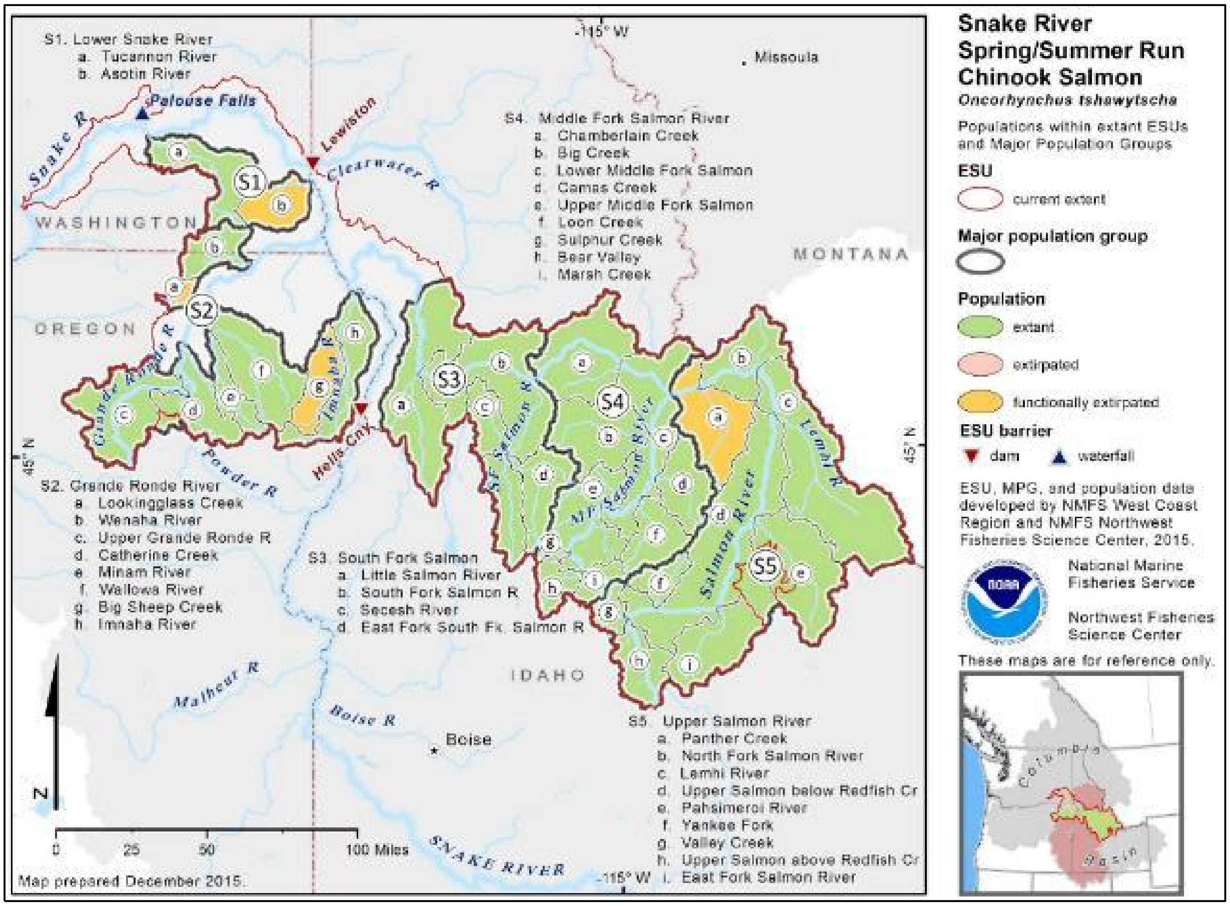


Figure 13. Snake River Spring/Summer-Run Chinook Salmon ESU spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

Chinook salmon have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. The Snake River Spring/Summer Chinook Salmon ESU consists of “stream-type” Chinook salmon, which spend 2 to 3 years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). See Table 14 for a general review of stream-type Chinook salmon. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species (NMFS 2012c).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River spring/summer-run Chinook Salmon ESU, remains at high overall risk, with the exception of one population (Chamberlain Creek in the MF MPG). NMFS has initiated recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries. A tributary recovery plan for one of the major management units, the Lower Snake River tributaries within Washington state boundaries, was developed under the auspices of the Lower Snake River Recovery Board (LSRB) and was accepted by NMFS in 2005. The LSRB Plan provides recovery criteria, targets, and tributary habitat action plans for the two populations of the spring/summer Chinook salmon in the Lower Snake MPG in addition to the populations in the Touchet River (Mid-Columbia Steelhead DPS) and the Washington sections of the Grande Ronde River (NWFSC 2015).

The recovery plans being synthesized and developed by NMFS will incorporate viability criteria recommended by the ICTRT. The ICTRT recovery criteria are hierarchical in nature, with ESU/DPS level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements – abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves (NWFSC 2015). Achieving recovery (i.e., delisting the species) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the recovery plan. Table 30 shows the most recent metrics for the Snake River spring/summer-run Chinook Salmon ESU.

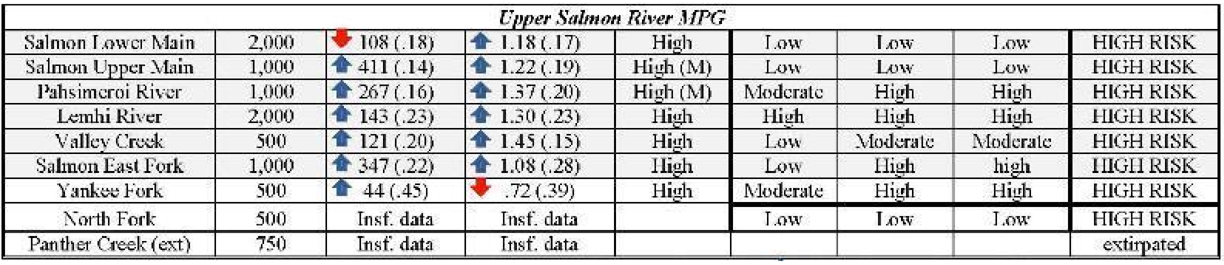
The majority of natural populations in the Snake River spring/summer-run Chinook Salmon ESU remain at high risk overall, with one population (Chamberlain Creek in the MF MPG) improving to an overall rating of maintained due to an increase in abundance (Table 30). Natural-origin abundance has increased over the levels reported in the prior review (Ford 2011) for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. Ten natural populations increased in both abundance and productivity, seven increased in abundance while their updated productivity estimates decreased, and two populations decreased in abundance and increased in productivity. One population, Loon Creek in the MF

MPG, decreased in both abundance and productivity. Overall, all but one population in this ESU remains at high risk for abundance and productivity and there is a considerable range in the relative improvements to life cycle survivals or limiting life stage capacities required to attain viable status. In general, populations within the South Fork grouping had the lowest gaps among MPGs. The other multiple population MPGs each have a range of relative gaps (NWFSC 2015).

Spatial structure ratings remain unchanged or stable with low or moderate risk levels for the majority of the populations in the ESU (Table 31). Four populations from three MPGs (Catherine Creek and Upper Grande Ronde of the Grande Ronde/Imnaha MPG, Lemhi River of the Upper Salmon River MPG MGP, and Lower MF Mainstem of the MF MPG) remain at high risk for spatial structure loss. Three of the four extant MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn – the more natural-origin fish that return the fewer hatchery fish that are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels. Efforts to evaluate key assumptions and impacts are underway for several programs (NWFSC 2015).

Table 30. Measures of viability and overall viability rating for Snake River spring/summer-run Chinook salmon populations[1].

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



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

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

Table 31. Snake River spring/summer-run Chinook salmon ecological subregions, populations, and scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for Snake River spring/summer-run Chinook salmon (Ford 2011).[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH), and extirpated (E). Extirpated populations were not evaluated as indicated by the blank cells (NMFS 2016j).

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

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River spring/summer-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The abundance of spring/summer-run Chinook salmon had already began to decline by the 1950s, and it continued declining through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon total adults (both hatchery and natural combined) returned to the Snake River (NMFS 2012c).

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

NMFS (2012c) determined the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). PCEs for Snake River spring/summer-run Chinook salmon are shown in Table 32.

Table 32. PCEs identified for Snake River spring/summer-run Chinook salmon (NMFS 2012c).

Habitat Component	Primary Constituent Elements (PCEs)
Spawning and juvenile rearing areas	1) spawning gravel 2) water quality 3) water quantity 4) cover/shelter 5) food 6) riparian vegetation 7) space

Juvenile migration corridors	1) substrate 2) water quality 3) water quantity 4) water temperature 5) water velocity 6) cover/shelter 7) food 8) riparian vegetation 9) space 10) safe passage
Areas for growth and development to adulthood	Ocean areas – not identified
Adult migration corridors	1) substrate 2) water quality 3) water quantity 4) water temperature 5) water velocity 6) cover/shelter 7) riparian vegetation 8) space 9) safe passage

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

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

On June 3, 1992, NMFS listed the Snake River fall-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat was designated on December 28, 1993 (58 FR 68543) (Table 9).

The Snake River fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). None of the hatchery programs are excluded from the ESU. As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c). Table 33 lists the natural and hatchery populations included in the ESU.

Table 33. Snake River Fall-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014 (see Table 9)
1 major population groups	2 historical populations (1 extirpated)

Major Population Group	*Population*
Snake River	Lower Mainstem Fall-Run
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry NFH fall, Acclimation Ponds Program fall, Nez Perce Tribal Hatchery fall, Idaho Power fall.
Hatchery programs not included in ESU (0)	n/a

Two historical populations (1 extirpated) within one MPG comprise the Snake River fall-run Chinook Salmon ESU. The extant natural population spawns and rears in the mainstem Snake River and its tributaries below Hells Canyon Dam. Figure 14 shows a map of the ESU area. The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901 and the Hells Canyon Complex from 1958 to 1967, which extirpated one of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River fall-run Chinook salmon since the 1980s (NMFS 2012c). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total exploitation rate has been relatively stable in the range of 40% to 50% since the mid-1990s (NWFSC 2015).

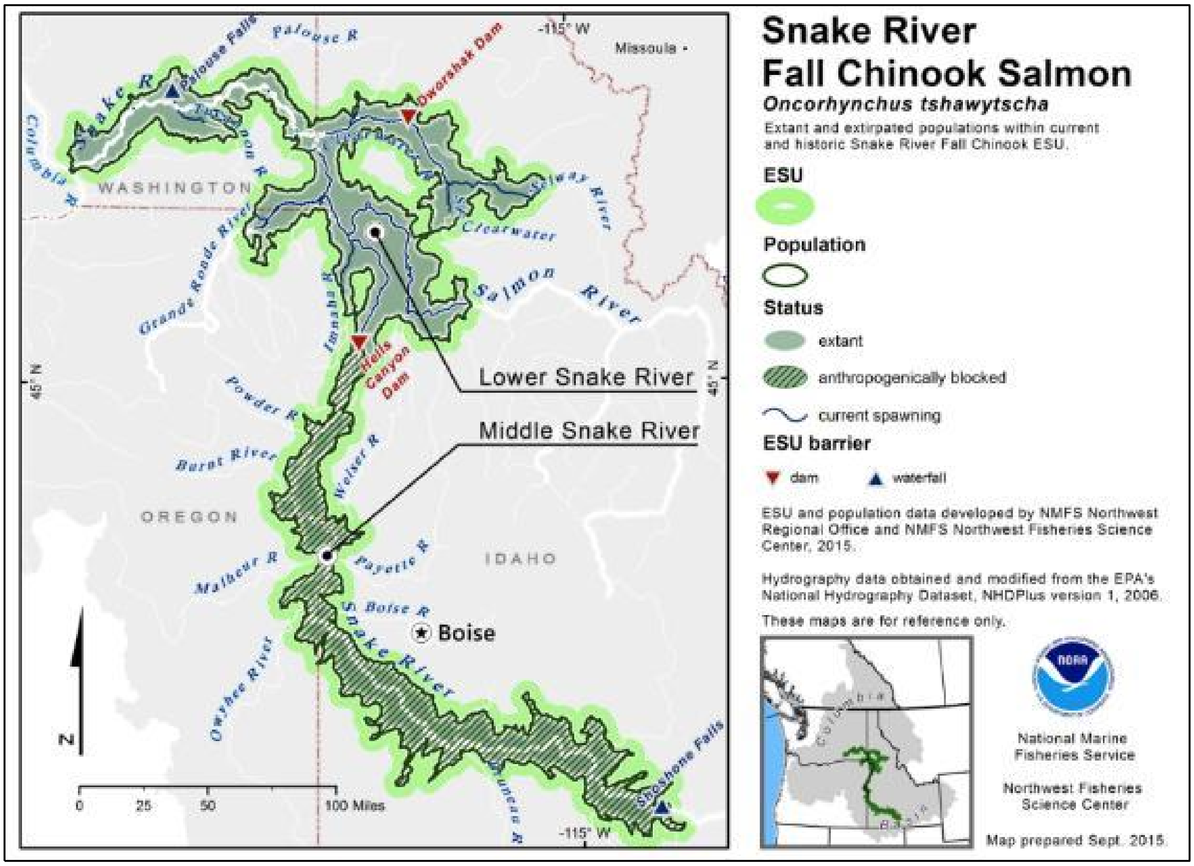


Figure 14. Map of the Snake River Fall-Run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

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

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

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

Spawner abundance, productivity, and proportion of natural-origin fish abundance estimates for the Lower Mainstem Snake River population are based on counts and sampling at Lower Granite Dam. Separate estimates of the numbers of adult (age 4 and older) and jack (age 3) fall Chinook salmon passing over Lower Granite Dam are derived using ladder counts and the results of sampling a portion of each year's run using a trap associated with the ladder. A portion of the fish sampled at the trap are retained and used as hatchery broodstock. The data from trap sampling, including the coded-wire tag (CWT) recovery results, passive integrated transponder (PIT) tag detections, and the incidence of fish with adipose-fin clips, are used to construct daily estimates of hatchery proportions in the run (NWFSC 2015).

At present, estimates of natural-origin returns are made by subtracting estimated hatchery-origin returns from the total run estimates (Young et al. 2012). In the near future, returns from a Parental Based Genetic Tagging (PBT)[11] program will allow for a comprehensive assessment of hatchery contributions and, therefore, a more direct assessment of natural returns and ESU abundance risk (NWFSC 2015).

Sampling methods and statistical procedures used in generating the estimated escapements have improved substantially over the past 10 to 15 years. Beginning with the 2005 return, estimates are available for the total run apportioned into natural and hatchery returns by age (and hatchery-origin) with standard errors and confidence limits (e.g., Young et al. 2012). Current estimates of escapement over Lower Granite Dam for return years prior to 2005 were also based on adult dam counts and trap sampling (Table 34). In recent years, naturally spawning fall-run Chinook salmon in the lower Snake River have included both returns originating from naturally spawning parents and from returning hatchery releases (NWFSC 2015). Hatchery-origin fall-run Chinook salmon escaping upstream above Lower Granite Dam to spawn naturally are now predominantly returns from hatchery supplementation program juvenile releases in reaches above Lower Granite Dam and from releases at LFH that have dispersed upstream.

Table 34. Escapement data for Snake River fall-run Chinook natural-origin salmon returning to LGR, from 2000-2015 (TAC 2015).

Year	LGR Count
2000	1,148
2001	5,163
2002	2,116
2003	4,257
2004	3,329
2005	5,177
2006	4,669
2007	3,742

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

2008	3,937
2009	4,653
2010	7,302
2011	8,370
2012	12,753
2013	20,807
2014	14,255
2015	16,102

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

The recently released Proposed NMFS Snake River Fall Chinook Recovery Plan (NMFS 2015c) proposes that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River fall-run Chinook salmon population; the recovery plan notes that such scenario could be possible if major spawning areas supporting the bulk of natural returns are operating consistent with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning, i.e., low hatchery influence for at least one major natural spawning production area. According to the most recent information available (i.e., escapements through 2014), there is no indication of a strong differential distribution of hatchery returns among major spawning areas, given the widespread distribution of hatchery releases and the lack of direct sampling of reach-specific spawner compositions.

In terms of spatial structure and diversity, the Lower Mainstem Snake River fall-run Chinook salmon population was rated at low risk for Goal A (allowing natural rates and levels of spatially mediated processes) and moderate risk for Goal B (maintaining natural levels of variation) in the status review update (NWFSC 2015), resulting in an overall spatial structure and diversity rating of moderate risk (Table 35). The moderate risk rating was driven by changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns. In addition, risk associated with indirect factors (e.g., the high levels of hatchery spawners in natural spawning areas, the potential for selective pressure imposed by current hydropower operations, and cumulative harvest impacts) contribute to the current rating level.

The overall current risk rating for the Lower Mainstem Snake River fall Chinook salmon population is viable (Table 35). The single population delisting options provided in the draft Snake River Fall Chinook Recovery Plan would require the population to meet or exceed minimum requirements for Highly Viable (green shaded combinations) with a high degree of certainty.

The current rating described above is based on evaluating current status against the criteria for the aggregate population. The overall risk rating is based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity. For abundance/productivity, the rating reflects remaining uncertainty that current increases in abundance can be sustained over the long run. The geometric mean natural-origin fish abundance obtained from the most recent 10 years of annual spawner escapement estimates (2005-2014) is 6,418 fish. The most recent status review used the ICTRT simple 20-year recruits per spawner (R/S) method to estimate the current productivity for this population (1990-2009 brood years) and determined it was 1.5. Given remaining uncertainty and the current level of variability, the point estimate of current productivity would need to meet or exceed 1.70, which is the present potential metric for the population to be rated at very low risk. While natural-origin spawning levels are above the minimum abundance threshold of 4,200, and estimated productivity is also high, neither measure is high enough to achieve the very low risk rating necessary to buffer against significant remaining uncertainty (NWFSC 2015).

Table 35. Lower Mainstem Snake River fall Chinook salmon population risk ratings integrated across the four viable salmonid population (VSP) metrics.[1]

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

[1] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk; Green shaded cells- meets criteria for Highly Viable; Gray shaded cells- does not meet viability criteria (darkest cells are at greatest risk) (NWFSC 2015).

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

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

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River fall-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2012c).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River fall-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2012c).

The draft recovery plan (NMFS 2015c) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Section 3.3 of the plan provides criteria for addressing the underlying causes of decline. Furthermore, Section B.4. of the plan (NMFS 2015c) describes the changes in current impacts on Snake River fall Chinook salmon. These changes include:

- Hydropower systems,
- Juvenile migration timing,
- Adult migration timing,

- Harvest,
- Age-at-return,
- Selection caused by non-random removals of fish for hatchery broodstock, and
- Habitat.

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

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

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

On March 24, 1999, NMFS listed the UWR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat was designated on June 28, 2005 (70 FR 37160) (Table 9).

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 15). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c). The ESU contains seven historical populations, within a single MPG (western Cascade Range, Table 36).

Table 36. UWR Chinook Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2016j).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014 (see Table 9)
1 major population group	7 historical populations
Major Population Group	***Populations***
Western Cascade Range	Clackamas River, Molalla River, North Santiam River, South Santiam River, Calapooia River, McKenzie River, MF Willamette River
Artificial production	
Hatchery programs included in ESU (6)	McKenzie River spring, North Santiam spring, Molalla spring, South Santiam spring, MF Willamette spring, Clackamas spring
Hatchery programs not included in ESU (0)	n/a

UWR Chinook salmon's genetics have been shown to be strongly differentiated from nearby populations, and are considered one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin (Waples et al. 2004; Beacham et al. 2006). For adult Chinook salmon, Willamette Falls historically acted as an intermittent physical barrier to upstream migration into the UWR basin, where adult fish could only ascend the falls at high spring flows. It has been proposed that the falls 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 salmon from reaching the UWR basin (NMFS and ODFW 2011).

The generalized life history traits of UWR Chinook are summarized in Table 37. Today, adult UWR Chinook salmon begin appearing in the lower Willamette River in January, with fish entering the Clackamas River as early as March. The majority of the run ascends Willamette Falls from late April through May, with the run extending into mid-August (Myers et al. 2006).

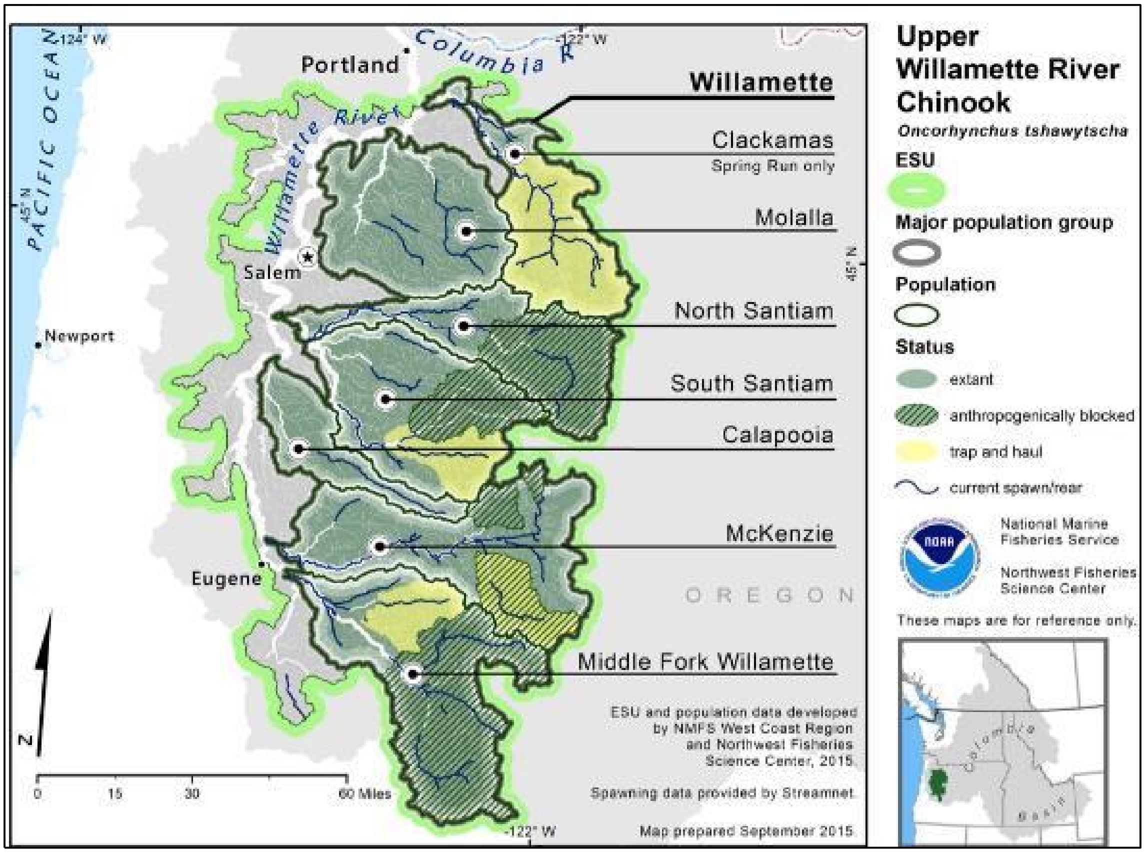

Figure 15. Map of the UWR Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

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 37. A summary of the general life history characteristics and timing of UWR Chinook salmon[1].

Life-History Trait	**Characteristic**
Willamette River entry timing	January-April; ascending Willamette Falls April-August
Spawn timing	August-October, peaking in September
Spawning habitat type	Larger headwater streams
Emergence timing	December-March
Rearing habitat	Rears in larger tributaries and mainstem Willamette
Duration in freshwater	12-14 months; rarely 2-5 months
Estuarine use	Days to several weeks
Life history type	Stream
Ocean migration	Predominately north, as far as southeast Alaska
Age at return	3-6 years, primarily 4-5 years

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

Abundance, Productivity, Spatial Structure, and Diversity

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

According to the most recent status review (NWFSC 2015), abundance levels for five of the seven natural populations in this ESU remain well below their recovery goals. Of these, the Calapooia River population may be functionally extinct, and the Molalla River population remains critically low (although perhaps only marginally better than the 0 VSP score estimated in the Recovery Plan). Abundances, in terms of adult returns, in the North and South Santiam Rivers have risen since the last review (Ford 2011), but still range only in the high hundreds of fish. Improvements in the status of the MF Willamette River population relates solely to the return of natural-origin adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the MF Willamette River individual population. The status review incorporates valuable information from the Fall Creek program that is relevant to the use of reservoir drawdowns as a method of juvenile downstream passage. The proportion of natural-origin spawners has improved in the North and South Santiam Basins, but is still below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production there. Additionally, the Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but both individual populations have experienced declines in abundance[12] (NWFSC 2015).

All seven historical natural populations of UWR Chinook salmon identified by the WLC-TRT occur within the Action Area and are contained within a single ecological subregion, the Western Cascade Range (Table 38).

Table 38. 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 (NMFS 2016j).

The Clackamas and McKenzie River populations had the best overall risk ratings within the ESU for A/P, spatial structure, and diversity, as of 2016. Data collected since the BRT status update in 2005 highlight the substantial risks associated with pre-spawning mortality. A recovery plan was finalized for this species on August 5, 2011 (NMFS and ODFW 2011). Although recovery

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[12] 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.

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 2016j). Furthermore, limited data are available for natural-origin spawner abundance for UWR Chinook salmon populations. Table 39 includes the most up-to-date available data for NOR Chinook salmon spawner estimates from UWR subbasins. The McKenzie subbasin has the largest amounts of NOR Chinook salmon spawners compared to the other surveyed subbasins.

Table 39. Estimated number of natural-origin spring Chinook salmon spawners in surveyed subbasins of the UWR from 2005 through 2015 (ODFW 2015b)[1].

Run Year	North Santiam	South Santiam	McKenzie	Middle Fork Willamette
2005	247	268	2,135	139
2006	201	209	2,049	664
2007	309	245	2,562	69
2008	412	323	1,387	368
2009	358	913	1,193	110
2010	292	376	1,266	189
2011	553	756	2,511	181
2012	348	544	1,769	175
2013	405	631	1,202	59
2014	566	886	1,031	90
2015	431	629	1,571	139

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

Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. The overview above for UWR Chinook salmon populations suggests that there has been relatively little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk (Table 40) (NWFSC 2015).

Table 40. Summary of VSP scores and recovery goals for UWR Chinook salmon populations (NWFSC 2015).

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

Limiting Factors

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

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, dams that block access to major production areas, loss and degradation of accessible spawning and rearing habitat, and degraded water quality and increased water temperatures; together, these factors have affected the populations of this ESU (NMFS 2016j).

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

Additionally, (NMFS 2016j) outlines additional limiting factors for the UWR Chinook Salmon ESU which include:

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

Although there has likely been an overall decrease in population VSP scores since the last review, the magnitude of this change in not sufficient to suggest a change in risk category for the ESU. Given current climatic conditions and the prospect of long-term climatic change, the inability of many populations to access historical headwater spawning and rearing areas may put this ESU at greater risk in the near future (NWFSC 2015).

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

On June 28, 2005, NMFS listed the listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014 (Table 9). Critical Habitat was originally proposed January 14, 2013 (Table 9) and was finalized on January 24, 2016 (81 FR 9252).

Inside the geographic range of the ESU, 24 hatchery coho salmon programs are currently operational (Table 41). Up through 2008, 25 hatchery programs produced coho salmon considered to be part of the ESU. As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c). In 2009, the Elochoman Type-S and Type-N programs were discontinued. In 2011, NMFS recommended that these two programs be removed from the ESU (Jones Jr. 2011). Table 41 lists the 23 hatchery programs currently included in the ESU and the one excluded program (Jones Jr. 2011). LCR coho salmon are primarily limited to the tributaries downstream of Bonneville Dam (Figure 16). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160).

Table 41. LCR Coho Salmon ESU description and MPGs (Jones Jr. 2011; NMFS 2013e).[13]

ESU Description	
Threatened	Listed under ESA in 2005; updated in 2014 (see Table 9)
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,

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

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

Twenty four historical populations within three MPGs comprise the LCR Coho Salmon ESU with generally low baseline persistence probabilities (Table 42). 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 16).

Table 42. Current status for LCR coho salmon populations and recommended status under the recovery scenario (NMFS 2013e).

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

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

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

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

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

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

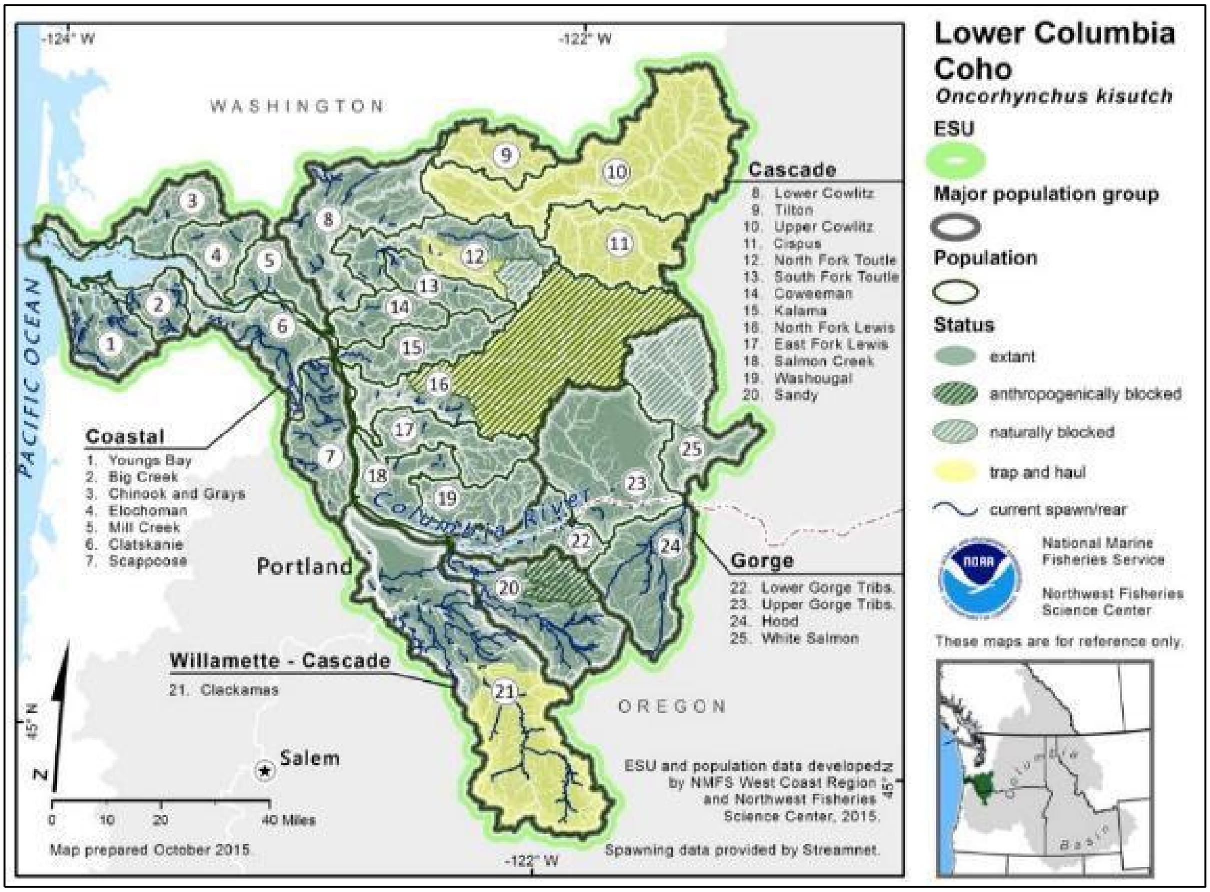

Figure 16. Map of the LCR Coho Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

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 fresh water entry. Fresh water entry timing for this ESU is also associated with ocean migration patterns (Table 43) 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 2013e). In general, early returning fish (Type-S) spawn further upstream than later migrating fish (Type-N), although Type-N fish enter rivers in a more advanced state of sexual maturity (Sandercock 1991).

Table 43. Life-History and population characteristics of LCR coho salmon.

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

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

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Coho Salmon ESU, is at high risk and remains at threatened status. Each population's baseline and target persistence probabilities are summarized in Table 42, along with target abundance for each population that would be consistent with delisting the species. Persistence probability is measured over a 100 year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

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

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

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

Hatchery production dominates the Washington side of this ESU and no populations are thought to be naturally self-sustaining because the majority of spawners are believed to be hatchery strays. Washington did not collect adult escapement estimates until recently. The state's monitoring strategy has instead relied primarily on a smolt monitoring program. Similar to the Washington populations, natural productivity on the Oregon side of the LCR Coho Salmon ESU is also believed to have decreased due to legacy effects of hatchery fish. While total hatchery production has been reduced from a peak in the 1980s most populations are still believed to have very low abundance of natural-origin spawners (NMFS 2013e; NWFSC 2015)[14].

In general, hatchery-origin fish comprise the large majority of LCR coho salmon annual adult returns (Table 44 and Table 45). Numbers can vary substantially from year-to-year because coho salmon encounter and are affected by the widely-varying conditions for marine survival related to environmental conditions particularly in the coastal upwelling zone. Until recently, no population was thought to be naturally self-sustaining, with the majority of spawners believed to be hatchery strays. Moreover, it is likely that hatchery effects have also decreased population productivity. New and added hatchery releases of coho salmon in areas upstream of the LCR may be impacting LCR coho salmon through straying, competition, and predation in the lower mainstem and estuary.

Information that has recently become available indicates that hatchery fish straying onto natural spawning grounds is actually quite low for several natural coho salmon populations, which are thought to be self-sustaining. Table 44 presents escapement of LCR coho salmon in selected Oregon tributaries (2002- 2015). Table 45 presents escapement of LCR coho salmon in selected Washington tributaries (2002 - 2015). New information about escapement of LCR coho salmon in Oregon and Washington that was not available in prior status reviews (Table 44 and Table 45) suggests that there has been an increase in the wild fraction of natural-origin coho salmon in their relative abundances. Additionally, hatchery-fish straying into Oregon populations within the LCR Coho Salmon ESU has decreased while pockets of natural production, such as with the Scappoose and Clackamas populations, are also now increasing in their contribution to the overall Oregon coho salmon abundance.

Table 44 and Table 45 provide estimates of escapement for tributaries on the Oregon and Washington sides of the lower Gorge population, respectively. It is unclear how comprehensive the surveys are or if the estimates are intended to be expanded estimates for the population as a whole. On the Washington side, the estimates are characterized as cumulative fish per mile index counts. This information, although limited, indicates there are several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are actually relatively low.

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

Table 44. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS[1]) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015 (http://www.odfwrecoverytracker.org/)*.

Major Population Group	Oregon Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Youngs Bay	Natural	411	113	149	79	74	21	82	26	68	161	129	-	-	-
		pHOS	86%	86%	86%	75%	84%	40%	22%	92%	61%	66%	46%	-	-	-
	Big Creek	Natural	98	435	112	219	225	212	360	792	279	160	409	-	-	-
		pHOS	90%	40%	70%	36%	50%	15%	54%	30%	52%	21%	18%	-	-	-
	Clatskanie[2]	Natural	167	563	398	494	421	927	995	1,195	1,686	1,546	619	611	3,246	240
		pHOS	22%	0%	0%	1%	10%	4%	0%	1%	3%	1%	11%	11%	4%	4%
	Scappoose	Natural	502	336	755	348	719	375	292	778	1,960	298	210	979	1,587	487
		pHOS	0%	10%	8%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cascade	Clackamas	Natural	1,981	2,507	2,874	1,301	3,464	3,608	1,694	7,982	1,757	2,254	1,580	3,202	10,670	1,784
		pHOS	57%	10%	16%	28%	76%	14%	45%	27%	57%	10%	10%	2%	14%	11%
	Sandy	Natural	382	1,348	1,213	856	923	687	1,277	1,493	901	3,494	1,165	667	5,942	443
		pHOS	57%	0%	9%	0%	-	9%	0%	10%	12%	8%	3%	12%	3%	5%
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%

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

*Date accessed: April 13, 2016.

[2] Data from ODFW (2016e)

Table 45. 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
Coast	Gray's/Chinook	Natural	-	-	-	-	-	-	-	-	388	152	795	1,212	3,700	86
		pHOS	-	-	-	-	-	-	-	-	81%	97%	22%	65%	32%	80%
	Eloch/ Skam	Natural	-	-	-	-	-	-	-	-	834	851	505	721	4,158	168
		pHOS	-	-	-	-	-	-	-	-	73%	56%	29%	43%	34%	50%
	Mill Creek	Natural	-	-	-	-	-	-	-	-	859	576	207	-	932	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Abernathy	Natural	-	-	-	-	-	-	-	-	490	183	256	-	832	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Germany	Natural	-	-	-	-	-	-	-	-	322	48	122	-	475	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
Cascade	Lower Cowlitz	Natural	-	-	-	-	-	-	-	-	6,274	3,394	-	-	12,661	5,132
		pHOS	-	-	-	-	-	-	-	-	15%	8%	-	-	5%	8%
	Upper Cowlitz/Cispus	Natural	54,188	20,695	28,665	22,329	25,574	5,691	13,805	16,162	18,905	7,326	2,397	7,941	25,147	-
		pHOS	13%	28%	14%	21%	18%	40%	26%	26%	13%	51%	40%	0%	22%	-
	Tilton	Natural	1,732	601	722	1,332	738	827	1,006	1,305	929	2,025	1,301	2,744	9,074	-
		pHOS	91%	92%	95%	85%	69%	66%	64%	70%	80%	75%	79%	67%	39%	-
	SF Toutle	Natural	-	-	-	-	-	-	-	-	1,518	490	2,063	-	10,960	1,537
		pHOS	-	-	-	-	-	-	-	-	21%	22%	14%	-	19%	53%
	NF Toutle[2]	Natural	-	-	-	-	-	-	-	-	1,454	365	1,425	-	6,597	868
		pHOS	-	-	-	-	-	-	-	-	60%	30%	24%	-	32%	65%
	Coweeman	Natural	-	-	-	-	-	-	-	-	3,528	2,436	2,964	4,047	5,021	767
		pHOS	-	-	-	-	-	-	-	-	10%	6%	5%	-	17%	25%
	Kalama	Natural	-	-	-	-	-	-	-	-	5	-	69	64	99	18
		pHOS	-	-	-	-	-	-	-	-	99%	-	78%	-	91%	90%
	NF Lewis[3]	Natural	-	-	-	-	-	-	-	-	700	604	827	-	0	45
		pHOS	-	-	-	-	-	-	-	-	1%	3%	11%	-	100%	75%
	EF Lewis	Natural	-	-	-	-	-	-	-	-	1,363	1,025	3,681	-	2,531	389

		pHOS	-	-	-	-	-	-	-	-	32%	6%	9%	-	20%	17%
	Salmon Creek	Natural	-	-	-	-	-	-	-	-	-	1,248	1,897	-	4,257	1,348
		pHOS	-	-	-	-	-	-	-	-	-	20%	22%	-	0%	0%
	Washougal	Natural	-	-	-	-	-	-	-	-	795	562	531	-	737	101
		pHOS	-	-	-	-	-	-	-	-	44%	8%	13%	-	65%	67%
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%

[1] For example, Mill Creek in 2010 had 859 natural-origin spawners and 12 % hatchery spawners. To calculate hatchery-origin numbers multiply (859/(1-.12))-859 = 117 hatchery-origin spawners.

[2] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Green River (NF Toutle) coho salmon, the North Fork Toutle River coho salmon, and trap count data.

[3] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Cedar Creek (NF Lewis) coho salmon and the North Fork Lewis River Mainstem coho salmon.

* Date accessed: April 13, 2016

Natural-origin smolt production in some Washington populations occurs within streams that have a substantial amount of hatchery-origin strays, while others occur in streams where hatchery straying is believed to be relatively limited. Information gathered over the last several years suggests there is more natural-origin smolt production than previously thought (Table 46).

Table 46. Most recent estimated smolt production from monitored coho salmon streams in the LCR Coho Salmon ESU (TAC 2008); WDFW wild coho salmon forecast reports for Puget Sound, Washington Coast, and LCR available at: http://wdfw.wa.gov/conservation/research/projects/wild_coho.

Out-migrant Year	Mill	Abernathy	Germany	Grays	Tilton	Upper Cowlitz	Coweeman	Cedar[1]
1997	--	--	--	--	700	3,700	--	--
1998	--	--	--	--	16,700	110,000	--	38,400
1999	--	--	--	--	9,700	15,100	--	28,000
2000	--	--	--	--	23,500	106,900	--	20,300
2001	6,300	6,500	8,200	--	82,200	334,700	--	24,200
2002	8,200	5,400	4,300	---	11,900	166,800	--	35,000
2003	10,500	9,600	6,200	--	38,900	403,600	--	36,700
2004	5,700	6,400	5,100	--	36,100	396,200	--	37,000
2005	--	--	--	--	40,900	766,100	--	58,300
2006	6,700	4,400	2,300	--	33,600	370,000	--	46,000
2007	6,665	4,410	2,327	--	33,650	370,100	7,995	38,450
2008	7,044	3,282	2,342	--	34,190	277,400	8,784	29,340
2009	9,097	5,077	3,976	4,453	36,240	113,000	12,170	36,340
2010	6,283	3,761	2,576	2,377	40,640	123,800	12,290	61,140
2011	11,230	3,375	1,240	4,051	53,350	216,200	21,640	43,940
2012	8,563	5,520	3,535	2,182	55,950	33,739	23,261	60,778

[1] Lewis River tributary

Currently, it is impossible to determine whether the juveniles are produced by naturally spawning hatchery-origin fish or natural-origin spawners, and whether these populations would be naturally self-sustaining in the absence of hatchery-origin spawners. WDFW suggests that a substantial number of natural-origin spawners may return to the LCR each year, but are not observed because, until recently, there was no monitoring for coho salmon spawners for the Washington populations. Adult escapement data for Washington populations between 2010 and 2012 confirms that natural-origin spawners return to populations in the Coast MPG of the LCR Coho Salmon ESU (Table 46).

Any changes from the previous status review in VSP score for coho salmon populations in Table 47 reflect improvements in abundance, spatial structure, and diversity, as well as in monitoring (NWFSC 2015). Table 48 shows an overall summary of the abundance, productivity, spatial structure, and diversity ratings for each natural population within this ESU. Previous status reviews lacked adequate quantitative data on abundance and hatchery contribution for a number of populations whereas recent surveys provide a more accurate understanding of the status of these populations. However, with only two or three years of data, it is not possible to determine whether there has been a true improvement in status, though it is evident that the contribution of natural-origin fish is much higher than previously thought (NWFSC 2015).

Table 47. Summary of VSP scores and recovery goals for LCR Coho salmon populations (NWFSC 2015).

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

Notes: Summaries taken directly from Figure 69 in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

Table 48. LCR Coho Salmon ESU populations and scores for the key elements (A/P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013e)[1].

Ecological Subregions	Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Coast Range	Youngs Bay (OR)	VL	VH	VL	VL
	Grays/Chinook rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L

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

[1] Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016j).

Figure 17 displays the extinction risk ratings for all four VSP parameters for Oregon natural populations (ODFW 2010a). This figure was updated in 2010 using data available through 2008. The results indicate low to moderate extinction risk for spatial structure for most LCR coho salmon populations in Oregon, but high risk for diversity for all but two populations (the Sandy and Clackamas River populations). The assessments of spatial structure are combined with those of abundance and productivity to give an assessment of the overall status of LCR populations in Oregon. Extinction risk is rated as high or very high in overall status for all populations except the Scappoose and Clackamas river populations (Figure 17). In Figure 17 where updated ratings differ from those of McElhany et al. (2007) assessment the older rating is shown as an open diamond with a dashed outline (ODFW 2010a).

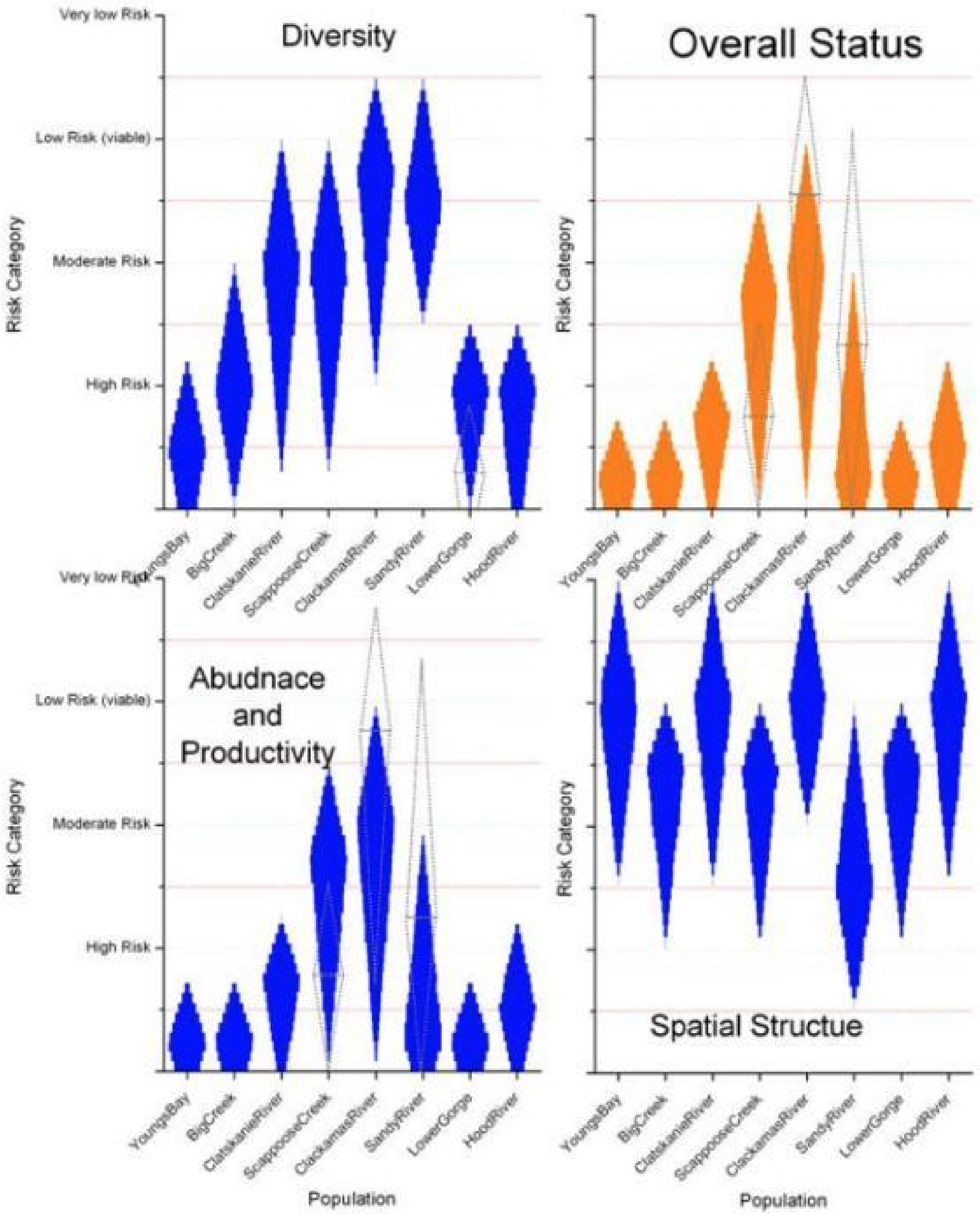

Figure 17. Extinction risk ratings for LCR coho salmon populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as an overall rating for populations that combines the three attribute ratings (adapted from McElhany et al. 2007).

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

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

Limiting Factors

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

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

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

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

- Ecological interactions,
- Climate change, and

- Human population growth.

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

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

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

2.2.1.8 Life-History and Status of the 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 9). 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 49 lists these hatchery programs, with three included in the ESU and one excluded from the ESU. As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

Table 49. 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 2013e).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014 (see Table 9)
3 major population groups	17 historical populations
Major Population Group	***Populations***
Coast	Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamokawa (C), Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Cowlitz-fall (C), Cowlitz-summer (C), Kalama, Lewis (C), Salmon Creek, Clackamas (C), Sandy, Washougal
Gorge	Lower Gorge (C,G), Upper Gorge[1]
Artificial production	
Hatchery programs included in ESU (3)	Chinook River/Sea Resources Hatchery, Grays River, Washougal Hatchery/Duncan Creek
Hatchery programs not included in ESU (1)	Big Creek Hatchery

[1]Includes White Salmon population.

The ESU includes all naturally spawning populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, along with the hatchery chum salmon described in Table 49. This ESU is comprised of three MPGs that has 17 natural populations (Table 50). 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 18).

Table 50. Current status for CR chum salmon populations and recommended status under the recovery scenario (NMFS 2013e).

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

	Clackamas (OR)	VL	Contributing	M	500
	Sandy (OR)	VL	Primary	H	1,000
	Washougal (WA)	VL	Primary	H+	1,300
Gorge	Lower Gorge (WA/OR)	H	Primary	VH	2,000
	Upper Gorge (WA/OR)	VL	Contributing	M	900

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

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

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

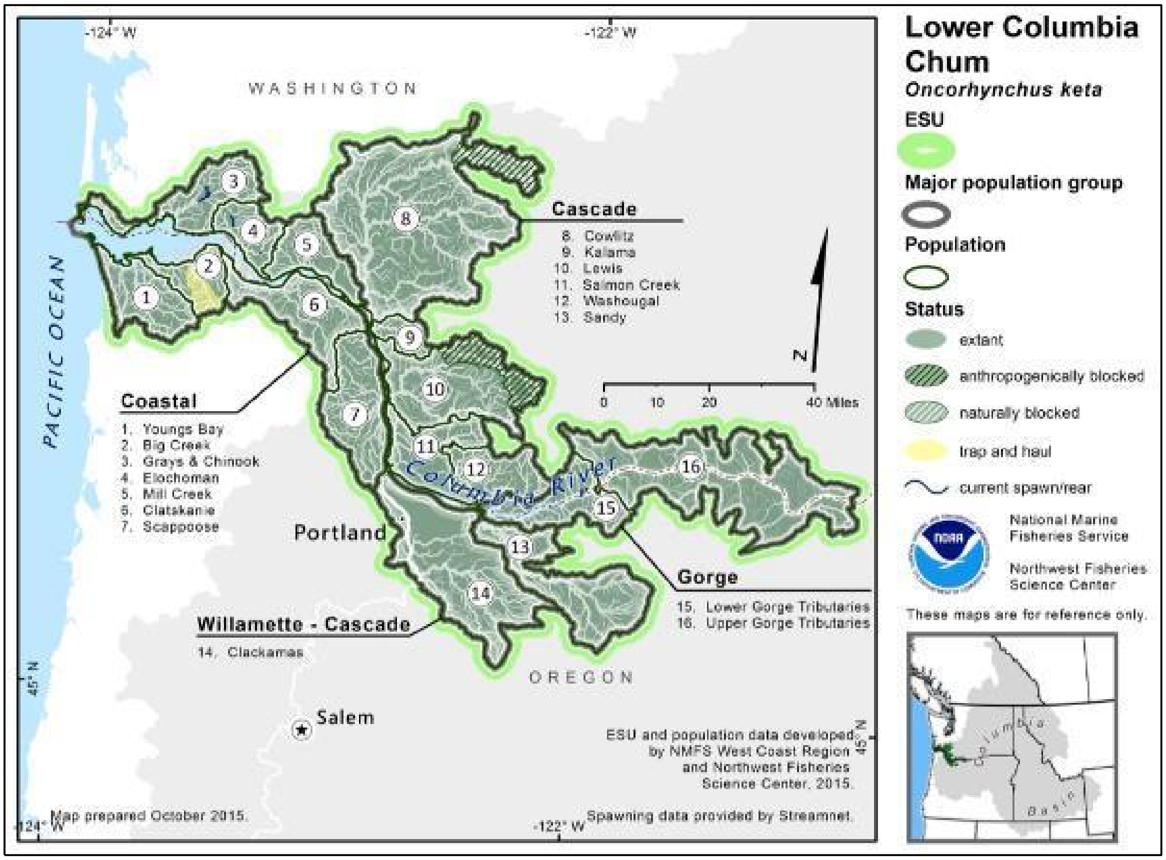

Figure 18. Map of the CR Chum Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

CR 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 50). 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 2010b), 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 2010b). Their small size at emigration is thought to make chum salmon more susceptible to predation mortality during this life stage (LCFRB 2010b).

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 2013f). Chum and ocean-type Chinook salmon usually spend more time in estuaries than do other anadromous salmonids—weeks or months, rather than days or weeks (NMFS 2013f). Shallow, protected habitats, such as salt marshes, tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon during estuarine residency (LCFRB 2010b).

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the CR Chum Salmon ESU, is at high risk and remains at threatened status. Each CR chum salmon natural population baseline and target persistence probability is summarized in Table 50 along with target abundance for each population that would be consistent with delisting criteria. Persistence probability is measured over a 100 year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

Over the last century, CR chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year (NMFS 2013e). Of the 17 natural populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low, extirpated, or nearly so (Ford 2011; NMFS 2013e; NWFSC 2015). The Grays River and Lower Gorge populations showed a sharp increase in 2002 for several years, but have since declined back to relatively low abundance levels in the range of variation observed over the last several decades. The abundance targets in Table 50 for Oregon populations are minimum abundance thresholds (MATs) because Oregon lacked sufficient data to quantify abundance targets. MATs are a relationship between abundance, productivity, and extinction risk based on specific assumptions about productivity; more information about MATs can be found in McElhany et al. (2006).

Currently almost all natural production occurs in just two populations: the Grays/Chinook Rivers and the Lower Gorge area. The most recent total abundance information for CR chum salmon in Washington is provided in Table 51, including chum salmon counted passing Bonneville Dam.

For the other Washington populations not listed in Table 51 and all Oregon populations there are only occasional reports of a few chum salmon in escapements (NWFSC 2015).

Table 51. Peak spawning ground counts for fall chum salmon in index reaches in the LCR, and Bonneville Dam counts 2001-2015 (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
2015	3,856	992	6,009	10,857				

[1] online at https://fortress.wa.gov/dfw/score/score/species/chum.jsp?species=Chum

*Date Accessed: October 14, 2016.

The methods and results for categorizing spatial distribution from the LCFRB (2010a) Plan for CR chum salmon populations are reported in the recovery plan, and updated scores are summarized here in Table 53. Under baseline conditions, constrained spatial structure at the ESU level (related to conversion, degradation, and inundation of habitat) contributes to very low abundance and low genetic diversity in most populations, increasing risk to the ESU from local disturbances. Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (LCFRB 2010a). 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 53). 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 52. CR Chum Salmon ESU populations and scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall net persistence probability of the populations (NMFS 2013e)[1].

MPG		Spawning Population (Watershed)	A/P	Diversity	Spatial Structure	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Coast Range	Fall	Youngs Bay (OR)	*	*	*	VL
		Grays/Chinook rivers (WA)	VH	M	H	M
		Big Creek (OR)	*	*	*	VL
		Elochoman/Skamokawa rivers (WA)	VL	H	L	VL
		Clatskanie River (OR)	*	*	*	VL
		Mill, Abernathy and Germany creeks (WA)	VL	H	L	VL
		Scappoose Creek (OR)	*	*	*	VL
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 2013e; 2016j).

* No data are available to make a quantitative assessment.

The most recent status review (NWFSC 2015) concluded that only 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these three populations are those that have very low recovery goals of 0 (Table 53). The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of natural populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (NWFSC 2015).

Table 53. 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	Clatskanie	0	3
	WA	Elochoman/Skamokawa	0.5	3
	WA	Mill/Abern/Ger	0.5	3
	OR	Scappoose	0	3
Cascade	WA	Cowlitz (fall)	0.5	2

	WA	Cowlitz (summer)	0.5	2
	WA	Kalama	0.5	2
	WA	Lewis	0.5	3
	WA	Salmon Creek	0.5	0
	OR	Clackamas	0	2
	OR	Sandy	0	3
	WA	Washougal	0.5	3.5
Gorge	WA	Lower Gorge	3	4
	WA	Upper Gorge	0	2

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.

Limiting Factors

Understanding the limiting factors and threats that affect the CR Chum Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. CR chum salmon were historically abundant and were subject to extensive harvest until the 1950s (Johnson et al. 1997; NWFSC 2015). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the CR Chum Salmon ESU. Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat including the estuary, impacts of main stem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the persistence probability of all populations (NMFS 2013e). Other threats to the species include climate change impacts, as discussed in Section 2.2.3.

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

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

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

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

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

The release of hatchery chum salmon juveniles was not identified as a limiting factor. Chum salmon have never been subject to significant hatchery production in the Columbia River for fishery mitigation programs. Chum salmon fry from all populations may experience predation by hatchery-origin coho salmon, steelhead, and Chinook salmon smolts, although differences in life history patterns may moderate effects, and the significance of interactions is unknown; however, predation by hatchery smolts of other species in the estuary is identified as a secondary limiting factor for all CR chum salmon (NMFS 2013e). Chum salmon may be also be impacted by hatchery fish through competition for space with other salmon and steelhead juveniles reared in hatcheries.

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

On April 5, 1991, NMFS listed the Snake River Sockeye Salmon ESU as an endangered species (56 FR 14055) under the Endangered Species Act (ESA). This listing was affirmed in 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat was designated on December 28, 1993 (58 FR 68543) and reaffirmed on September 2, 2005 (Table 9).

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015) (Table 54).

Table 54. Snake River Sockeye Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2015b).

ESU Description	
Threatened	Listed under ESA in 1991; updated in 2014 (see Table 9)
1 major population group	5 historical populations (4 extirpated)
Major Population Group	***Population***
Sawtooth Valley Sockeye	Redfish Lake
Artificial production	
Hatchery programs included in ESU (1)	Redfish Lake Captive Broodstock
Hatchery programs not included in ESU (0)	n/a

The ICTRT treats Sawtooth Valley Sockeye salmon as the single MPG within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015b) (Figure 19). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades; once residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure et al. 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been outplanted to Pettit and Alturas lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011a).

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

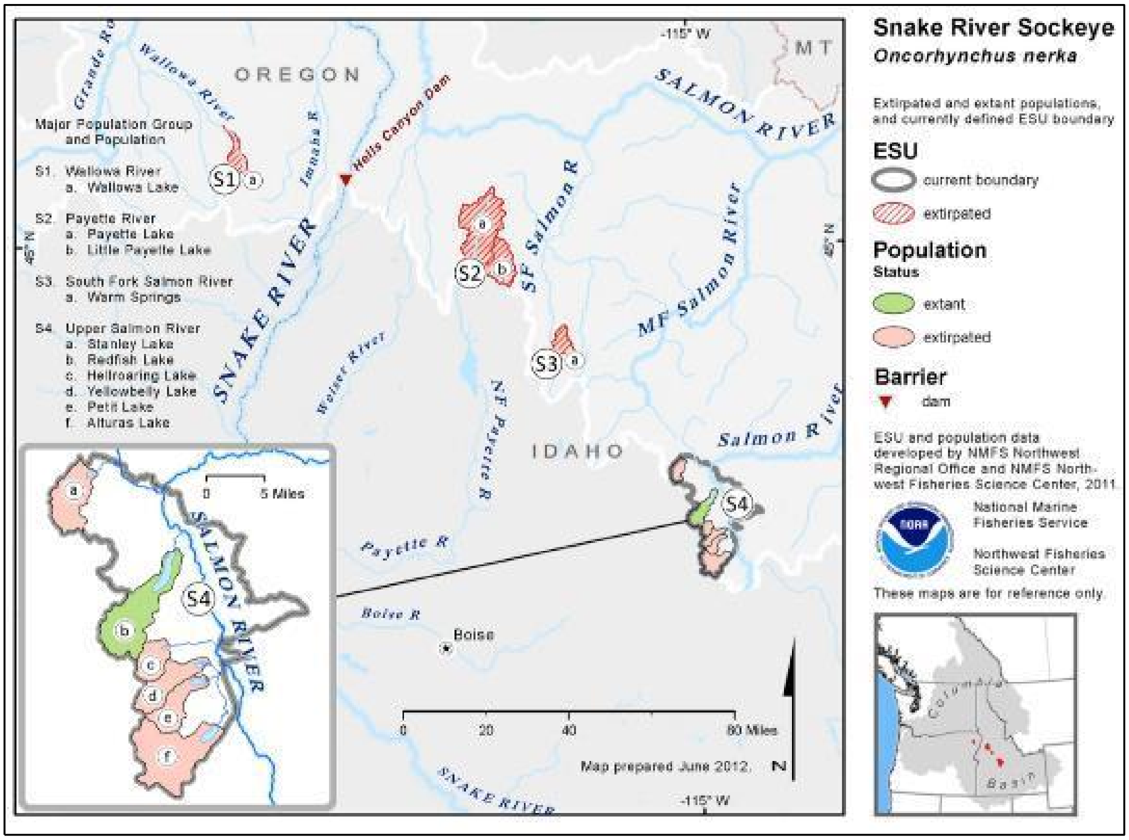

Figure 19. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historic population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean (Figure 19). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major federal dams, four on the Columbia River and four on the lower Snake River. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015b).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Sockeye Salmon ESU, is at high risk and remains at endangered status. Although the endangered Snake River Sockeye Salmon ESU has a long way to go before it will meet the biological viability criteria (i.e., indication that the ESU is self-sustaining and naturally producing and no longer qualifies as a threatened species), annual returns of sockeye salmon through 2013 show that more fish are returning than before initiation of the captive broodstock program which began soon after the initial ESA listing (Table 55). Between 1999 and 2007, more than 355 adults returned from the ocean from captive brood releases – almost 20 times the number of natural-origin fish that returned in the 1990s. Though this total is primarily due to large returns in the year 2000. Adult returns in the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015b).

Table 55. Hatchery- and natural-origin sockeye salmon returns to Sawtooth Valley, 1999-2014 (IDFG, in prep.; NMFS 2015b).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns*	Observed Not Trapped
1999	7	0	7	0	0
2000	257	10	233	0	14
2001	26	4	19	0	3
2002	22	6	9	1	7
2003	3	0	2	0	1
2004	27	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0

2008	646	140	456	1	50
2009	832	86	730	2	16
2010	1,355	178	1,144	14	33
2011	1,117	145	954	2	18
2012	257	52	190	0	15
2013	272	79	191	0	2
2014	1,579	453	1,062	0	63

*These fish were assigned as sockeye salmon returns to Alturas Lake and are included in the natural return numbers.

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 2015b; NWFSC 2015).

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

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

Limiting Factors

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

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

The most recent recovery plan (NMFS 2015b) 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 2015b).

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).

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

On March 19, 1998, NMFS listed the LCR Steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834) and most recently on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833) (Table 9).

The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive), and the Willamette and Hood Rivers, Oregon (inclusive), as well as multiple artificial propagation programs (NWFSC 2015). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

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 56). In recent years, there were several programs discontinued within the boundary of the DPS, such as the Cowlitz Trout Hatchery Late Winter Steelhead plant in the Tilton and the Hood River Summer Steelhead (Skamania Stock) programs in 2009, the Hood River Summer (ODFW stock #50) Steelhead program in 2011, and the Cowlitz Trout Hatchery Late Winter plants in the Upper Cowlitz and Cispus Rivers in 2012. Most recently, in 2014 the Cowlitz Early Winter Steelhead program was discontinued (Jones Jr. 2015), as well as the are the East Fork Lewis River (EFLR) Hatchery Summer Steelhead program, the North Toutle Hatchery Summer Steelhead program, the EFLR Skamania Hatchery Winter Steelhead Outplant program (LeFleur 2014). Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, Oregon, and from the Little and Big White Salmon Rivers, Washington.

The LCR Steelhead DPS is composed of 23 historical populations, distributed through two ecological zones, split by summer or winter life history resulting in four MPGs (Table 56). There are six summer populations and seventeen winter populations (Figure 20).

Table 56. LCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA in 1998; updated in 2014 (see Table 9)
4 major population groups	23 historical populations
Major Population Group	***Populations***
Cascade summer	Kalama (C), North Fork Lewis, East Fork Lewis (G), Washougal (C)
Gorge summer	Wind (C), Hood
Cascade winter	Lower Cowlitz, Upper Cowlitz (C, G), Cispus (C, G), Tilton, South Fork Toutle, North Fork Toutle (C), Coweeman, Kalama, North Fork Lewis (C), East Fork Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge winter	Lower Gorge, Upper Gorge, Hood (C, G)
Artificial production	
Hatchery programs included in DPS (7)	Kalama River Wild Winter, Kalama River Wild Summer, Hood River Winter (ODFW stock # 50), Cowlitz Trout Hatchery Late Winter, Clackamas Hatchery Late Winter (ODFW stock # 122), Sandy Hatchery Late Winter (ODFW stock # 11), Lewis River Wild Late Winter.
Hatchery programs not included in ESU (22)	Upper Cowlitz River Wild Late Winter, Tilton River Wild Late Winter, Cowlitz Summer, Friends of the Cowlitz Summer, Cowlitz Game and Anglers Summer, North Toutle Summer, Kalama River Summer, Merwin Summer, Fish First Summer, Speelyai Bay Net-Pen Summer, EF Lewis Summer, Skamania Summer, Kalama River Winter, Cowlitz Early Winter, Merwin Winter, Coweeman Ponds Winter, EF Lewis Winter, Skamania

	Winter, Klineline Ponds Winter, Eagle Creek NFH Winter, Clackamas Summer, Sandy River Summer.

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

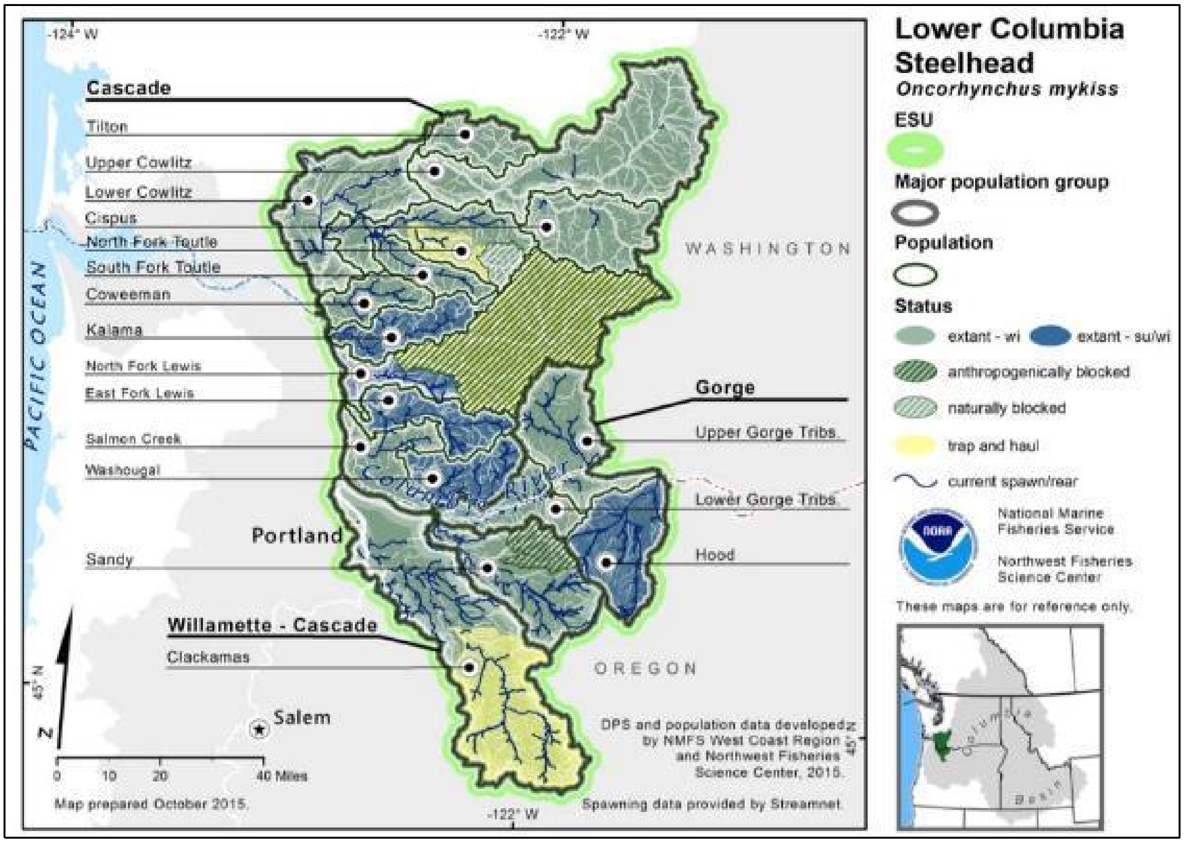

Figure 20. Map of populations in the LCR Steelhead DPS (NWFSC 2015).

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

LCR basin populations include summer and winter steelhead (Table 57). The two life history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013e). Generally, summer steelhead enter 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).

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

Table 57. Life history and population characteristics of LCR steelhead.

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

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

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

Following emergence, fry usually move into shallow and slow-moving margins of the stream. As they grow, they inhabit areas with deeper water, with a wider range of velocities, and larger substrate, and they may move downstream to rear in large tributaries or main stem rivers. Young steelhead typically rear in streams for some time before migrating to the ocean as smolts. Steelhead smolts generally migrate at ages ranging from 1 to 4 years with most smolting after 2 years in freshwater (Busby et al. 1996). Smoltification for steelhead has been described by Thorpe (1994) as a ‘‘developmental conflict’’ whereby juvenile steelhead are faced with three distinct possibilities every year: 1) undergo smoltification, followed by migration to the ocean; 2) begin maturation and attempt to spawn as a resident fish in the following winter (precocial residuals); and 3) remain in fresh water (natal steams, other tributaries, or the main channel of large rivers such as the Columbia River, etc.) and revisit these options in the following year (residuals, collectively). These possibilities represent a case of developmental plasticity where adoption of one of these three life-history strategies is initiated through the interplay of phenotypic expression with environmental and biological cues. In the LCR, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May (NMFS 2013e).

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

Abundance, Productivity, Spatial Structure and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Steelhead DPS, is at moderate risk and remains at threatened status. Each natural population’s baseline and target persistence probabilities are summarized in Table 58, 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 58. Current status for LCR steelhead populations and recovery scenario targets (NMFS 2013e).

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

Cascade summer	Kalama (WA)	M	Primary	H	500
	North Fork Lewis (WA)	VL	Stabilizing	VL	--
	EF Lewis (WA)	VL	Primary	H	500
	Washougal (WA)	M	Primary	H	500
Gorge summer	Wind (WA)	H	Primary	VH	1,000
	Hood (OR)	VL	Primary	H*	2,008
Cascade winter	Lower Cowlitz (WA)	L	Contributing	M	400
	Upper Cowlitz (WA)	VL	Primary	H	500
	Cispus (WA)	VL	Primary	H	500
	Tilton (WA)	VL	Contributing	L	200
	South Fork Toutle (WA)	M	Primary	H+	600
	North Fork Toutle (WA)	VL	Primary	H	600
	Coweeman (WA)	L	Primary	H	500
	Kalama (WA)	L	Primary	H+	600
	North Fork Lewis (WA)	VL	Contributing	M	400
	East Fork Lewis (WA)	M	Primary	H	500
	Salmon Creek (WA)	VL	Stabilizing	VL	--
	Washougal (WA)	L	Contributing	M	350
	Clackamas (OR)	M	Primary	H*	10,671
	Sandy (OR)	L	Primary	VH	1,519
Gorge winter	Lower Gorge (WA/OR)	L	Primary	H	300
	Upper Gorge (WA/OR)	L	Stabilizing	L	--
	Hood (OR)	M	Primary	H	2,079

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

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

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

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

If the recovery scenario in Table 58 is achieved, it would exceed the WLC TRT's viability criteria in the Cascade winter and summer MPGs. This is intentional given the scenario for uncertainties about the feasibility of meeting the viability criteria for populations within the Gorge MPGs. Questions remain concerning the historical role of the populations, specifically with the winter populations in the Gorge MPGs, and the current habitat potential (NMFS 2013e).

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

Cascade Summer MPG

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

Summer steelhead have the greatest distribution of the Kalama subbasin populations. The Upper Kalama River Falls at RM 35 is the upstream limit to anadromous fish passage. Prior to the creation of a complete passage barrier at the Kalama Falls Hatchery through installation of the fish ladder in 1936, only summer steelhead are believed to have regularly passed upstream of the Lower Kalama Falls at RM 10 (NMFS 2013e). Only unmarked steelhead are passed upstream of the ladder, where WDFW estimates a pHOS of 4% (WDFW 2014b). Hatchery summer steelhead trapped at the ladder are released back into the lower Kalama River which re-exposes them to harvest (a practice referred to as "recycling"), and are not included in the pHOS estimate. Since brood year 1997, Kalama Falls Hatchery trap counts indicate a high of 817 summer steelhead in 2003, after which annual returns dropped below 440 fish each brood year from 2005 to 2009 (Table 59).

Table 59. Total Cascade MPG summer steelhead natural-origin spawner abundance estimates in the LCR, 1997-2015 (WDFW SCORE[1])*.

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

2009	308	800	433
2010	370	600	787
2011	534	1,036	na
2012	646	1,084	842
2013	738	1,059	na
2014	400	617	544
2015	814	843	783

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score
* Date Accessed: April 19, 2016

The East Fork Lewis summer steelhead population is targeted for the largest improvement within the Cascade summer steelhead MPG. Mid-July snorkel index escapement surveys have been conducted in the East Fork Lewis (HSRG 2009), and indicate 2003, 2011, 2012, 2013 and 2015 as the only years that WDFW's established escapement goal of 814 adults spawning was exceeded for this population (Table 59). From 2005 to 2009 an average of 562 adult steelhead have been observed spawning, and the spawning population is reported to have the highest pHOS estimate, 35%, for any summer steelhead population in the LCR Steelhead DPS (LCFRB 2010a).

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

Washougal summer steelhead abundance estimates show a recent increasing trend (Table 59). From 2005 to 2009 snorkel surveys indicate an average of just over 600 annual summer steelhead adults spawning in the Washougal River, or roughly 50% of WDFW's established 1,210 escapement goal. Spawning occurs throughout the Washougal Basin, extending to the main stem Washougal and tributaries upstream of Dougan Falls (RM 21), the Little Washougal, and the North Fork Washougal.

There are no adequate abundance trend data for the North Fork Lewis summer steelhead population. The North Fork Lewis summer steelhead population likely has low numbers of natural-origin returns (NORs) because of loss of habitat access related to Merwin Dam, ongoing hatchery programs that produce summer steelhead for harvest, and the WDFW's desire not to interfere with winter steelhead recovery efforts in the upper North Fork Lewis. Recovery efforts for summer steelhead in the North Fork Lewis River are likely to occur below Merwin Dam (NMFS 2013e). Summer steelhead counts at the Merwin Dam Fish Collection Facility have remained below 100 NOR steelhead for the past 12 years (Table 60). Current spawning is in the lower North Fork Lewis River and tributaries (most notable is Cedar Creek) below Merwin Dam (NMFS 2007a).

Table 60. Summer steelhead trapped at Merwin Dam Fish Collection Facility (Personal comm., E. Kinne 2016).

Year[1]	**Hatchery Origin**	**Natural Origin**

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

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

Gorge Summer MPG

The Wind River and Hood River are the two natural populations in this MPG. Hood River summer-run steelhead have not been monitored since the last status review in 2011 (Ford 2011); efforts are currently underway to provide accurate estimates of fish ascending the west fork of the Hood River. Adult abundance in the Wind River remains stable, but at a low level (hundreds of fish; Table 61). In addition, there is a catch and release fishery that allows targeting natural-origin summer steelhead in the Wind River; but in the Hood River estimates for encounters and incidental mortality from fisheries are not currently available. Given the presence of only two summer-run populations, and only one is still currently monitored in this MPG (Table 61), the overall status of the MPG is uncertain (NWFSC 2015).

Table 61. Total Gorge MPG summer steelhead natural-origin spawner abundance estimates in the LCR, 1997-2015.

Brood Year	Wind River (WA)[1 a *]	Hood River (OR)[2 *]
1997	734	179
1998	320	65
1999	323	98
2000	218	147
2001	454	180
2002	690	414
2003	1,113	543
2004	893	182
2005	600	152
2006	658	170
2007	766	169

2008	638	120
2009	605	280
2010	777	41
2011	1,497	na
2012	815	na
2013	760	na
2014	281	na
2015	577	na

[1] online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

[*] Date Accessed: April 19 and November 9, 2016, for Wind River and Hood River data, respectively.

[a] Data since 2000 are based on jumper estimates at Shipherd Falls and are considered preliminary estimates.

The Wind River population has a high baseline persistence probability and is targeted for very high persistence. The smolt yield trend has been increasing, and the adult escapement exceeded the escapement goal of 957 in 2003 and again in 2011 (Table 61). Baseline abundance and productivity of the Wind River summer steelhead population are the highest in the DPS; however, improvements in diversity will be needed in the population to meet recovery objectives (NMFS 2013e).

Cascade Winter MPG

This MPG includes natural-origin winter-run steelhead in 14 populations from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and, in general, are correlated with cyclical changes in ocean conditions. For most populations, total abundances and natural-origin abundances (where available) have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas[15] and Sandy River winter-run steelhead populations, which are exhibiting recent rises in NOR abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (Jacobsen et al. 2014b). Abundances in the Tilton and Upper Cowlitz/Cispus rivers are highly variable, in part because juvenile fish passage at dams in the Cowlitz system is highly variable as well as the use of natural-origin adults as broodstock in developing an integrated hatchery stock (NWFSC 2015) which are intercepted prior to reaching the upper tributaries. The most recent total abundance information is provided in

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

Table 62. Total Cascade MPG winter steelhead spawner abundance estimates in the LCR, 1997-2016 (ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCORE[2])*.

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

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

* Date Accessed: October 14, 2016

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

* Date Accessed: October 14, 2016

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

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

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

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

[7] Natural-origin spawners.

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

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

Gorge Winter MPG

This MPG contains three populations, Lower Gorge, Upper Gorge, and Hood River. In both the Lower and Upper Gorge populations, surveys for winter steelhead are very limited. Abundance levels have been low, but relatively stable, in the Hood River population. In recent years, spawners from the integrated hatchery program have constituted the majority of naturally spawning fish (NWFSC 2015). The most recent total abundance information for the Hood River winter steelhead population is provided in Table 63. The total winter steelhead return to Hood River has numbered in the hundreds in recent years, but has been extremely variable. There are no adequate abundance trend data for the Lower Gorge winter steelhead population.

Table 63. Total Gorge MPG winter spawner abundance estimates in the LCR, 2001-2015 (ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCORE[2])*.

Year	Hood River[1]	Upper Gorge (Wind River)[2,3]
2001	877	49
2002	950	47
2003	654	25
2004	507	26
2005	273	20
2006	342	21
2007	423	11
2008	264	6
2009	170	18
2010	568	28
2011	271	16
2012	653	19

2013	312	17
2014	177	5
2015	1,233	10

[1] online at: http://odfwrecoverytracker.org/summary/#/species=2&run=3&esu=223/esu=223&metric=1&level=3/filter=223&start_year=1992&end_year=2016

[2] online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

[*] Date Accessed: November 9, 2016

[3] Wind River subpopulation. Trap count data for Winter Steelhead on Wind River near Shipherd Falls

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

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

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

Summary

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

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

The methods and results for categorizing spatial distribution from the LCFRB (2010a) Plan for LCR steelhead populations are reported in Appendix B of NMFS' recovery plan and summarized with updates from NWFSC (2015) below in Table 64. This overview suggests that risk related to diversity is higher than that for spatial structure (Table 64).

Table 64. Summary of VSP scores and recovery goals for LCR steelhead populations (NWFSC 2015).

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

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

The estimated changes in VSP status for steelhead populations in Table 64 indicate that a total of 5 out of 22 populations are at or near their recovery viability goals, although only two of these populations had scores above 2.0 under the recovery plan scenario. The remaining populations generally require substantial improvements to reach their viability goals (NWFSC 2015).

Table 65 displays the abundance, productivity, spatial structure, diversity, and overall persistence probability for LCR steelhead, organized by individual populations. It is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 are considered to have a “low” or “very low” probability of persisting over the next 100 years, and six populations have a “moderate” overall persistence probability. All four strata in the DPS fall short of the WLC-TRT criteria for viability (NMFS 2016j).

Baseline persistence probabilities were estimated to be “low” or “very low” for three out of the six summer steelhead populations that are part of the LCR Steelhead DPS, moderate for two, and high for one – the Wind, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have “low” or “very low” baseline probabilities of persistence, and the remaining four are at “moderate” probability of persistence (Table 65) (NMFS 2016j).

Table 65. LCR steelhead populations, and scores for the key elements (A/P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013e)[1].

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

[1]Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016j).

Figure 21 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for Oregon populations (ODFW 2010b; Ford 2011). The results indicate low to moderate spatial structure and diversity risk for all but two populations.

The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR steelhead populations in Oregon. Risk is characterized as high or very high for three populations and moderate for the remaining populations. For populations other than Sandy, less than 5% of historical habitat has been lost for Oregon populations, indicating spatial structure for Oregon populations is a lower risk factor (NMFS 2013e, Appendix A).

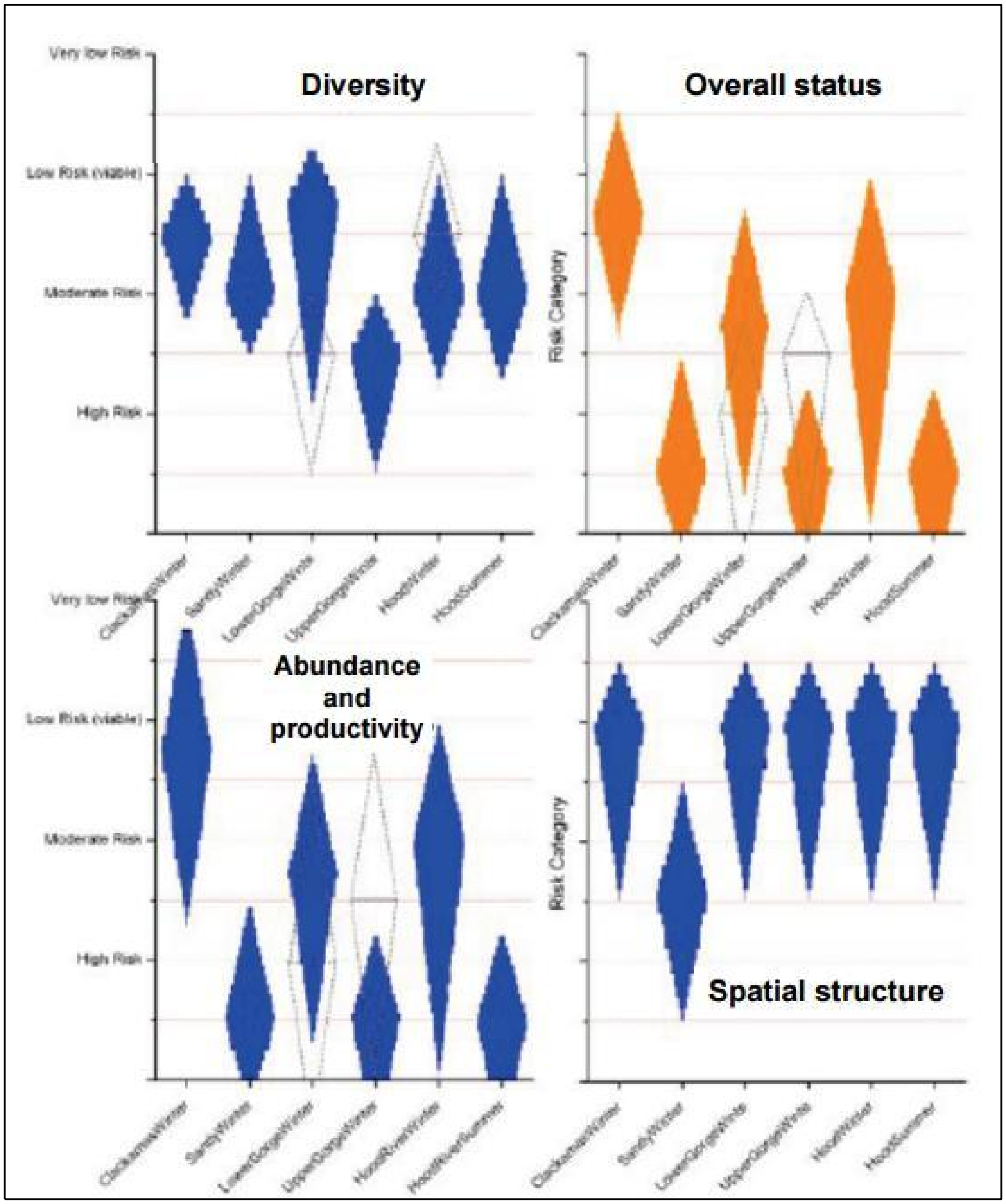


Figure 21. Extinction risk ratings for LCR steelhead populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combined the three attributes (Ford 2011).

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

Limiting Factors

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

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

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

Chapter 4 includes additional details on large scale issues including:

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

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. However, summarizing the recovery plan's discussion of the threat hatchery induced selection poses to LCR steelhead indicates population-level effects of hatchery fish interbreeding with natural-origin fish is a primary limiting factor. This is coupled with the low to very low baseline persistence probabilities of most LCR steelhead populations that reflects low abundance and productivity. It is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks (NMFS 2013e).

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

On August 18, 1997, NMFS listed the UCR Steelhead DPS as an endangered species (62 FR 43937). The UCR steelhead was then listed as a threatened species as of January 5, 2006 (71 FR 834). This DPS was re-classified as endangered on January 13, 2007 (74 FR 42605). However, the status was changed to threatened again in 2009 (74 FR 42605) and was reaffirmed on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat for the UCR Steelhead DPS was designated on September 2, 2005 (70 FR 52630) (Table 9).

The UCR Steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well as five artificial propagation programs (Table 66, Figure 22) (Jones Jr. 2015; NWFSC 2015). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

As with LCR Steelhead DPS, NMFS has defined the UCR Steelhead DPS to include only the anadromous members of this species (70 FR 67130). The UCR Steelhead DPS is composed of three MPGs, two of which are isolated by dams (Table 66 and Figure 22).

Table 66. UCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as endangered in 1997; reviewed and listed as threatened in 2009 and updated in 2014 (see Table 9)
3 major population groups	4 historical populations
Major Population Group	***Populations***
North Cascades	Wenatchee River, Entiat River, Crab Creek, Methow River, Okanogan River
Upper Columbia River above Chief Joseph Dam	Sanpoil River, Kettle River, Pend Oreille, Kooteney River
Spokane River	Spokane River, Hangman Creek
Artificial production	
Hatchery programs included in DPS (5)	Wenatchee River summer, Okanogan River summer, Wells Hatchery summer, Winthrop NFH summer, Ringold Hatchery summer
Hatchery programs not included in DPS (0)	n/a

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

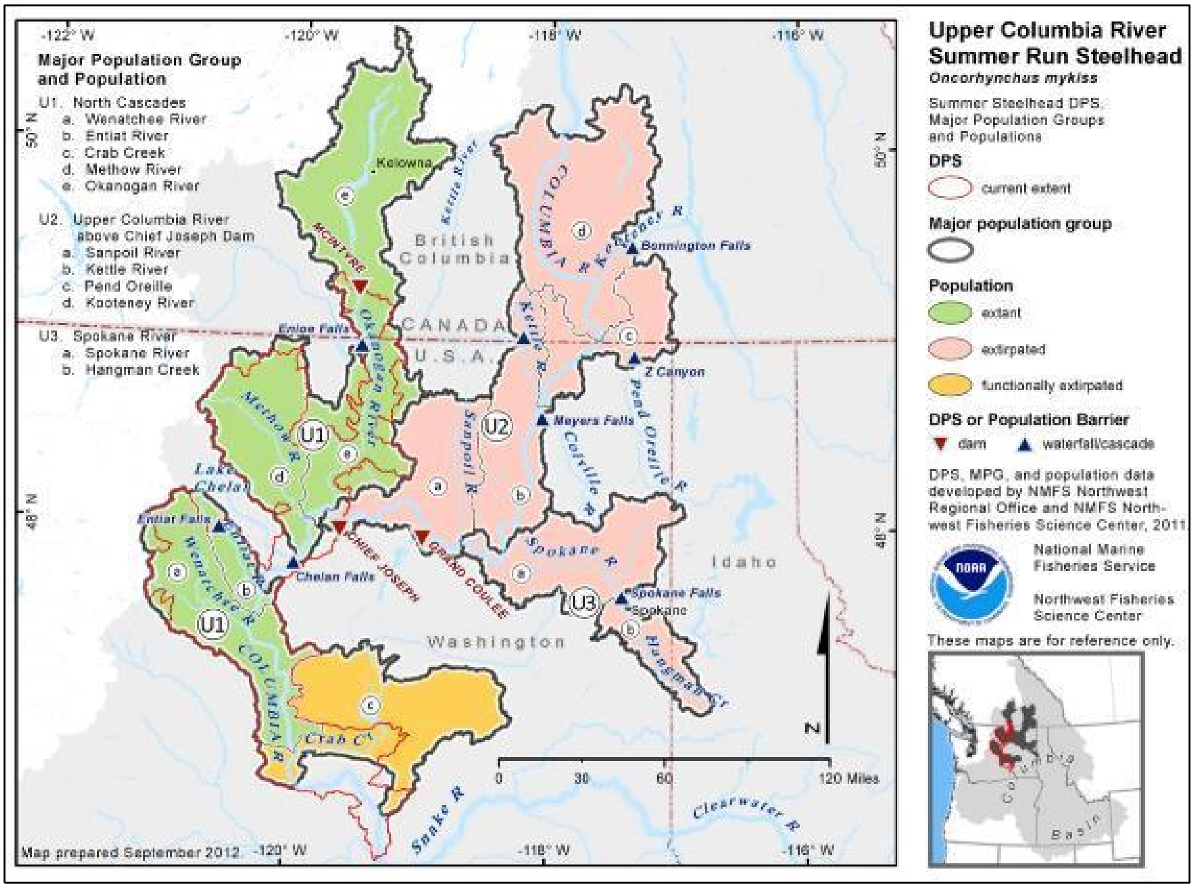


Figure 22. Map of the UCR Steelhead DPS's spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

The most recent estimates of natural-origin spawner abundance for each of the four populations in the UCR Steelhead DPS show fairly consistent patterns throughout the years (Table 67). None of the populations have reached their recovery goal numbers during any of the years, much less in successive years with the recovery goals being 500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee (Table 67). Specifically, the Okanogan River natural-origin spawner abundance estimates are well below the recovery goal for that population.

Table 67. UCR Steelhead DPS natural-origin spawner abundance estimates for each of the four populations (WDFW SCORE[1])*.

Year	Entiat River	Methow River	Okanogan River	Wenatchee River
1997	31	147	22	242
1998	37	68	20	252
1999	38	131	38	239
2000	51	247	65	356
2001	98	332	98	704
2002	266	554	155	1,968
2003	117	488	142	853

2004	94	637	185	656
2005	116	484	138	813
2006	128	419	118	906
2007	59	366	102	387
2008	123	688	201	714
2009	102	634	177	709
2010	297	1,102	314	2,237
2011	293	987	285	2,189
2012	190	770	235	1,420
2013	129	494	152	931
2014	185	1,024	313	1,151
2014	234	1,130	336	1,736

[1] online at:
https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geoarea=SRR_UpperColumbia&geocode=srr
*Date Accessed: April 25, 2016

All extant natural populations are considered to be at high risk of extinction (Table 68) (Ford 2011; NWFSC 2015). The high risk ratings for SS/D are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery-origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations. In 2015, the 5-year review for the UCR steelhead concluded the species should maintain its threatened listing classification (NWFSC 2015).

Table 68. Summary of the key elements (A/P, diversity, and SS/D) and scores used to determine current overall viability risk for UCR steelhead populations (NWFSC 2015).[1]

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

[1] Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016j).

The recovery plan for this species (UCSRB 2007) incorporates viability criteria recommended by the ICTRT. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements- abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). Achieving recovery (delisting) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the recovery plan (NWFSC 2015). Table 69 shows the most recent metrics for the UCR Steelhead DPS. This recovery plan includes specific quantitative criteria expressed relative to population viability curves (ICTRT 2007). The plan also establishes minimum productivity thresholds.

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

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

UCR steelhead populations have increased in natural origin abundance in recent years, but productivity levels remain low. The modest improvements in natural returns are probably primarily the result of several years of relatively good natural survival in the ocean and tributary habitats (NMFS 2016j). The UCR steelhead populations sizes have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations (Table 70). The status of the Wenatchee River steelhead population continued to improve, based on the additional years information available for the most recent 2015 status review. The abundance and productivity viability rating for the Wenatchee River population exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review at high risk, driven by low abundance and productivity relative to viability objectives and diversity concerns. The required improvements to improve the abundance/productivity estimates for the UCR steelhead populations are at the high end of the range for all listed IC DPS populations (NWFSC 2015).

Table 69. Viability assessments for extant natural populations within the UCR Steelhead DPS.[1]

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

[1] Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error and number of qualifying estimates for productivities in parentheses. Upward arrows: current estimates increased over prior review. Oval: no change since prior review. Downward arrow: current estimates decreased over prior review. (NWFSC 2015).

[2] This column is expressed in most recent 10-year geometric mean, with the range in parentheses.

[3] This column is expressed in 20-year geometric mean for parent escapements below 75% of population threshold.

Table 70. UCR Steelhead DPS natural population viability ratings integrated across the four VSP parameters.

Spatial structure/diversity risk					
		Very low	Low	Moderate	High
Abundance/ productivity risk	Very low (<1%)	HV	HV	V	M
	Low (1–5%)	V	V	V	M Wenatchee
	Moderate (6–25%)	M	M	M	HR
	High (>25%)	HR	HR	HR	HR Entiat Methow Okanogan

[1] Viability key: HV, highly viable; V, viable; M, maintained; and HR, high risk (does not meet viability criteria) (NWFSC 2015).

Limiting Factors

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

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

The Upper Columbia Recovery Plan (UCSRB 2007) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them (Chapters 4, 5, and 8).

The plan indicates that the highest priority for protecting biological productivity of UCR salmonids should be to allow unrestricted stream channel migration, complexity and floodplain function. The principal means to meet this objective is to protect riparian habitat in category 1 and 2 sub-watersheds. The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference.
Some of the main limiting factors are listed below:

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

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

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

On August 18, 1997, NMFS listed the Snake River Basin Steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769) (Table 9).

The Snake River Basin Steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (NWFSC 2015). Twenty four historical populations within six MGPs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 19 hatchery steelhead programs are currently operational. Nine of these artificial programs are included in the DPS (Table 71) (Jones Jr. 2015). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

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

Table 71. Snake River Basin Steelhead DPS description and MPGs (NMFS 2012c; Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014 (see Table 9)
6 major population groups	27 historical populations (3 extirpated)
Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, North Fork Clearwater, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater
Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	n/a
Artificial production	
Hatchery programs included in DPS (7)	Tucannon River summer, Little Sheep Creek/Imnaha River Hatchery summer, EF Salmon River A, Dworshak NFH B, Lolo Creek B, Clearwater Hatchery B, SF Clearwater (localized) B

Hatchery programs not included in DPS (12)	EF Salmon River B, Squaw Creek B, Little Salmon River B, Lyons Ferry NFH summer, Cottonwood Pond summer, Wallowa Hatchery and Big Canyon Satellite Pond summer, Lower Snake and Hells Canyon Mitigation A, Pahsimeroi Hatchery A, Sawtooth Hatchery A, Streamside Incubator Project A, Little Salmon Steelhead A, Yankee Fork A

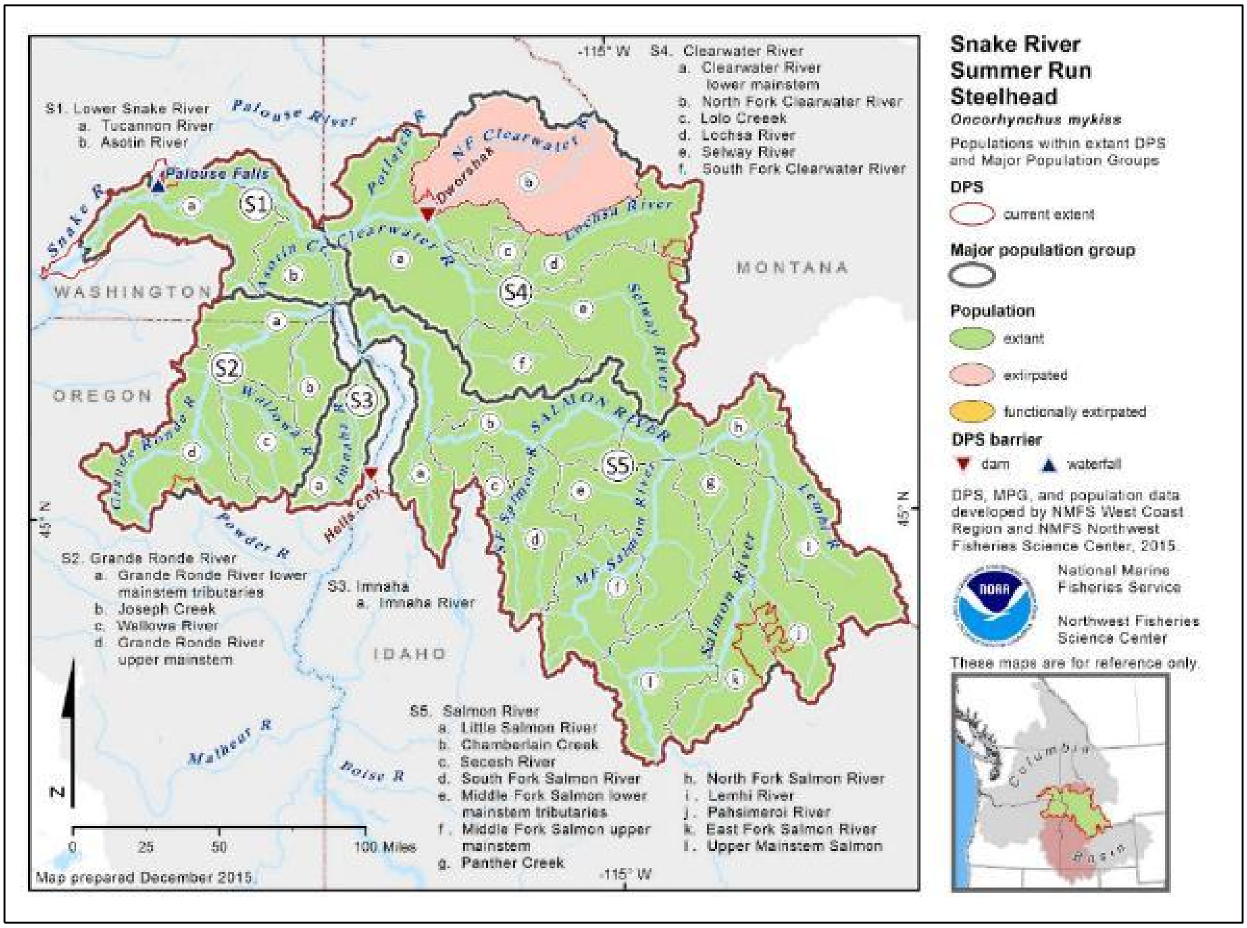


Figure 23. Snake River Basin Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

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

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

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

Population-specific adult population abundance is generally not available for the Snake River Basin steelhead due to difficulties conducting surveys in much of their range. Evaluations in the 2015 status review were done using both a set of metrics corresponding to those used in prior

BRT reviews, as well as a set corresponding to the specific viability criteria based on ICTRT recommendations for this DPS. The BRT level metrics were consistently done across all ESUs and DPSs to facilitate comparisons across domains. The most recent five year geometric mean abundance estimates for the two long term data series of direct population estimates (Joseph Creek and Upper Grande Ronde Mainstem populations) both increased compared to the prior review estimates; each of the populations increased an average of 2% per year over the past 15 years. Hatchery-origin spawner estimates for both populations continued to be low, and both populations are currently approaching the peak abundance estimates observed since the mid-1980s (NWFSC 2015).

The ICTRT viability criteria adopted in the draft Snake River Management Unit Recovery Plans include spatial explicit criteria and metrics for both spatial structure and diversity. With one exception, spatial structure ratings for all of the Snake River Basin steelhead populations were low or very low risk, given the evidence for distribution of natural production with populations. The exception was the Panther Creek population, which was given a high risk rating for spatial structure based on the lack of spawning in the upper sections. No new information was provided for the 2015 status update that would change those ratings (NWFSC 2015).

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

The overall viability ratings for natural populations in the Snake River Basin Steelhead DPS range from moderate to high risk (Table 72). Under the approach recommended by the ICTRT, the overall rating for a DPSs depends on population-level ratings organized by MPG within that DPS.

Table 72. Ecological subregions, populations, and scores for the key elements (A/P, diversity, and SS/D) used to determine current overall viability risk for the Snake River Basin Steelhead DPS (Ford 2011; NMFS 2011a).[1]

Ecological subregions	Spawning Populations (Watershed)	A/P	Diversity	Integrated SS/D	Overall Viability Risk*
Lower Snake River	Tucannon River	**	M	M	H
	Asotin Creek	**	M	M	MT
Grande Ronde River	Lower Grande Ronde	**	M	M	Not rated
	Joseph Creek	VL	L	L	Highly viable
	Upper Grande Ronde	M	M	M	MT
	Wallowa River	**	L	L	H
	Lower Clearwater	M	L	L	MT

Ecological subregions	Spawning Populations (Watershed)	A/P	Diversity	Integrated SS/D	Overall Viability Risk*
Clearwater River	South Fork Clearwater	H	M	M	H
	Lolo Creek	H	M	M	H
	Selway River	H	L	L	H
	Lochsa River	H	L	L	H
Salmon River	Little Salmon River	**	M	M	MT
	South Fork Salmon	**	L	L	H
	Secesh River	**	L	L	H
	Chamberlain Creek	**	L	L	H
	Lower MF Salmon	**	L	L	H
	Upper MF Salmon	**	L	L	H
	Panther Creek	**	M	H	H
	North Fork Salmon	**	M	M	MT
	Lemhi River	**	M	M	MT
	Pahsimeroi River	**	M	M	MT
	East Fork Salmon	**	M	M	MT
	Upper Main Salmon	**	M	M	MT
Imnaha River	Imnaha River	M	M	M	MT

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

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

** Insufficient data.

The level of natural production in the two populations with full data series and the Asotin Creek index reaches in encouraging, but the status of most populations in the DPS remains highly uncertain (Table 72). Population-level natural origin abundance and productivity inferred from aggregate data and juvenile indices indicate that many populations are likely below the minimum combination defined by the ICTRT viability criteria (NMFS 2016j).

Population level abundance data sets are available for all populations in this DPS except for the two populations in the Lower Snake River MPG (i.e., Tucannon River and Asotin Creek populations). Both these populations (the only two in the Lower Snake River MPG) are targeted for viable status, with at least one meeting the criteria for highly viable. Even though population level spawner escapement estimates are not available for the Tucannon River population, indications are that numbers of spawning steelhead in the system are low. One contributing factor to this low spawning numbers is an apparent high overshoot rate of returning adults passing by and continuing upstream from their natal stream. A portion of the outmigrating natural smolt production from the Tucannon River population has been PIT tagged in recent years (Bumgarner and Dedloff 2013). Analysis of returning PIT tagged adults (2005-2012 return years) indicates overshoot rates past the Tucannon River and over LGR (Bumgarner and Dedloff 2013; NWFSC 2015).

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

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

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

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

Limiting Factors

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

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Basin Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower projects, predation, harvest, hatchery effects, tributary habitat, and ocean conditions; together these factors have affected the natural populations of this DPS (NMFS 2012c). Specifically, limiting factors also include:

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

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

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

On March 25, 1999, NMFS listed the MCR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802) (Table 9). Critical habitat for the MCR steelhead was designated on September 2, 2005 (70 FR 52808) (Table 9).

The MCR Steelhead DPS includes naturally spawned anadromous *O. mykiss* originating from below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind River (Washington) and Hood River (Oregon) to and including the Yakima River, excluding the Upper Columbia River tributaries (upstream of Priest Rapids Dam) and the Snake River. Four MPGs, composed of 19 historical populations (2 extirpated), comprise the MCR Steelhead DPS. Inside the geographic range of the DPS, 11 hatchery steelhead programs are currently operational. Seven of these artificial programs are included in the DPS (Table 73). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

Table 73. MCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014 (see Table 9)
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.

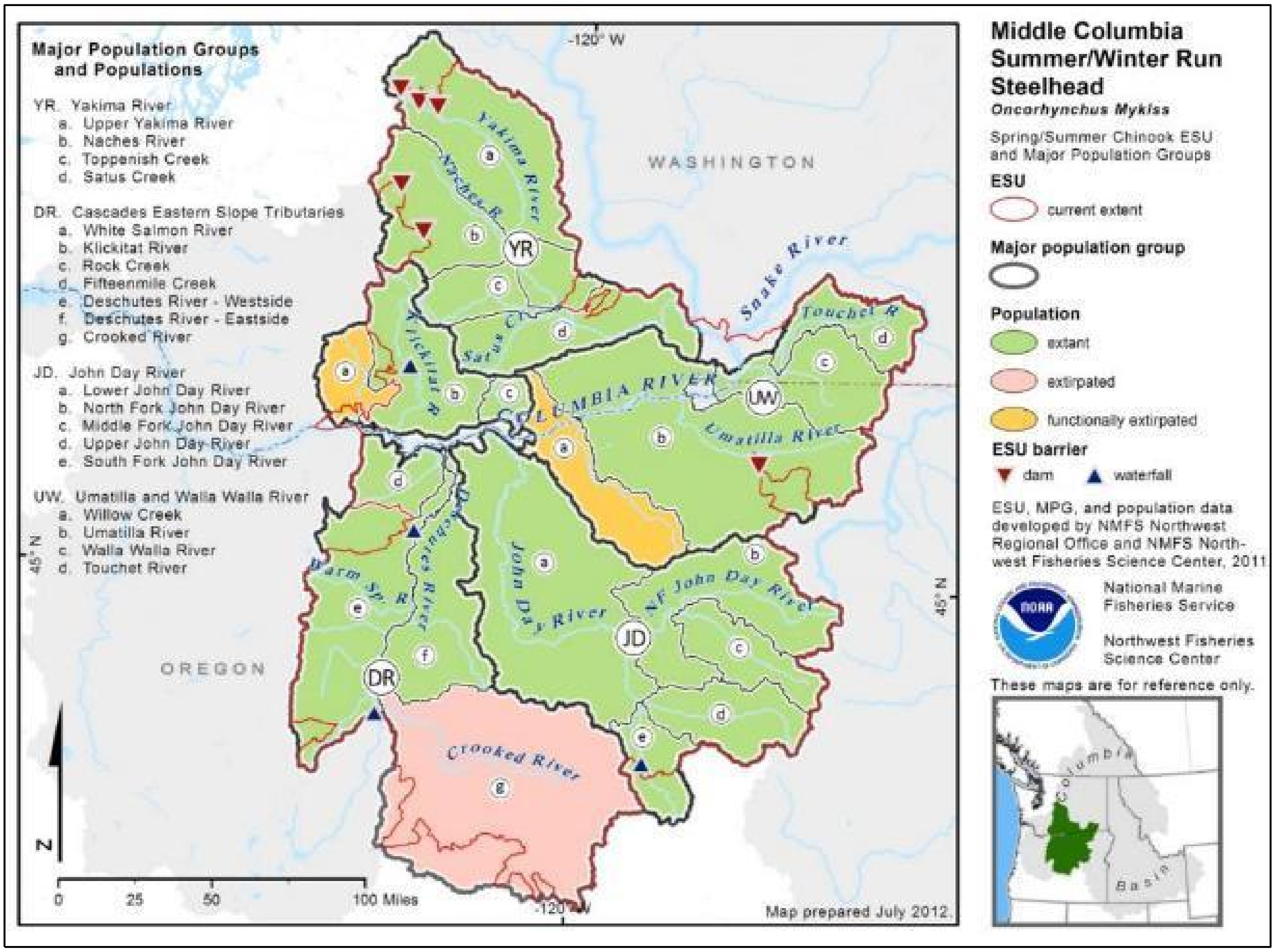


Figure 24. Map of the MCR Steelhead DPS's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Steelhead exhibit more complex life history traits than other Pacific salmonid species as discussed in previous steelhead specific DPS sections above (for example see Table 57 for general characteristics). While MCR steelhead share these general life history traits, it is worth review they typically reside in marine waters for two to three years before returning to their natal stream to spawn at four or five years of age (Table 74) (NMFS 2011e).

Table 74. Key habitat requirements by life stage and time period for steelhead (NMFS 2009b).

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Mar-June	Riffles, tailouts, and glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	Mar-June	Riffles, tailouts, and glides are needed for spawning, with sufficient flow for egg and alevin development

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

The MCR Steelhead DPS includes the only populations of inland winter steelhead in the United States. Variations in the migration timing exist between populations. Both summer and winter steelhead occur in British Columbia, Washington and Oregon; Idaho only has summer steelhead; California is thought to have only winter steelhead (Busby et al. 1996). In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April (NMFS 2011e).

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

Abundance, Productivity, Spatial Structure, and Diversity

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

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

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

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 75) (NMFS 2009b).

Table 75. 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

Ecological Subregions	Population (Watershed)	A/P	Diversity	Integrated SS/D	Overall Viability Risk
	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 2009b).

[2] This population is re-establishing itself following removal of Condit Dam.

[3] This population was designated an experimental population on January 15, 2013 (78 FR 2893)

Limited population abundance data are available for the populations in the MCR Steelhead DPS. Of the 17 populations in this DPS, data on natural-origin spawner abundances for 14 populations is provided below in Table 76; such information for the remaining three populations is not available. In the last status review, Ford (2011) summarized that natural-origin and total spawning escapements have increased in the most recent brood cycle, relative to the period associated with the 2005 BRT review, for all four populations in the Yakima River MPG. It is apparent that this trend is continuing through the recent years as well (Table 76). 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 76). There is significant tribal and sport harvest associated with the Klickitat steelhead run, with the sport harvest being targeted on hatchery fish (NWFSC 2015). Overall, natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. Natural-origin returns to the Umatilla, Walla Walla, John Day, and Klickitat Rivers have increased over the last several years (Table 76).

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

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

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

Table 76. MCR Steelhead DPS natural-origin spawner abundance estimates for the populations with data available (from WDFW SCORE[1] and ODFW Salmon & Steelhead Recovery Tracker[2])*.

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

[1] Data available at: https://fortress.wa.gov/dfw/score/score/maps/map_details.jsp?geoarea=SRR_MiddleColumbia&geocode=srr (Date accessed: April 28, 2016)

[2] Data available at: http://odfwrecoverytracker.org/explorer/

[3] Estimates combine both summer and winter counts

**Source for 2009-2014 data: TAC (2015). Data are verified using mark-recapture estimates at Lyle Falls.

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

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

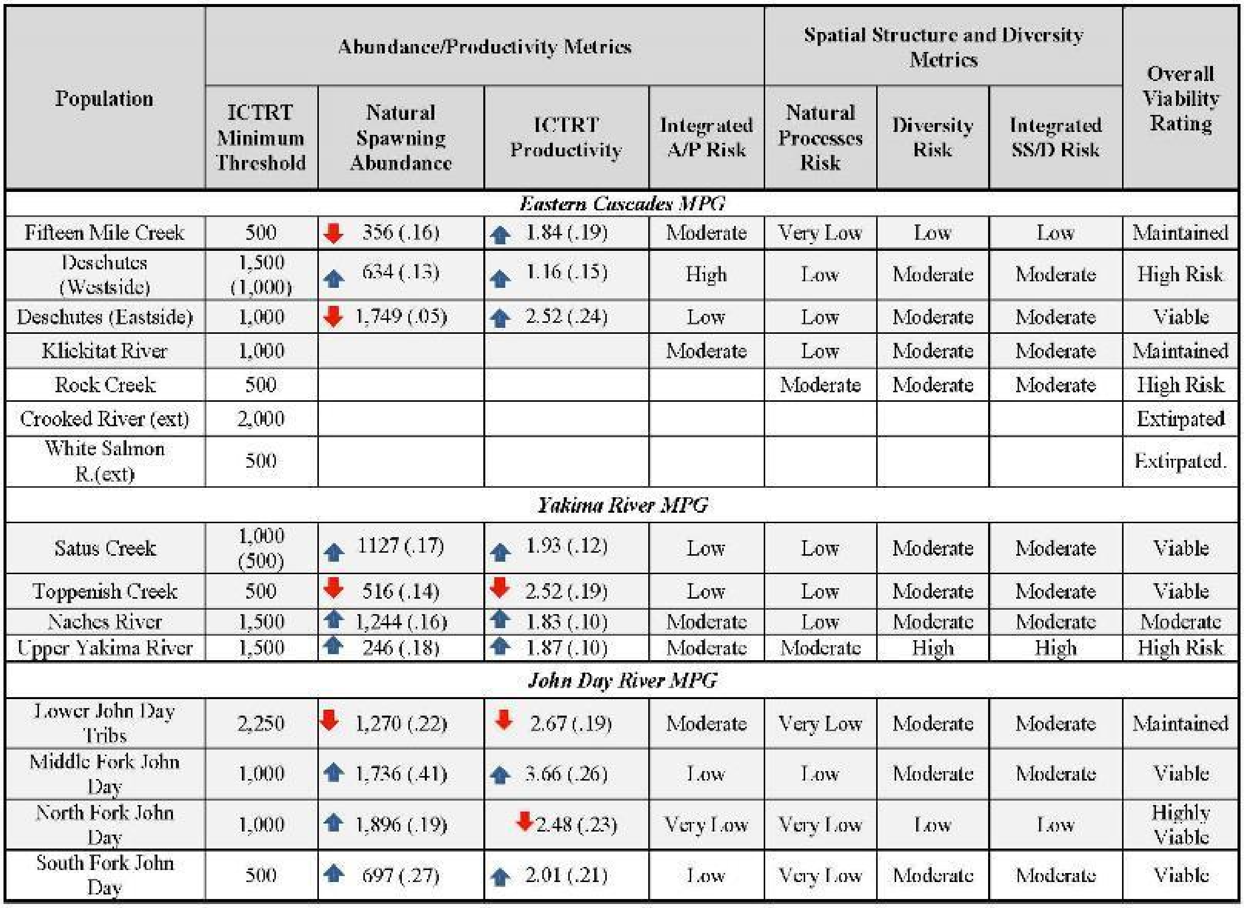
Strategies outlined in the recovery plan (NMFS 2009b) and its management unit components are targeted on achieving, at a minimum, the ICTRT biological viability criteria which require that the DPS should "have all four MPGs at viable (low risk) status with representation of all the major life history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

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

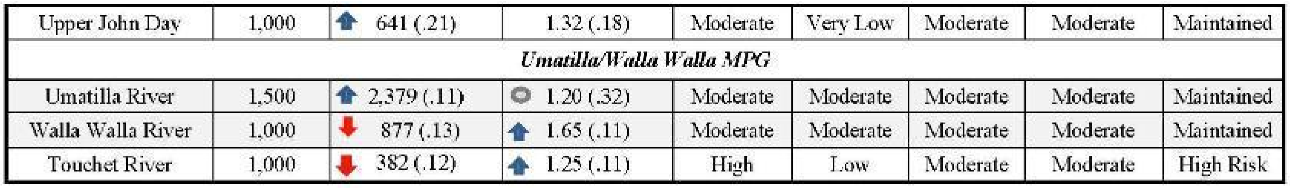
The Mid-Columbia Recovery Plan identifies a set of most likely scenarios to meet the ICTRT recommendations for low risk populations at the MPG level. In addition, the management unit plans generally call for achieving moderate risk ratings (maintained status) across the remaining extant populations in each MPG. Table 77 shows the most recent abundance, productivity, spatial structure, and diversity metrics for the 17 populations in the DPS. Overall viability ratings for the populations in the MCR Steelhead DPS remained generally unchanged from the prior five year review (Table 77). One population, Fifteen Mile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its

ICTRT minimum abundance threshold. The Toppenish River population (in Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the 5% viability curve, and, therefore, its overall rating remained as viable (Table 77). The majority of the populations showed increases in estimates of productivity (NWFSC 2015).

Table 77. Summary of MCR Steelhead DPS status relative to the ICTRT viability criteria, grouped by MPG (NWFSC 2015)[1].



Population	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
Eastern Cascades MPG								
Fifteen Mile Creek	500	⬇ 356 (.16)	⬆ 1.84 (.19)	Moderate	Very Low	Low	Low	Maintained
Deschutes (Westside)	1,500 (1,000)	⬆ 634 (.13)	⬆ 1.16 (.15)	High	Low	Moderate	Moderate	High Risk
Deschutes (Eastside)	1,000	⬇ 1,749 (.05)	⬆ 2.52 (.24)	Low	Low	Moderate	Moderate	Viable
Klickitat River	1,000			Moderate	Low	Moderate	Moderate	Maintained
Rock Creek	500				Moderate	Moderate	Moderate	High Risk
Crooked River (ext)	2,000							Extirpated
White Salmon R.(ext)	500							Extirpated.
Yakima River MPG								
Satus Creek	1,000 (500)	⬆ 1127 (.17)	⬆ 1.93 (.12)	Low	Low	Moderate	Moderate	Viable
Toppenish Creek	500	⬇ 516 (.14)	⬇ 2.52 (.19)	Low	Low	Moderate	Moderate	Viable
Naches River	1,500	⬆ 1,244 (.16)	⬆ 1.83 (.10)	Moderate	Low	Moderate	Moderate	Moderate
Upper Yakima River	1,500	⬆ 246 (.18)	⬆ 1.87 (.10)	Moderate	Moderate	High	High	High Risk
John Day River MPG								
Lower John Day Tribs	2,250	⬇ 1,270 (.22)	⬇ 2.67 (.19)	Moderate	Very Low	Moderate	Moderate	Maintained
Middle Fork John Day	1,000	⬆ 1,736 (.41)	⬆ 3.66 (.26)	Low	Low	Moderate	Moderate	Viable
North Fork John Day	1,000	⬆ 1,896 (.19)	⬇ 2.48 (.23)	Very Low	Very Low	Low	Low	Highly Viable
South Fork John Day	500	⬆ 697 (.27)	⬆ 2.01 (.21)	Low	Very Low	Moderate	Moderate	Viable



Upper John Day	1,000	↑ 641 (.21)	1.32 (.18)	Moderate	Very Low	Moderate	Moderate	Maintained
Umatilla/Walla Walla MPG								
Umatilla River	1,500	↑ 2,379 (.11)	○ 1.20 (.32)	Moderate	Moderate	Moderate	Moderate	Maintained
Walla Walla River	1,000	↓ 877 (.13)	↑ 1.65 (.11)	Moderate	Moderate	Moderate	Moderate	Maintained
Touchet River	1,000	↓ 382 (.12)	↑ 1.25 (.11)	High	Low	Moderate	Moderate	High Risk

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

Limiting Factors

Understanding the limiting factors and threats that affect the MCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the MCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of main stem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the viability of natural population in the MCR Steelhead DPS. Historically, extensive beaver activity, dynamic patterns of channel migration in floodplains, human settlement and activities, and loss of rearing habitat quality and floodplain channel connectivity in the lower reaches of major tributaries, all impacted the MCR Steelhead DPS populations (NMFS 2016j).

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

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

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

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

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

2.2.1.14 Life-History and Status of the 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 9). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52848) (Table 9).

The UWR Steelhead DPS includes all naturally spawned anadromous winter-run steelhead originating below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (NWFSC 2015). One MPG, composed of four historical populations, comprises the UWR Steelhead DPS. Inside the geographic range of the DPS, 1 hatchery program is currently operational., though it is not included in the DPS (Table 78, Figure 25) (Jones Jr. 2015). Hatchery summer-run steelhead also occur in the Willamette River Basin but are an out-of-basin stock that is not included as part of this DPS (NMFS 2011a). As explained above in Section 2.2.1.2, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005c).

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 25) (NWFSC 2015).

Table 78. UWR Steelhead DPS description and MPGs[1].

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014 (see Table 9)
1 major population group	4 historical populations
Major Population Group	***Populations***
Willamette	South Santiam River (C,G), North Santiam River (C,G), Molalla River, Calapooia River
Artificial production	
Hatchery programs included in DPS (0)	n/a

Hatchery programs not included in DPS (1)	Upper Willamette summer (in South Santiam River, North Santiam, McKenzie, MF Willamette)

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

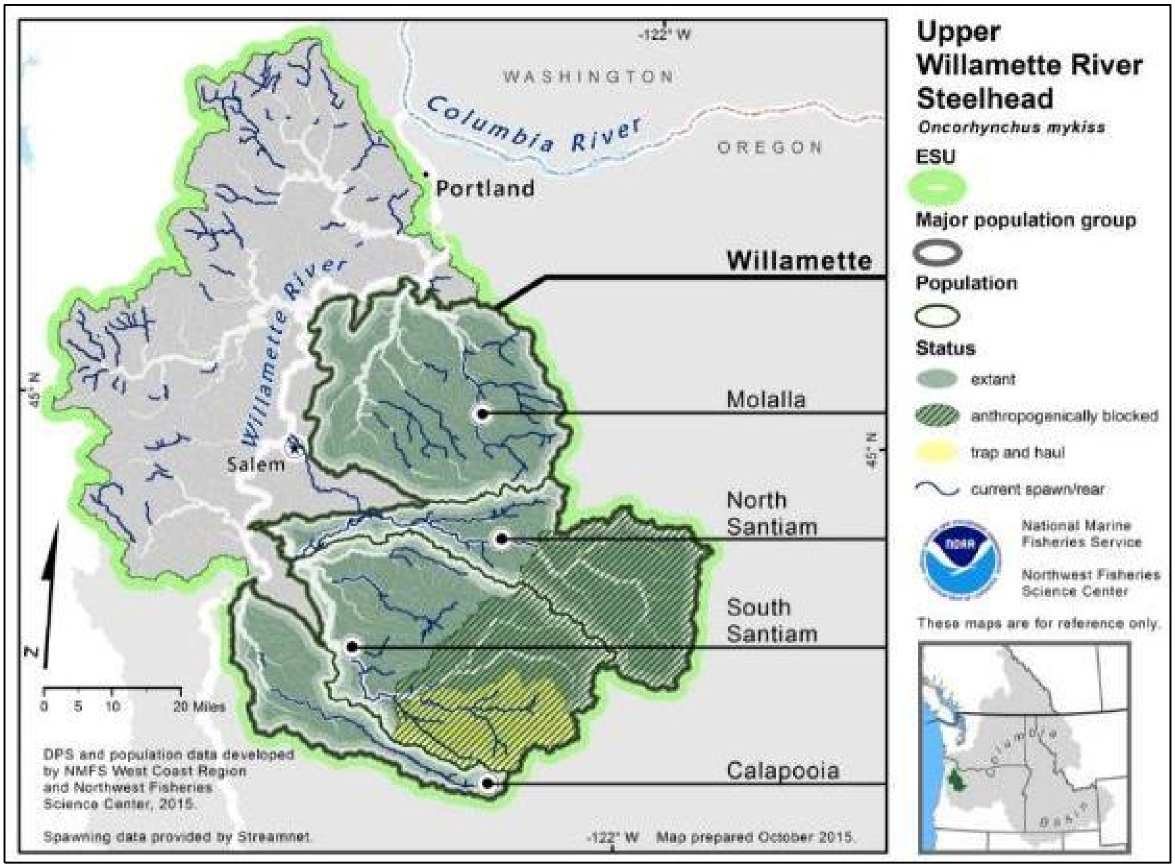


Figure 25. UWR Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).

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

Table 79 summarizes the general life history traits for UWR steelhead. This species may spawn more than once; however, the frequency of repeat spawning is relatively low. The repeat spawners are typically females that spend more than one year post spawning in the ocean and spawn again the following spring (ODFW 2010b).

Table 79. A summary of the general life history characteristics and timing of UWR steelhead (ODFW 2010b).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

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

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

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

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

Currently, the best measure of steelhead abundance is the count of returning winter-run adults to the Upper and Lower Bennett Dams for the North Santiam River population. Recent passage improvements at the dams and an upgraded video counting system have contributed to a higher level of certainty in adult estimates. The Bennett Dam counts may also approximate spawner counts, given that post-dam prespawning mortality is thought to be low for winter steelhead. Unfortunately, steelhead were not counted at Bennett Dam from 2006 to 2010, due to budget constraints. The most recent average count for unmarked (presumed native) winter steelhead (2010-1014) is 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 abundance over those years (recognizing that the 2010 return reflected good ocean conditions). In addition to steelhead spawning in the mainstem South Santiam River, annual spawning surveys of tributaries below Foster Dam (Thomas, Crabtree, and Wiley Creeks) indicate the consistent presence of low numbers of spawning steelhead (NWFSC 2015).

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

The available data on natural-origin spawner abundances for the four populations in the MPG are summarized below in Table 80.

Table 80. 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 81). The elimination of winter steelhead hatchery releases in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity. In 2011 and 2015, a 5-year review for the UWR steelhead concluded that the species should maintain its threatened listing classification (Ford 2011; NWFSC 2015).

Table 81. Scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall viability risk for UWR steelhead populations (NMFS and ODFW 2011)[1].

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

[1] All populations are in the Western Cascade Range MPG. Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016j).

Recovery strategies outlined in the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (recovery plan) (ODFW 2010b) are targeted on achieving viability criteria identified by the WLC-TRT (McElhany et al. 2003), which are used as the foundation for biological delisting criteria. Though the viability criteria relate to the biological delisting criteria, they are not identical (ODFW 2010b). The most recent status review (NWFSC 2015) determined that none of the populations are meeting their recovery goal (Table 82).

Table 82. 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.

Limiting Factors

Understanding the limiting factors and threats that affect the UWR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. The populations in this DPS have experienced long-term declines in spawner abundances, but the underlying cause(s) of these declines is not well understood (NWFSC 2015). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of main stem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the abundance, productivity, spatial structure, and diversity of the populations in this DPS (NMFS 2016j).

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

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

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

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

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

2.2.1.15 Life-History and Status of the Southern Resident Killer Whale DPS

The Southern Resident Killer Whale (SRKW) DPS (Krahn et al. 2004; Olesiuk et al. 2005; Hanson and Emmons 2010) was listed as endangered on February 16, 2006 (70 FR 69903), and critical habitat in inland waters of Washington was designated on November 29, 2006 (71 FR 69054). On February 24, 2015, NMFS announced a 12-month finding regarding a petition requesting to designate coastal critical habitat; this finding identified how NMFS intend to proceed with a revision to critical habitat and develop a proposed rule for publication in 2017 (80 FR 9682). 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 2008f).

SRKW are genetically, behaviorally, and ecologically distinct from sympatric killer whale populations and consist of three pods, identified as the J, K, and L pods. Resident killer whales, including SRKW, differ from transient and offshore killer whales as they prey exclusively on fishes and form stable pods consisting of matrilineal family groups (Ford et al. 1998; Barrett-Lennard 2000; Ford 2000; NMFS 2008f).

The life history of SRKW contributes to the population's slow growth rate. Females give birth to their first surviving calf at an average of 15 years old and males show enlarged dorsal fins that is indicative of maturity on average at 13 years of age (Olesiuk et al. 2005). Only single calves are born to mature females every 5 to 8 years following a gestation period of 17 months (Olesiuk et al. 1990; Krahn et al. 2002; Krahn et al. 2004). Females generally produce calves until they reach 38 to 45 years of age after which they enter a post-reproductive stage which has been recorded as lasting between 10 and 30 years until death.

Range, Distribution, and Diet

SRKW 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 northern British Columbia (NMFS 2008f; Hanson et al. 2013). During the spring, summer, and fall SRKW spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford 2000; Krahn et al. 2002; Hanson and Emmons 2010). During this time, pods (particularly K and L pods) make frequent trips from inland waters to the outer coasts of Washington and southern Vancouver Island, typically lasting, a few days (Ford 2000). The whales typically travel along the southern coast of Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound during these frequent trips to the outer coast. Sightings in Monterey Bay, California coincided with occurrence of salmon, with feeding witnessed in 2000 (Wiles 2004; Krahn et al. 2009). L pod was also seen feeding on unidentified salmon off Westport, Washington, in March 2004 and these fish were thought to be from the spring Chinook salmon run in the Columbia River (M. B. Hanson, personal observation as cited in (Krahn et al. 2004). In March, 2005 L pod was sighted working a circuit across the Columbia River plume from the North Jetty across to the South Jetty during the spring Chinook salmon run in the Columbia River (Zamon et al. 2007). 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).

As part of an effort to track SRKW in the winter to determine their winter habitat use, NOAA Northwest Fisheries Science Center (NWFSC) researchers, in collaboration with Cascadia Research Collective researchers, have continued a satellite tagging project that began in 2011. The researchers use location data from satellite tags deployed on SRKW to find out more about their winter migration and the extent of their geographic range. This research was recommended by an independent science panel that evaluated the available science about SRKW, their feeding habits, and the potential effects of salmon fisheries on the abundance of Chinook salmon available to SRKW (Hilborn et al. 2012). Preliminary results of the satellite tagging from 2012 to 2016 indicate the J pod has limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait. Because J pod spent very little time in coastal waters during tag deployments, we know less of their coastal distribution than we do for K and L pods. J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast; they do not appear to travel to Oregon or the California coast as K and L pods do (Hanson et al. 2013). Detection rates of K and L pods on the passive acoustic recorders indicate SRKW occur with greater frequency off the 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 SRKW movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months.

SRKW consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey (that is, a high percent of prey consumed during spring, summer, and fall, was found to be salmon in long-term studies of resident killer whale diet (Ford and Ellis 2006; Hanson et al. 2010; Hanson and Emmons 2010; Ford et al. 2016). The satellite tagging project has allowed for the collection of prey and fecal samples in the winter months. Preliminary analysis of prey remains sampled indicated the majority of prey samples were Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut. One hypothesis as to why killer whales primarily consume Chinook salmon even when they are not the most abundant salmon available, is because of the Chinook salmon's relatively high energy content (Ford and Ellis 2006). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (expressed in kcal/kg) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, it would need to consume approximately 2.7 coho salmon, 3.1 chum salmon, 3.1 sockeye salmon, or 6.4 pink salmon (O'Neill et al. 2014). SRKW 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 the SRKW' diet consists of a high percentage of Chinook salmon, with an overall average of 88% Chinook salmon across the timeframe and monthly proportions as high as >90% (Hanson et al. 2010; Ford et al. 2016). DNA quantification methods are also used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the SRKW in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples.

Abundance, Productivity, Spatial Structure, and Diversity

The historical abundance of SRKW is estimated to have ranged from 140 to 200 or more whales. The minimum historical estimate (about 140) included SRKW killed or removed from the population for public display in the 1960s and 1970s added to the remaining population at the time the captures ended. Several lines of evidence from known kills and removal numbers (Olesiuk et al. 1990), salmon declines (Krahn et al. 2002), and genetics (Krahn et al. 2002; Ford 2011) indicate that the population was larger than it is now, but there is currently no reliable estimate of the upper bound of the historical population size.

At present, the SRKW population has declined to essentially the same size it was during the early 1960s, when it was considered likely to be depleted (Olesiuk et al. 1990). The population suffered an almost 20% decline from 1996 to 2001 (from 97 whales in 1996 to 81 whales in 2001), largely driven by lower survival rates in L pod. Since then, the overall population has fluctuated but remained fairly consistent.

NMFS has continued to fund the Center for Whale Research (CWR) to conduct an annual census of the SRKW population, and census data are now available through July 2016. Between the July 2015 census count of 81 whales and July 2016, three whales died (a post-reproductive female and a young adult male from L pod and a J pod calf), and five SRKW were born (3 from J pod and 2 from L pod), bringing the number of SRKW to 83. At the end of December 2016 the population numbered 78 individuals due to deaths of five individuals from J pod. Five SRKW all from the J pod were confirmed or assumed to have died in late 2016 and early 2017. A mature female and her dependent calf were observed to be losing body condition becoming emaciated and showing the "peanut head" indentation associated with poor condition in SRKW. A second mature female and a post-reproductive female which both disappeared in late 2016 were observed in good condition before disappearing. The carcus of a deceased mature male showing signs of blunt force trauma was recovered (www.whaleresearch.com). Aside from the mature male, it is not known as to what factors contributed to their deaths. Even with the recent increase in births for the SRKW population, there is some evidence of a decline in fecundity rates through time for reproductive females. This decline is correlated with fluctuations in abundance of Chinook salmon prey, and possibly other factors.

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

Population growth is important because demographic and individual heterogeneity influences the population's long-term viability. Population-wide distribution of lifetime reproductive success can be highly variable, such that some individuals produce more offspring than others to subsequent generations, and male variance in reproductive success can be greater than that of females (Ford et al. 2011). For long-lived vertebrates such as SRKW, some females in the population might contribute less than the number of offspring required to maintain a constant population size (n = 2), while others might produce more offspring. The smaller the population, the greater effect an individual's reproductive success has on the population's growth or decline (McLoughlin et al. 2006). This further illustrates the risk of demographic stochasticity for a small population like SRKW – the smaller a population, the greater the chance that random variation will result in too few successful individuals to maintain the population.

Limiting Factors

Several factors identified in the final recovery plan for SRKW may be limiting recovery including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact SRKW. Although it is not clear which threat or threats are most significant to the survival and recovery of the SRKW DPS, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008f).

NMFS has implemented conservation measures and has also convened an independent science panel to critically evaluate the effects of salmon fisheries on the abundance of Chinook salmon available to SRKW. Overall, the panel concluded that the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to SRKW is not clear, and cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn et al. 2012). NMFS has also been developing a risk assessment framework relating Chinook salmon abundance to SRKW population dynamics that will help evaluate the impacts of salmon management on the whales. At this time, development of the framework is on a coast-wide scale and intended for broad applicability across actions that impact salmon. NMFS' work to develop the risk assessment for this purpose currently remains ongoing.

As described in Sections 2.2.1.2 through 2.2.1.6, the majority of the Chinook salmon stocks available to the SRKW are depressed or declining (Ford et al. 2016). Additionally, the population structure of salmon populations has shifted towards younger and smaller returning adults (Hilborn et al. 2012). Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to

SRKW. Because SRKW predominantly prey on Chinook salmon as discussed above, Chinook salmon abundance is correlated with the population growth rate of SRKW.

Currently, hatchery production is a significant component of the salmon prey base returning to watersheds within the range of SRKW (Barnett-Johnson et al. 2007; NMFS 2008e; PFMC 2011c). Although hatchery production has contributed some offset of the historical declines in the abundance of natural-origin salmon within the range of SRKW, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007). Healthy natural-origin salmon populations are important to the long-term maintenance of prey populations available to SRKW because it is uncertain whether a hatchery dominated mix of stocks is sustainable indefinitely and because hatchery fish can differ, relative to natural-origin Chinook salmon, for example, in size and hence caloric value and in availability/migration location and timing. However, the release of hatchery fish has not been identified as a threat to the survival or persistence of SRKW. It is possible that hatchery produced fish may benefit SRKW by enhancing prey availability as scarcity of prey is the greatest threat to SRKW survival and hatchery fish often contribute to the salmon stocks consumed by SRKW (Hanson et al. 2010).

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

Killer whales are exposed to persistent pollutants primarily through their diet. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the killer whale’s blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons. The release of pollutants can also occur during gestation or lactation. High levels of these pollutants have been measured in blubber biopsy samples from SRKW (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009), and more recently, these pollutants were measured in fecal samples collected from SRKW providing another potential opportunity to evaluate exposure to these pollutants (Lundin et al. 2016a; Lundin et al. 2016b). High levels of persistent pollutants within SRKW have the potential to affect the killer whales’ endocrine and immune systems and reproductive fitness (Krahn et al. 2002).

In April 2015, NMFS hosted a 2-day SRKW health workshop to assess the causes of decreased survival and reproduction in the killer whales. Following the workshop, a list of potential action items to better understand what is causing decreased reproduction and increased mortality in this population was generated and then reviewed and prioritized to produce the Priorities Report

(NMFS 2015d). The report also provides prioritized opportunities to establish important baseline information on SRKW and reference populations to better assess negative impacts of future health risks, as well as positive impacts of mitigation strategies on SRKW health.

As described in NMFS 2011, vessel activities may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. Noise levels that SRKW experience are largely determined by the speed of the vessel and reducing vessel speed is recommended to reduce noise exposure (Houghton et al. 2015). In 2011, NMFS announced final regulations to protect SRKW in the coastal waters of Washington State from the effects of various vessel activities (50 CFR 224.103(e)). NMFS is currently using the 5 years of data from monitoring groups and several years of data from the NWFSC acoustic tagging program to evaluate the effectiveness of these regulations.

2.2.2 Status of Critical Habitat

This Section of the Opinion examines the range-wide status of designated critical habitat for the affected salmonid and killer whale species. NMFS has reviewed the status of critical habitat affected by the Proposed Action. Within the Action Area (defined above in Section 1.4, Action Area), critical habitat is designated for those species in Table 9. Critical habitat for these species includes the stream channels within designated stream reaches and a lateral extent, as defined by the ordinary high-water line (33 CFR 319.11).

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

For salmon and steelhead, NMFS categorized watersheds as high, medium, or low in terms of the conservation value that the watersheds provide to each listed species they support[16] within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC_5). To determine the conservation value of each watershed to species viability, NMFS's critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (i.e., spawning gravels, wood and water condition, side channels), the relationship of the specific geographic area being examined compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005a). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential because of factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution to the population it served (e.g., for a population at the extreme end of geographic distribution), or the fact that it serves another important role besides providing habitat (e.g., obligate area for migration to upstream spawning areas).

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

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

NMFS determines the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The species in Table 9 have overlapping ranges, similar life history characteristics, and, therefore, many of the same PCEs. While Pacific eulachon differ slightly in their life history characteristics, they evolved together and co-exist, successfully, with other anadromous salmon and steelhead species in areas throughout the Action Area utilizing similar PCEs. These PCEs include sites essential to support one or more life stages (spawning, rearing, and/or migration) and contain the physical and biological features essential to the conservation of each species. For example, important features include spawning gravels, forage species, cover in the form of submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

The complex life cycle of many salmonids gives rise to complex habitat needs, particularly when the salmonids are in freshwater. ESU's or DPS's specific needs are captured in each general life history characteristic table in Sections 2.2.1.1 through 2.2.1.15. For each species, the gravel they utilize for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need in-stream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold water springs and deep pools. Returning adults generally do not feed in fresh water, but instead, rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b).

The watersheds within the Action Area (as described in Section 1.4) have been designated as essential for spawning, rearing, juvenile migration, and adult migration for many of the listed species in Table 9. Specific major factors affecting PCEs and habitat related limiting factors within the Action Area are described for each species in Sections 2.2.1.1 through 2.2.1.15. However, across the entire Action Area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

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

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

SRKW also have defined critical habitat, which was designated in 2006 (71 FR 69054, November 29, 2006). Critical habitat consists of three specific areas: 1. The Summer Core Area in Haro Strait and waters around the San Juan Islands; 2. Puget Sound; and 3. the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the SRKW and their habitat needs, NMFS identified the following physical or biological features of critical habitat that are 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. As discussed in the Status of Species Section, the current condition all three of these biological features essential to conservation are limiting survival and growth of SRKW.

On January 21, 2014, NMFS received a petition to revise critical habitat for SRKW, which cited recent information on the SRKW habitat use along the West Coast of the United States. The petitioner, the Center for Biological Diversity, requested that the critical habitat designation be revised and expanded to include areas of the Pacific Ocean between Cape Flattery, WA, and Point Reyes, CA, extending approximately 47 miles (76 km) offshore. NMFS published a 90-day finding on April 25, 2014 (79 FR 22933) that the petition contained substantial information to support the proposed measure and that NMFS would further consider the action and also solicited information from the public.

On February 24, 2015 NMFS issued a 12-month finding based upon a review of public comments and the available information, which described how NMFS intends to proceed with the requested revision. NMFS identified next steps that must be followed to support the development of a proposed rule, including completing data collection and analysis, identifying areas meeting the definition of critical habitat, completing a Section 4(b)(2) analysis under the ESA, and developing a proposed rule for public comment. NMFS is in the process of working through these steps and is planning to publish a proposed rule to revise SRKW critical habitat in 2017.

As part of the Proposed Action no new permanent facilities are being proposed for these hatchery programs. The installation and operation of temporary weirs will result from implementation of the Proposed Action and may affect PCEs for rearing and freshwater migration. However, these factors are considered in the effects analysis below (Section 2.4). Furthermore, the effects of operation of hatchery facilities, as a result of funding provided through implementation of the Proposed Action, on floodplain connectivity, sediment input, water temperature effects, channel morphology and stability, and access to spawning and rearing habitat are also considered in the effects analysis.

Willamette/Lower Columbia Recovery Domain

NMFS has designated critical habitat in the WLC recovery domain for the UWR spring-run Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, UWR Steelhead DPS, CR Chum Salmon ESU, and the Pacific Eulachon Southern DPS (Table 9). This recovery domain is described in Section 1.4. In addition to the Willamette River and Columbia River mainstems, important tributaries to the WLC are listed in Table 7 for both Oregon and Washington. Most watersheds have some or a high potential for improvement and the only watersheds in good to excellent condition with no potential for improvement are the watersheds in the upper McKenzie River and its tributaries (NMFS 2016j).

Land management activities have severely degraded stream habitat conditions in the Willamette River mainstem above Willamette Falls and in associated subbasins. In the Willamette River mainstem and lower subbasin mainstem reaches, high density urban development and widespread agricultural effects have reduced aquatic and riparian habitat quality and complexity, and altered sediment composition and water quality and/or quantity, and watershed processes. The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75% since before modern development began. In addition, the construction of 37 dams in the basin blocked access to more than 435 miles of stream and river habitat, including much of the best spawning habitat in the basin. The dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally-spawned eggs and fry. Logging, agriculture, urbanization, and gravel mining in the Cascade and Coast Ranges have contributed to increased erosion and sediment loads throughout the WLC domain (NMFS 2016j).

On the mainstem of the Columbia River, hydropower projects, including the FCRPS, have significantly degraded salmon and steelhead habitats. The series of dams and reservoirs that make up the FCRPS block an estimated 12 million cubic yards of debris and sediment that would otherwise naturally flow down the Columbia River and replenish shorelines along the Washington and Oregon coasts. The Columbia River estuary has lost a significant amount of the tidal marsh and tidal swamp habitats that are critical to juvenile salmon and steelhead, particularly small or ocean-type species as a result of the FCRPS modifications to these mainstem river processes. Furthermore, habitat and food-web changes within the estuary, and other factors affecting salmon population structure and life histories, have altered the estuary's capacity to support juvenile salmon (NMFS 2016j).

Interior Columbia Recovery Domain

Critical habitat has been designated in the IC recovery domain, which includes the Snake River Basin, for the Snake River spring/summer-run Chinook Salmon ESU, Snake River fall-run Chinook Salmon ESU, UCR spring-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, MCR Steelhead DPS, UCR Steelhead DPS, and Snake River Basin Steelhead DPS (Table 9). Major tributaries relative to the IC recovery domain are listed in Table 1 for areas where the WLC and IC overlap, as well as tributaries specific just to the IC upstream into Oregon, Washington, and Idaho. This large and diverse recovery domain is described in Section 1.4. In Washington, the Upper Methow, Lost, White, and Chiwawa watersheds are in good-to-excellent condition with no potential for improvement. In Oregon, only the Lower Deschutes, Minam, Wenaha, Upper and Lower Imnaha Rivers HUC_5 watersheds are in good-to-excellent condition with no potential for improvement. In Idaho, some watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, MF Salmon, Little Salmon, Selway, and Lochsa Rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (NMFS 2016j).

Habitat quality in tributary streams in the IC recovery domain varies from excellent in wilderness and road-less areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the IC recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the IC recovery domain (NMFS 2016j).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in higher water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016j).

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016j). They can negatively impact critical habitat and the organisms associated with these areas.

Estuaries

Critical habitat has been designated in the estuary of the Columbia River for every species listed in Table 9. This area is described in Section 1.4. Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to 2 miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008h).

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

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

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

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

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

2.2.3 Climate Change

One factor affecting the rangewide status of species in Table 9, and aquatic habitat at large is climate change. Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007a). Average annual Northwest air temperatures have increased by approximately 1ºC since 1900, or about 50% more than the global average over the same period (ISAB 2007a). The latest climate models project a warming of 0.1 ºC to 0.6 ºC per decade over the next century. According to the Independent Scientific Advisory Board (ISAB), these effects pose the following impacts over the next 40 years:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

- With a smaller snowpack, these watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007a).

To mitigate for the effects of climate change on listed salmonids, the ISAB (2007a) recommended in 2007 to prepare for future climate conditions by implementing protective tributary, main stem, and estuarine habitat measures, as well as protective hydropower mitigation measures. In particular, the ISAB (2007a) suggests increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in main stem reservoirs and the estuary; and the protection and restoration of riparian buffers, wetlands, and floodplains.

While planning for future general effects, it is important to note that climate change is already actively altering environments around the globe as temperature and precipitation patterns change and become more variable. The year 2015 broke numerous global records, including the highest greenhouse gas concentration and highest land and sea surface temperatures ever recorded (Blunden and D.S. Arndt 2016). The year 2016 surpassed global temperature records set in 2015 (NOAA website, http://www.ncdc.noaa.gov/cag)[17], and has already set records for minimum sea ice extent in the Arctic (2nd lowest on record) and maximum sea ice extent in the Antarctic (lowest on record; http://nsidc.org/arcticseaicenews).

Projections of how earth's climate will continue to change depend on the rate of anthropogenic emissions. By the end of the 21st century, global temperatures are expected to increase by 0.3°C (with reduced emissions), to 4.8°C (high emissions) from the present, with more frequent extreme hot temperatures and fewer extreme cold temperatures (IPCC 2014). Precipitation is also expected to change, with some areas becoming wetter and others drier. Extreme precipitation events will very likely become more intense and more frequent (IPCC 2014). In the ocean, global sea level is expected to rise by 0.3 m (low emissions) to 0.9 m (high emissions) by the end of the century. The oceans are also expected to become more acidic as more CO_2 is absorbed by the world's oceans (IPCC 2014).

In the Pacific Northwest (defined as southern British Columbia, Washington, and Oregon) likely some air and stream temperature changes due to climate change have already occurred. The current status and viability of anadromous ESA-listed animals reflect these effects. Both air and stream temperatures are expected to increase by roughly 2°C by 2040 (Mote and Eric P. Salathé Jr. 2010; Beechie et al. 2013; PCIC 2016). There is likely no trend in precipitation over this period (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).

In marine waters of the Pacific Northwest, sea surface temperatures (SSTs) are expected to increase by 1.2°C by 2040 (Mote and Eric P. Salathé Jr. 2010) and up to 2°C in northern British

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[17] Pending final analysis for December 2016 data and possible error corrections. This information won't be final till the first quarter of 2017, but is unlikely to change drastically in scale.

Columbia and Alaska (Hollowed et al. 2009; Foreman et al. 2014). Increased temperatures will increase water column stratification, which can be beneficial for productivity in northern areas but detrimental in southern areas (Gargett 1997). Effects of climate change on the timing and intensity of ocean upwelling, which brings nutrient-rich waters to the surface in coastal areas of the California Current, are poorly understood with some climate models show upwelling will be delayed in the spring and become more intense in the summer, while others show it largely unchanged (Bakun et al. 2015; Rykaczewski et al. 2015). Our intent with this summary is not to provide an exhaustive review of what is known about current conditions contributing to current status delineations, but instead to provide an overview, with a particular emphasis on environmental factors that are important to anadromous fish productivity and survival. In many cases, current environmental conditions are outside the range of observations, therefore their biological effects are difficult to predict. Only in hindsight will we be able to tell how these conditions affected survival and these effects are discussed here to ensure that it's understood they are incorporated into status levels.

Climate change and Pacific Northwest salmon

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

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

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

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Temperature Effects

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

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

Freshwater Effects

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

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

Estuarine Effects

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

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

Marine Impacts

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

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

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

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

California Current

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

Gulf of Alaska

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling[18] and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

Ocean acidification

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish (see reviews by Haigh et al. (2015); Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015).

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[18] Downwelling occurs when wind causes surface water to build up along a coastline and the surface water eventually sinks toward the bottom (http://oceanservice.noaa.gov/facts/upwelling.html).

Uncertainty in climate predictions

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

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

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

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

In conclusion, the current literature supports previous concerns that natural climatic variability can amplify and exacerbate long-term climate change impacts. Recent estimates of rates of climate change are similar to those previously published. Anthropogenic climate change will likely to varying degrees effect all west coast anadromous fish species, especially when interacting factors are incorporated (e.g., existing threats to populations, water diversion, accelerated mobilization of contaminants, hypoxia, and invasive species). However, through historic selective processes anadromous fish have adapted their behavior and physiology to inhabit available habitat ranging from southern California up to the Alaskan western coastline. This process by which Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments required a certain degree of plasticity, and may show resilience to future environmental conditions that mimic this natural variation. While climate change effects will certainly result in changes, it is unlikely that specifics are possible to predict. Alternate life history types, such as those associated with extended lake or estuarine rearing, provide an important component of the species diversity with which to guard against an uncertain future. However, the life history types that will be successful in the future is neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is essential for continued existence of populations into the future (Schindler et al. 2010; Bottom et al. 2011).

Climate Change and Marine Mammals

The effects of climate change on marine species including the SRKW is not definitively known, however, it is likely that any changes in weather and ocean conditions effecting salmon populations would have consequences for fish-eating SRKW (NMFS 2008f). Warming water and air temperature trends are ongoing and are expected to disrupt annual precipitation cycles, alter prevailing patterns of wind and ocean currents, and raise sea levels (Glick 2005; Snover et al. 2005). Together with increased acidification of ocean waters, these changes are expected to have substantial effects on marine productivity and food webs, including populations of salmon and other killer whale prey (NMFS 2008f). Climate change could result in changes to migration patterns, alteration of ecological community composition and structure as species relocate from areas they currently use in response to changes in oceanic conditions, changes in species abundance, increased susceptibility to disease and contaminants, alterations to prey composition and availability, and altered reproductive timing (MacLeod et al. 2005; Robinson et al. 2005; McMahon and Hays 2006). Such changes could affect reproductive success and survival, and therefore would have consequences for the survival and recovery of SRKW (Robinson et al. 2005; Learmonth et al. 2006; Cotte´ and Guinet 2007). Naturally occurring climatic patterns, such as the Pacific Decadal Oscillation and El Niño and La Niña events, cause major changes to marine productivity and may also influence SRKW prey abundance (Mantua et al. 1997; Francis and Hengeveld 1998; Beamish et al. 1999; Hare et al. 1999; Benson and Trites 2002; Dalton et al. 2013). Prey species such as salmon are most likely to be affected through changes in food availability and oceanic survival (Benson and Trites 2002), with biological productivity increasing during cooler periods and decreasing during warmer periods (Hare et al. 1999; NMFS 2008f).

2.3 Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

In order to understand what is affecting a species, it is first necessary to understand the biological requirements of the species. Each stage in a species' life-history has its own biological requirements (Groot and Margolis 1991; NRC 1996; Spence et al. 1996). Generally speaking, anadromous fish require clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100% saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling. Embryo survival and fry emergence depend on substrate conditions (e.g., gravel size, porosity, permeability, and oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 13ºC or less. Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting. Migration of juveniles to rearing areas, whether the ocean, lakes, or other stream reaches, requires free access to these habitats.

Wide varieties of human activities have affected the ESA listed animals in Table 9 and PCEs in the Action Area. The quality and quantity of habitat throughout the Columbia River Basin has declined dramatically in the last 150 years. The current state of the Action Area baseline originates from hydropower system effects, tributary habitat effects, estuary and plume habitat effects, predation and disease effects, hatchery effects, harvest effects, and large-scale environmental factors. In general, Columbia River anadromous species have been adversely affected by a broad number of human activities including habitat losses from all causes (population growth, urbanization, roads, diking, etc.), fishing pressure, flood control, irrigation dams, pollution, municipal and industrial water use, introduced species, and hatchery production (NRC 1996). In addition, these species have also been strongly affected by ocean and climate conditions.

The discussion of the environmental baseline for this action takes place in the greater context of the environmental baseline discussed in detail in Chapter 5 of the SCA, which NMFS hereby incorporates by reference (NMFS 2008h, Chapter 5). Chapter 5 of the SCA provides an analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats and ecosystems, within the entire Columbia River Basin. In addition to Chapter 5 of the SCA, the environmental baseline for this Opinion is updated to include by reference, relevant actions and their effects from the FCRPS and Reclamation Opinion (NMFS 2008d), the Opinion evaluating the effects of federal and non-federal hatchery programs that collect, rear and release unlisted fish species in the Columbia River Basin (NMFS 1999a), the Opinion evaluating Fisheries Management and Evaluation Plans (FMEPs) submitted by the WDFW and the ODFW for recreational fisheries in tributaries to the LCR affecting LCR ESA-listed species under Limit 4 of the ESA 4(d) Rule (50 CFR 223.203(b)(4))(65 FR 42422, July 10, 2000) (NMFS 2003b), and the Opinion associated with the *U.S. v Oregon* Columbia River Fisheries Management Agreement (CRFMA) (NMFS 2008e).

The following discussion reviews recent developments in each of the sectors, and outlines their anticipated impacts on natural conditions and the future performance of the listed ESUs and DPSs affected by the Proposed Action.

2.3.1 Climate Change

In the Status of Listed Species, Section 2.2.1, local-scale climate effects were listed as a limiting factor for the majority of the species.

2.3.2 Hydropower System

The Columbia River Basin has more than 450 dams, which are managed for hydropower, flood control, and other uses. Together, these dams provide active storage of 42 million acre-feet of water, with dams in Canada accounting for about half of the total storage (Northwest Power and Conservation Council 2001, as cited in NMFS 2011c). Within the U.S., 14 multi-purpose hydropower projects operate as a coordinated system in the Columbia River Basin. Bonneville Dam is the only mainstem hydropower facility within the geographic range of LCR salmon and steelhead populations, but flow management operations at large storage reservoirs in the interior of the Columbia River Basin (Grand Coulee, Dworshak, etc.) affect habitat in the LCR mainstem and estuary, and, potentially, the Columbia River plume. In addition, large tributary hydropower dams are located on the Cowlitz and Lewis Rivers in Washington and on the Willamette, Clackamas, and Sandy Rivers in Oregon. Condit Dam, on the White Salmon River in Washington was breached in October, 2011 and completely removed by September, 2012. The impacts of hydropower facility constructions and operations on LCR salmon and steelhead populations occur both locally (at the projects as well as upstream and downstream) and downstream, in the Columbia River estuary and, potentially, the plume (NMFS 2013e).

The Action Area, as described in Section 1.4, includes multiple watersheds that have no hydropower impacts that affect specific anadromous ESUs and DPSs. Smaller dams—even temporary dams—have had similar effects as mainstem dams, though on much smaller scales. Overall, 11 mainstem dams exist on the Columbia River, starting at the Bonneville Dam and going upstream to the U.S. border with Canada. The largest tributary to the Columbia River is the Snake River; there are an additional 4 dams that are passable by anadromous fish on the Snake River, and there is no passage beyond Brownlee Dam (Hells Canyon Complex). On the North Fork Clearwater River (a tributary to the Snake River in northern Idaho), there is no passage beyond the Dworshak Dam. Some notable tributary dams that also act as complete barriers for anadromous fish passage include Merwin, Yale, Swift, Mayfield, and Mossyrock Dams. These tributary dams exist downstream of Bonneville dam.

Here, NMFS incorporates, by reference, the environmental baseline in its Opinions for PacifiCorp and Cowlitz Public Utility District operating the Lewis River Hydroelectric Projects NMFS 2007 and Tacoma Power operating the Cowlitz River Hydroelectric Project (NMFS 2004b). Furthermore, the loss of habitat from irrigation and hydropower dams on the Cowlitz and Lewis Rivers have substantially reduced the available spawning and rearing habitat for the listed species located in both watersheds. Hydropower projects in both rivers impede downstream migration, for both outmigrating salmon and steelhead smolts and adults falling back over the dams.

Dams have inhibited or delayed anadromous fish from reaching their spawning and rearing habitats. Those dams without adequate fish passage systems have extirpated anadromous fish from their pre-development spawning and rearing habitats. Also, dams have greatly altered the river environment and have affected fish passage (NMFS 2008g). For example, smolts migrate through mainstem hydroelectric projects through turbines, fish ladders, spillways, navigation locks, and smolt passage facilities (Witty et al. 1995). The hydrologic process of the river (i.e., sediment transport, temperature control, overall velocity) is altered by dams, therefore, even if a fish does not encounter that specific dam (migrating below or above), migration may still be impacted by altered flows.

When smolts are collected or bypassed using smolt passage facilities, crowding can occur (Witty et al. 1995). Crowding is caused directly by the total number of fish collected, the size of the fish, and the operation of fish passage facilities. Competition for space due to crowding is likely a problem for large numbers of fish collected in gatewells before they are able to exit, in addition to congregation during passage through pipes (Witty et al. 1995). These large numbers of migrants (hatchery- and natural-origin) may lead to crowding effects, ultimately delaying or inhibiting fish migration.

Many of these hydropower system specific limiting factors were previously described in each species' status Section (see Sections 2.2.1.1 through 2.2.1.15). In this Section, NMFS reviews those specifically related to hydropower, which was defined as a limiting factor for each species. Anywhere hydropower exists, some general effects exist, 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 at the eight run-of-river mainstem dams on the mainstem Snake and Columbia Rivers (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)

These hydro projects affect the ESU/DPSs described in Sections 2.2.1.1 through 2.2.1.15 in varying degrees. Broad scale differences between the two categories are described below.

The FCRPS is a series of multi-purpose, hydroelectric facilities constructed and operated by the U.S. Army Corps of Engineers (COE) and the U.S. Bureau of Reclamation (BOR). These facilities are located throughout the Pacific Northwest. A transmission system was constructed and is operated by the BPA to market and deliver electric power. Columbia River Basin anadromous salmonids and their migration, rearing, and in some cases spawning habitat, have been affected by the development and operation of the FCRPS. General information on the effects of past and continuing operation of these dams and reservoirs, including effects on flow from FCRPS water storage projects in British Columbia can be found in the environmental baseline section of the SCA for the 2008 FCRPS Biological Opinion (NMFS 2008h), in NMFS

"Recovery Plan Module for Mainstem Columbia River Hydropower Projects" (NMFS 2008g), and in its 2014 Supplement for Snake River species (NMFS 2014g).

NMFS has been consulting on the effects of the FCRPS since the first salmonid species in the basin was listed under the ESA in 1992 (Snake River sockeye salmon). The most recent set of consultations produced the 2008 FCRPS Opinion (2008 Opinion). Since the 2008 Opinion, which addressed effects on the species and critical habitat for 13 salmon ESUs and steelhead DPSs, in addition to eulachon, green sturgeon, and the Southern Resident killer whale, NMFS has supplemented that Opinion. In 2010 and 2014, NMFS supplemented the 2008 Opinion. In 2014 the court directed NMFS and the FCRPS Action Agencies (USACE[19], BOR, and the BPA) to keep the 2014 Opinion and its incidental take statement in place and also directed the Action Agencies to continue to fund and implement the 2014 Opinion until a 2018 Opinion is prepared and filed. The extent to which the negative effects described above limit the viability of each species or limit the functioning of designated critical habitat varies as described in NMFS (2008d); 2008h).

The Federal Energy Regulatory Commission (FERC) licenses mainstem Columbia River hydroelectric projects owned and operated by Douglas Public Utility District (PUD) (Wells Dam at RM 515 and its reservoir), Chelan PUD (Rocky Reach and Rock Island at RMs 473 and 453, respectively), and Grant PUD (Wanapum and Priest Rapids; RMs 415 and 379, respectively). The FERC also licenses hydroelectric projects owned and operated by PacifiCorp on the Lewis River and by Tacoma PUD on the Cowlitz River, with both rivers being tributaries to the Columbia River below Bonneville Dam.

The mainstem Columbia River serves as a migration corridor for juvenile and adult salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow, altered its seasonality, and reduced sediment discharge and turbidity (Simenstad et al. 1982; Sherwood et al. 1990; Weitkamp 1994; NRC 1996). Flow affects juvenile travel time to reach the ocean and the distribution of individuals among the various routes of dam passage. In general, the lower the flow through the mainstem reservoirs, the longer juveniles remain in project reservoirs, the longer the juveniles take to travel out to the ocean, and the greater their exposure to predation, elevated temperatures, disease, and other sources of mortality and injury.

Effects of Hydropower on Species summaries

The following Sections contain updated environmental baseline information specific to the hydropower effects according to the previous analyses on the effects of the FCRPS for each individual species, as not all of the effects are equal or present across varying geographic ranges. All text below is referenced originally from NMFS (2008d) with updates where new science is available (except for Pacific Eulachon, see NMFS (2014b).

Pacific Eulachon:

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[19] U.S. Army Corps of Engineers

Eulachon, which is an anadromous species, uses the mainstem Columbia River within the Action Area to migrate to spawning grounds as adults and to emigrate from freshwater into marine waters as larvae. Aquatic habitats have been significantly modified in the LCR by a variety of anthropogenic activities, including dams and water diversions, dredging, urbanization, agriculture, silviculture, and the construction and operation of port and shipping terminals. Since the development of the Canadian and FCRPS storage projects in the UCR Basin (1940s through 1970s), water is stored during spring and released for power production and flood control during winter, shifting the annual hydrograph. Water withdrawals and flow regulation in the Columbia River Basin have reduced the average flow, altered its seasonality, and altered sedimentation processes and seasonal turbidity events, e.g., estuary turbidity maximum (NMFS 2014b). Water withdrawals and flow regulation have significantly affected the timing, magnitude, and duration of the spring freshet through the Columbia River estuary such that they are about one-half of the pre-development levels (NMFS 2008d), all of which are important for eulachon adult, larval, and egg life stages.

LCR Chinook Salmon:

Direct mainstem hydropower system impacts on LCR Chinook salmon are most significant for the five gorge tributary populations upstream from Bonneville Dam, all of which are within the Gorge Fall (Upper Gorge, White Salmon, Hood) and Gorge Spring MPGs (White Salmon and Hood). These populations are affected by upstream and downstream passage at Bonneville Dam and important spawning habitat in the lower reaches of the tributaries used by the Upper Gorge fall run population that was inundated by Bonneville pool. Federal hydropower impacts on populations originating in downstream subbasins are limited to effects on migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary.

UCR spring-run Chinook Salmon:

UCR spring-run Chinook salmon uses need spawning sites with water quantity and quality and particular substrate supporting spawning, incubation and larval development; they also need to use rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that help ensure their survival. The following are the major factors that have limited the functioning of, and thus, the conservation value of habitat types used by UCR spring-run Chinook salmon for spawning and rearing:

- Physical passage barriers (i.e., mortality at hydroelectric projects in the mainstem Columbia River through water withdrawals and unscreened diversions);

- Excess sediment in spawning gravels and in substrates that support forage organisms (i.e., land and water management activities); and

- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures (i.e., degraded riparian and channel function).

Factors that have limited the functioning and conservation value of habitat in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers (i.e., push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles);
- Juvenile and adult passage mortality (i.e., hydropower projects in the mainstem Columbia River);
- Pinniped predation on adults due to habitat changes in the lower river (i.e., existence and operation of Bonneville Dam); and
- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators (i.e., Caspian terns and double-crested cormorants).

In the mainstem FCRPS migration corridor, the FCRPS Action Agencies have improved safe passage through the hydropower system for yearling Chinook salmon with the construction and operation of surface bypass routes at LGR, Ice Harbor, and Bonneville Dams and other configuration improvements listed in Section 5.3.1.1 of USACE (2007). NMFS reauthorized the states of Oregon, Washington, and Idaho to continue the lethal removal of certain individually identified California sea lions that prey on adult spring-run Chinook salmon in the tailrace of Bonneville Dam. This authorization covers the removal for five years, through June 30, 2021 (NMFS and NOAA 2016). Between 2008-2015, sea lions had a negative impact on survival for spring Chinook salmon populations at the tailrace of Bonneville Dam, by a 1.7% reduction, on average, from their base survival period (USACE 2016).

Snake River spring/summer-run Chinook Salmon:

More than 80% of the historic range of Snake River fall-run Chinook salmon, including primary spawning and rearing areas, is blocked by dams. For the remaining accessible habitat, several hydropower-related activities have improved the functioning of habitat for spawning and rearing. Since 1991, Idaho Power Company (IPC) has stabilized outflows from Hells Canyon Dam starting in late October and November to provide water for redds established during that period through their emergence in April. However, if rearing fry move to the shallow river margin, they can become entrapped in several pool complexes.

- Physical passage barriers (i.e., culverts; push-up dams; low flows);
- Reduced tributary stream flow (i.e., limits usable stream area and alters channel morphology by reducing the likelihood of scouring flows [water withdrawals]);
- Altered tributary channel morphology (i.e., bank hardening for roads or other development and livestock on soft riparian soils and streambanks);
- Excess sediment in gravel (i.e., roads; mining; agricultural practices; livestock on soft riparian soils and streambanks, and recreation) [20]; and

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[20] In some subbasins (e.g., Middle Fork and Upper Salmon), high levels of sediment in gravel are due, at least in part, to the geologically unstable nature of the watershed.

Degraded tributary water quality, including high summer temperatures and in some cases, chemical pollution from mining (i.e., water withdrawals; degraded riparian condition).

Snake River fall-run Chinook Salmon:

Several hydropower-related activities have improved the functioning of habitat for spawning and rearing of the Snake River fall-run Chinook salmon. Since 1991, IPC has voluntarily stabilized outflows from Hells Canyon Dam starting late October and November to provide water for redds established during that period through their emergence in April. However, if rearing fry move to the shallow river margin, they can become entrapped in several pool complexes.

Factors limiting the functioning, and thus, conservation value of habitat in the available spawning areas (i.e., affecting water quality, water quantity, space, and/or spawning gravel) are:

- In the Hells Canyon Reach of the mainstem Snake River—changes in:
    - river flow (i.e., reductions in flow entrap and strand fry);
    - temperature regime (i.e., warmer in fall when adults arrive for spawning and cooler during the spring incubation period due to the existence and operation of IPC's Brownlee reservoir [Hells Canyon complex], which may delay the emergence of fry production by later spawning adults); and
    - dissolved oxygen (i.e., episodic low dissolved oxygen conditions can persist into early fall when adult fish arrive and stage for spawning).

In the LCR and estuary—diking and reduced peak spring flows have eliminated much of the shallow water and low velocity habitat (i.e., agriculture and other development in riparian areas).

UWR Chinook Salmon:

The COE operates 13 dams in the largest five tributaries to the Willamette River for flood control, irrigation, and hydropower. Major habitat blockages for UWR Chinook salmon resulted from Big Cliff and Detroit Dams on the North Fork Santiam River, Cougar Dam on the McKenzie River, Hills Creek and Dexter/Lookout Point on the MF Willamette River (all of which were built in approximately 1952), and from Green Peter Dam on the South Fork Santiam River, built in approximately 1967. Historically, fish primarily spawned in habitat above these dams, the best spawning and rearing habitat is located upstream of the dams. In addition to blocking spring-run Chinook salmon access to historical habitat, these dams affect flows, water quality, sediment transport, and channel structure in the mainstem and in the South and North Santiam, McKenzie, and MF Willamette Rivers where spring-run Chinook salmon are present. Flow storage, release operations, and, to a lesser extent, irrigation withdrawals have altered temperatures and channel-forming processes.

UWR Chinook salmon also pass by several FERC hydropower projects: Willamette Falls on the lower mainstem Willamette River; City of Albany/Lebanon Dam on the South Santiam River; Stayton, Water Street, and Ferry projects on the North Santiam River; the decommissioned Thompson Mills on the Calapooia River; and the Eugene Water and Electric Board's (EWEB)

Leaburg-Walterville Project on the McKenzie River. Except for the Stayton project, which is currently shut down, all of these FERC projects have recently or will soon install improved fish screens, ladders, and in some cases, tailrace barriers, thereby reducing adverse effects on UWR Chinook salmon. EWEB worked with NMFS, other resource agencies, and local tribes to reach agreement on a reintroduction plan that would ensure upstream and downstream passage for UWR Chinook salmon (and bull trout)[21]. FERC may issue the new license by the end of 2017, and, then EWEB would complete construction of fish passage facilities about 3 years later (Michael McCann, EWEB, letter sent to Kimberly Bose, FERC. May 19, 2016, regarding Carmen-Smith hydroelectric project progress).

It is highly unlikely that fish from this ESU encounter FCRPS mainstem projects. Therefore, the impacts on UWR populations from the FCRPS projects are limited to effects on migration and habitat conditions in the LCR (below the confluence of the Willamette), including the estuary.

LCR Coho Salmon:

Direct mainstem hydropower system impacts on LCR coho salmon are most significant for the two gorge tributary populations upstream from Bonneville Dam, both of which are in the Gorge MPG: Upper Gorge/White Salmon in Washington, and Upper Gorge/Hood in Oregon. These populations are affected by upstream and downstream passage at Bonneville Dam and by inundation of historical habitat at the lower ends of the smaller tributaries by the reservoir (McElhany et al. 2004; McElhany et al. 2007). On the Oregon side of the gorge, the tributary streams are especially short and end at impassable waterfalls. FCRPS impacts on populations originating in downstream subbasins are limited to effects on migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary.

CR Chum Salmon:

Direct impacts of mainstem hydropower system on the CR Chum Salmon ESU are most significant for the Upper and Lower Gorge populations. For the Upper Gorge population, some productive historical spawning habitat was inundated by Bonneville pool. FCRPS flow management affects the amount of available spawning habitat for the mainstem component of the Lower Gorge population and whether adults can enter and fry can emerge from two important chum salmon production areas, Hardy and Hamilton Creeks. Impacts on populations originating in subbasins further downstream (i.e., the Cascade and Coast MPGs) are limited to migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary.

Snake River Sockeye Salmon:

Compared to Snake River spring/summer-run Chinook salmon, there is relatively little route-specific information on the survival of Snake River sockeye salmon through the FCRPS. Reach survival estimates are imprecise because sample sizes of migrants from the Snake River are

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[21] EWEB's original FERC license expired in 2008, yet for a variety of reasons, FERC has not yet issued a new license. This plan is included in EWEB's relicensing application to FERC. NMFS reviewed this plan as part of its 2011 biological opinion on the proposed relicensing of the Carmen-Smith Hydroelectric Project. NMFS expects to issue a new biological opinion in 2017 to reflect the schedule.

small. Williams et al. (2005) used detections of all PIT-tagged sockeye salmon smolts (2000-2003) to the tailrace at LGR for annual estimates of survival between LGR and McNary Dams. In 2003, the estimated survival of sockeye salmon smolts was 72.5%, similar to that of yearling Chinook salmon, but in 2000 through 2002, sockeye salmon survival was considerably lower (23.9% to 56%). The reason for low survival rates is unclear, but descaling may contribute a role, since sockeye salmon juveniles appear to be prone to it. Williams et al. (2005) reported that between 1990 and 2001, two adults returned from 478 juveniles transported (smolt-to-adult returns, or SAR, of 0.4%) and only one adult returned from 3,925 PIT-tagged fish that migrated in-river (SAR of 0.03%). As with Chinook salmon, most untagged sockeye salmon smolts were transported to below Bonneville Dam.

LCR Steelhead:

Direct mainstem hydropower system impacts on LCR steelhead are most significant for the four gorge tributary populations upstream from Bonneville Dam, all of which are in the Gorge winter (Upper Gorge and Hood) and Gorge summer (Wind and Hood) MPGs. These populations are affected by upstream and downstream passage at Bonneville Dam and by the inundation of historical habitat, which has been used by juveniles in the past (McElhany et al. 2004). Impacts on populations originating in subbasins below Bonneville Dam are limited to effects on migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary.

UCR Steelhead:

UCR steelhead use spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; they also use rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that increase survival rates. The following are the major factors that have limited the functioning of, and thus, the conservation value of habitat types used by UCR steelhead for spawning and rearing:

- Physical passage barriers (i.e., mortality at hydroelectric projects in the mainstem Columbia River; water withdrawals and unscreened diversions);

- Excess sediment in spawning gravels and in substrates that support forage organisms (i.e., land and water management activities); and

- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures (i.e. degraded riparian and channel function).

Factors that have limited the functioning and conservation value of habitat in juvenile and adult migration corridors (i.e., affecting safe passage) are:

- Tributary barriers (i.e., push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles);

- Juvenile and adult passage mortality (i.e., hydropower projects in the mainstem Columbia River); and

- Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators (Caspian terns and double-crested cormorants).

In the mainstem FCRPS corridor, mainstem survival of juvenile steelhead has improved with the construction and operation of surface bypass routes at Bonneville Dam and other configuration improvements listed in Section 5.3.1.1 of USACE (2007).

Snake River Basin Steelhead:

Snake River Basin steelhead use spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; they also use rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that increase survival rates. The following are the major factors that have limited the functioning of, and thus, the conservation value of habitat types used by Snake River Basin steelhead for spawning and rearing:

- Degraded tributary channel morphology (i.e., bank hardening for roads or other development; livestock on soft riparian soils and streambanks);

- Physical passage barriers (i.e., culverts; pushup dams; low flows);

- Excess sediment in gravel (i.e., roads; agricultural and silvicultural practices; livestock on soft riparian soils and streambanks; recreation);

- Degraded riparian condition (i.e., grazing);

- Reduced tributary stream flow (i.e., limiting of usable stream area and alters channel morphology by reducing the likelihood of scouring flows [water withdrawals]); and

Degraded tributary water quality including elevated summer temperatures (i.e., water withdrawals; groundwater depletion; degraded riparian condition).

MCR Steelhead:

MCR steelhead use spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development; they also use rearing sites with water quality, water quantity, floodplain connectivity, forage, and natural cover allowing juveniles to access and use the areas needed to forage, grow, and develop behaviors that increase survival rates. The following are the major factors that have limited the functioning of, and thus, the conservation value of habitat types used by MCR steelhead for spawning and rearing:

- Tributary barriers (i.e., push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles);

- Excess sediment in spawning gravels and in substrates that support forage organisms (i.e., land and water management activities);

- Loss of habitat complexity, off-channel habitat and large, deep pools due to sedimentation and loss of pool-forming structures (i.e., degraded riparian and channel function); and

- Degraded water quality (i.e., toxics from agricultural runoff; high temperatures due to water withdrawal/return practices).

In recent years, the Action Agencies, in cooperation with numerous non-Federal partners, have implemented actions in spawning and rearing areas to increase streamflow, install or improve fish screens at irrigation facilities to prevent entrainment, remove passage barriers and improve access, improve channel complexity, and protect and enhance riparian areas to improve water quality and other habitat conditions.

UWR Steelhead:

The COE operates 13 dams in the largest five tributaries to the Willamette River for flood control, irrigation, and hydropower. Major habitat blockages for UWR steelhead resulted in approximately 1952 from the construction of Big Cliff and Detroit Dams on the North Santiam River, and in approximately 1967 from Green Peter Dam on the South Santiam River (Foster Dam on the South Santiam was built with trap and haul fish passage facilities). These dams were identified by NMFS as the upper limit of winter-run steelhead distribution in past status reviews, although historically, these fish spawned in habitat above the dams (NMFS 2006a). In addition to blocking winter-run steelhead access to historical upstream habitat in the South and North Santiam Rivers, these dams also affect flows, water quality, sediment transport, and downstream habitat in the North and South Santiam Rivers and in the mainstem Willamette River. Flow storage, release operations, and, to a lesser extent, irrigation withdrawals have all altered temperatures and channel-forming processes.

Adult and juvenile UWR steelhead also pass several smaller FERC-licensed hydropower projects: Willamette Falls on the lower mainstem Willamette River; the City of Albany/Lebanon Dam on the South Santiam River; Stayton, Water Street, and Fery projects on the North Santiam River; and the decommissioned Thompson Mills on the Calapooia River. Except for the Stayton project, which is currently shut down, improved fish screens, ladders, and, in some cases, tailrace barriers have recently been installed at all of these FERC projects, thereby reducing adverse effects on UWR steelhead. It is highly unlikely that fish from this DPS encounter FCRPS projects, meaning Bonneville Dam or other projects upstream of Bonneville Dam. Impacts from those projects on UWR populations are limited to effects on migration and habitat conditions in the LCR (below the confluence of the Willamette), including the estuary.

Overall, the hydropower system that includes both FCRPS, Willamette Project, and FERC facilities have adverse effects on both abiotic and biotic aspects of the Columbia River and its tributaries, including LCR salmon and steelhead.

2.3.3 Habitat Effects

Salmon and steelhead habitat in the Columbia River Basin is greatly affected by hydropower development. Much material in this Section has, therefore, been taken from or based on Chapter 5 of the FCRPS 2008 Opinion's SCA (NMFS 2008h), which as mentioned above, has been incorporated by reference. As in that document, this Section takes the approach of dividing habitat in the Action Area into three main regions: 1) tributary streams flowing into Columbia River; 2) the Columbia River itself upstream of the estuary (often referred to as the migration corridor); and 3) the estuary and plume. In addition to the SCA material, the tributary Section has been augmented by material from various recovery plans developed within the basin. The estuary and plume material has been taken largely from the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. The estuary and plume Section and the mainstem Section have discussions of greater detail than the tributary Section because fish released into tributaries as part of the Proposed Action leave the tributaries and enter the mainstem within a few days, and all fish spend some time in the estuary and plume regardless of the release location. The discussion covers effects to eulachon as well as salmon and steelhead, but unless otherwise specified, pertains to salmon and steelhead. However, effects to eulachon are only relevant in the LCR tributaries and estuaries, as eulachon do not migrate farther inshore than these areas. Material pertaining to eulachon was taken from Gustafson et al. (2010); personal comm., R. Anderson (2016); Gustafson (2016).

2.3.3.1 Tributary Habitat

With the exception of Snake and upper Columbia fall-run Chinook salmon, which generally spawn and rear in the mainstem, salmon and steelhead spawning and rearing habitat is found in tributaries to the Columbia and Snake Rivers. The quality and quantity of habitat in many Columbia River Basin watersheds has declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydrosystem development, mining, and urbanization have changed the historical habitat conditions. Currently, spawning and rearing is limited now to thirty-two subbasins in the Action Area.

Many tributaries are significantly depleted by water diversions. In 1993, state, Tribal, and conservation group experts estimated that 80% of 153 Columbia tributaries had low flow problems, of which two-thirds were caused, at least in part, by irrigation withdrawals (OWRD 1993). The NPCC showed similar problems in many Idaho, Oregon, and Washington tributaries (NPPC 1992). Diminished tributary streamflows have been identified a major limiting factors for most species in the Columbia River Basin upstream of Bonneville Dam (NMFS 2007c).

In many watersheds, access to historical habitat areas is also lost to land development, primarily due to road culverts that are not designed or installed to permit fish passage.

Water quality in many Columbia River Basin streams is degraded to varying degrees by human activities, such as construction and operation of dams and diversion structures, water withdrawals, farming and grazing, road construction, timber harvest activities, mining activities, and urbanization.

A large number of the streams, river segments, and lakes draining into the Columbia River Basin do not meet federally-approved, state or Tribal water quality standards and are now listed as water-quality-impaired under Section 303(d) of the Clean Water Act (CWA). Water quality problems in the upper tributaries contribute to poor water quality in mainstem reaches and the estuary, where sediment and contaminants from the tributaries settle.

Most of the water bodies in Oregon, Washington, and Idaho in the Columbia River Basin are on the 303(d) list and do not meet water quality standards for temperature. Temperature alterations affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification. Many factors can cause high stream temperatures, but they are primarily related to general land-use practices rather than localized discharges, such as at dams and hatcheries. Some common actions that result in high stream temperatures are the removal of trees or shrubs that directly shade streams, excessive water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals have contributed to lower base-stream flows, which in turn contribute to water temperature increases because streams with lower flow increase in temperature more rapidly than streams with higher flow. Channel widening and land uses that create shallower streams also increase water temperatures because such streams also increase in temperature more rapidly than deeper streams.

Pollutants also degrade tributary water quality. Salmon require clean gravel for spawning, egg incubation, and emergence of fry. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs and they also can entomb fry and prevent them from emerging into the water column. Excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH also directly affect water quality for salmon and steelhead.

Effects of the Hydrosystem on Nutrients in Tributaries

Hydrosystem mortality of anadromous fish (including eulachon) also reduces the transport of marine-derived nutrients (MDN) to freshwater spawning and rearing areas, which are important for salmonid production, and consequently for the ecosystem that is dependent on salmon, both directly and indirectly (e.g., Bisson and Bilby 1998; Naiman et al. 2002). Gresh et al. (2000) estimated that the marine-derived nitrogen and phosphorus load delivered to Pacific Northwest Rivers has decreased over 90% in the last 140 years. That study attributed the loss of MDN to habitat changes due to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and sport fishing.

MDN have been shown to support the growth of coastal populations of coho salmon, which feed on salmon eggs and spawned-out carcasses. Bilby et al. (2001) observed an increase in the amount of marine-derived nitrogen in the muscle of coho salmon parr with increasing abundance of carcass tissue up to about 0.15 kg/m^2-wet weight. Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading. Helfield and Naiman (2001) hypothesized that MDN are transferred from streams to riparian vegetation through the transfer of dissolved nutrients from decomposing carcasses into shallow subsurface flow paths and through the dissemination in feces, urine, and carcasses partially eaten by bears and other animals. Bilby et al. (2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material at sites in the Salmon and John Day Rivers.

In summary, an increasing body of work suggests that carcass biomass affects the productivity of salmonid rearing habitat, but functional and quantitative relationships are poorly understood and difficult to generalize from the specific conditions studied. Limiting factors, and thus the ecological importance of MDN, differ among streams, but reduced adult returns caused by mortality from hydrosystems are likely limiting biogeochemical processes that are important to salmonid productivity in some watersheds by depriving rearing areas of some nutrient inputs. These nutrient limitations also result from habitat degradation, harvest, and adverse ocean conditions, all of which have reduced salmon survival and adult returns over time (Scheuerell and Williams 2005).

Basin-Specific Tributary Habitat Details

Information in this Section is taken from completed recovery plans for the LCR, UWR, MCR, and UCR Basins (NMFS 2009b; 2012e; UCSRB 2014) and from several draft Snake River Basin management unit recovery plan (SRSRB 2011; NMFS 2012a; 2014a), all of which are incorporated by reference.

Lower Columbia River Basin

Historically, tributary habitat in the ranges of the LCR Salmon ESUs and steelhead DPS supported millions of fish in populations that were adapted to the characteristics of individual watersheds (NMFS 2013e). Stream channels contained abundant large wood from the surrounding riparian forests that helped structure pools and create complex habitat in streams. Beavers also contributed to diverse instream habitats, with deep pools and strong connections to floodplains. Water temperatures sufficient to support salmon and steelhead throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored streambanks, thus shading the water, protecting against erosion, and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side-channel, and off-channel habitats and lower reaches included important refuge and feeding areas in the form of swamp and marsh habitat. However, over the last 150 years, tributary habitat conditions have been severely degraded or the habitat has been eliminated altogether.

Tributary habitat loss and degradation from land and water use development is limiting LCR salmon and steelhead populations, and eulachon populations. Widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most of the LCR subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon, steelhead, and eulachon (LCFRB 2010b; 2010a; ODFW 2010a; NMFS 2014b). Specific land use or water management activities and their impacts include the following:

- Logging and other forest management practices on unstable slopes and in riparian areas is degraded watershed processes through erosion and sedimentation. Improperly located, constructed, or maintained forest roads disrupt stream flow patterns and sediment supply processes, disconnect streams from floodplains, and reduce wood recruitment to streams. Past use of splash dams to transport logs reduced instream structure and spawning gravel in several stream systems. Impacts continue in many areas, and the legacy of historical practices will continue for some time.

- Agricultural activities have diminished overall habitat productivity and connectivity and degraded riparian areas and floodplains in many areas of the LCR region, especially along lowland valley bottoms. Floodplain habitats have been lost through levee construction and the filling of wetlands. Pesticide, herbicide, and fertilizer runoff from agricultural lands has reduced water quality. Water withdrawal for irrigation alters stream flow and raises water temperatures. Livestock grazing affects soil stability (via trampling), reduces streamside vegetation (via foraging), and delivers potentially harmful bacteria and nutrients (via animal wastes) to streams.

- Man-made fish passage barriers affect salmon and steelhead habitat in the LCR. The main barriers for anadromous fish passage are dams and culverts, with occasional barriers such as irrigation diversion structures, fish weirs, road crossings, tide gates, channel alterations, and localized temperature increases (LCFRB 2010a). Although dams are responsible for the greatest share of blocked habitat, inadequate culverts make up the vast majority of all barriers (LCFRB 2010a). Many barriers have been improved to allow for fish passage, but a substantial number of barriers remain. Hatchery structures also sometimes act as passage barriers in tributaries (LCFRB 2010a; ODFW 2010a).

- Urban and rural development has diminished overall habitat productivity and connectivity, degraded riparian and floodplain conditions, and increased urban surface water runoff. The drainage network from roads, ditches, and impervious surfaces alters the hydrograph and delivers sediment and contaminants to streams, reducing water quality, and thus, the health and fitness of salmonids and other aquatic organisms. Loss of riparian vegetation to development increases stream temperatures by increasing the sun exposure of the stream, bank hardening, channel simplification, and disruptions in natural flow regimes. Municipal water withdrawal alters stream flows and increased water temperatures.

- Mining. Sand and gravel mining along some lower Columbia streams has reduced the quantity and quality of spawning habitat (ODFW 2010a).

Collectively, these factors have reduced the amount and quality of habitat available to LCR salmon and steelhead, severed access to other historically productive habitats, and degraded watershed processes and functions that once created healthy ecosystems for salmon and steelhead production. Many streams now have lower pool complexity and frequency compared to historical conditions and stream channels also lack the complex structures needed to retain gravels for spawning and invertebrate (prey) production. Also missing from many channels is connectivity with shallow, off-channel habitat and floodplain areas that once provided productive early rearing habitat, flood refugia, overwintering habitat, and cover from predators. In many areas, contemporary watershed conditions have changed so much that they now pose a significant impediment to achieving recovery of the listed species (LCFRB 2010a; ODFW 2010a).

Willamette River Basin

The Willamette River Basin covers 11,500 square miles and encompasses parts of three physiographic provinces. The Cascade Range covers 60% of the basin and consists of volcanic rocks with elevations exceeding 10,000 feet. The range forms the eastern boundary of the basin. The Willamette River Valley covers 30% of the basin. The elongated valley floor is structurally an erosional lowland, filled with flows of Columbia River Basalt (in the northern half of the basin) and younger unconsolidated sediment (Wentz et al. 1998). The Coast Range, comprised of marine sedimentary and volcanic rocks at elevations over 4,000 feet, covers the remainder of the basin and constitutes the western boundary of the Willamette River Valley. The Willamette River Valley is home to 70% of Oregon's human population (NPCC 2004a) including Oregon's three largest cities (Portland, Eugene, and Salem). Approximately 70% of the basin is forested, with approximately 36% of the basin in Federal forest ownership. Most of the Federal forest land is located in the higher elevations of the Cascade and Coast Ranges and is managed by the U.S. Forest Service and U.S. Bureau of Land Management. About 22% of the basin area is in agricultural production, and the remaining 8% is urbanized or in other uses (Wentz et al. 1998). More than 60% of the basin area is outside the urban growth boundaries, and more than 90% of the valley floor is privately owned (PNERC 2002). Several major flood control or hydropower facilities have been developed in the Clackamas River subbasin and in subbasins of the upper Willamette River Basin, including facilities in the North Santiam, South Santiam, McKenzie and MF Willamette Rivers. Dam construction and operations impact salmonids by hindering fish passage to the most productive and important upstream spawning and rearing habitat, and by altering the natural hydrologic regimes, especially during summer and fall low flow periods. Anadromous fish habitat in the Willamette River Basin has been strongly affected by flood control, hydropower management, and land use.

Specific threats from flood control and hydropower management include: 1) blocked or impaired fish passage for adults and juveniles, 2) loss of riverine habitat (and associated functional connectivity) due to reservoirs, 3) reduction in instream flow volume due to water withdrawals, 4) lack of sediment transport that provides spawning habitat, 5) altered physical habitat structure, and 5) altered water temperature and flow regimes.

Within the Willamette River Basin, the largest flood control/hydropower complex, called the Willamette Project, is managed principally as a flood control system by the COE. Operation of the Willamette Project has been determined to jeopardize UWR Chinook salmon and steelhead (NMFS 2008d). Where these projects are located, the flood control structures block or delay adult fish passage to the most important holding and spawning habitat for UWR Chinook salmon and UWR steelhead. In addition, most Willamette Project dams have limited facilities or operational provisions to safely pass juvenile Chinook salmon and steelhead downstream of the facilities. Current operations and configurations of the Willamette Project impact several salmonid life stages, through impacts on water flows, water temperatures, total dissolved gas (TDG), sediment transport, and channel structure.

In addition to the federally owned and operated flood control/hydropower facilities, other facilities, such as the Portland General Electric (PGE) complex in the Clackamas River basin, the

EWEB Carmen Smith complex in the McKenzie River basin, and municipal flow control facilities, contribute to the flood control/hydropower effects.

In the UWR subbasins, reservoirs associated with dams have created habitat conditions that make juvenile salmonids more susceptible to introduced predatory fishes, especially largemouth and smallmouth bass. Predation by bass is a concern in other areas as well, such as slow water areas in sub-basins and the mainstem Willamette River that are associated with the remaining floodplain.

Past and present land management affects salmonid population viability by affecting abundance, productivity, spatial structure, and/or diversity. Past land uses (including agriculture, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR Chinook salmon and UWR steelhead. These factors severed access to historically productive habitats and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. Oregon's Independent Multidisciplinary Science Team (IMST) recently published an extensive review of land use effects (including those imposed by dams) on the rehabilitation of salmonids in Oregon, and references therein can be reviewed for conditions specific to the Willamette River Basin (IMST 2010).

Mid-Columbia River Basin

In the MCR region, only steelhead are listed, but other salmon species are not; so, habitat discussion is focused on effects on steelhead. The range of the MCR Steelhead DPS extends over approximately 35,000 square miles in the Columbia plateau of eastern Washington and eastern Oregon. Major drainages within the range of this DPS are the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat River systems. The Cascade Mountains form the western border of the plateau in both Oregon and Washington, while the Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day basins from the Oregon high desert and drainages to the south. The Wenatchee Mountains and Palouse areas of eastern Washington border the MCR Basin on the north.

Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the western and eastern boundaries and warmer and drier climates at the lower elevations. The mountainous regions are predominately coniferous forests, while the arid regions are characterized by sagebrush steppe and grassland.

Most of the region is privately owned (64%), with the remaining area under Federal (23%), tribal (10%) and state (3%) ownership. The landscape, throughout the range of this DPS, is heavily modified for human use, even where populations are low. Most of the landscape consists of rangeland and timberland with significant concentrations of dryland agriculture in parts of the range. Irrigated agriculture and urban development are generally concentrated in valley bottoms and human populations in these regions are growing.

Habitat degradation from past and/or present land use impacts the steelhead populations in this DPS. Extensive beaver activity created diverse instream habitats, with deep pools and strong connections to floodplains. Many stream channels contained abundant large wood from surrounding riparian forests, which included cottonwood, aspen, willow, and upstream conifers. Stream temperatures sufficient to support all steelhead life stages throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored stream banks, providing protection against erosion and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side channel, and off-channel habitats.

Today, nearly all historical habitat lies in areas modified by human settlement and activities. Historical land use exerted a large and widespread impact on steelhead habitat quality and quantity across the range of the DPS. These development practices included removal of wood from streams, even through the 1980s; removal of riparian vegetation; timber harvest; road construction; agricultural development; livestock grazing; urbanization; wetland draining; gravel mining; alteration of channel structure through stream relocation, channel confinement, and straightening; beaver removal; construction of dams for multiple purposes; and direct withdrawal of water for irrigation or human consumption.

While some streams and stream reaches retain highly functional habitat conditions to this day, these various human activities have degraded streams and stream reaches across the range of the MCR Steelhead DPS, leaving them with insufficient large wood in channels, insufficient instream complexity and roughness, and inadequate connectivity to associated wetlands and off-channel habitats. Many streams lack sinuosity and associated meanders and suffer from excessive streambank erosion and sedimentation, as well as altered flow regimes and higher summer water temperatures. In many areas, the contemporary watershed conditions created by past and current land use practices are so different from those under which native fish species evolved that these conditions now pose a significant impediment to achieving recovery. The recovery plans contain detailed descriptions of tributary habitat threats and limiting factors.

The human population in the Yakima River subbasin is growing (now over 300,000) and most likely will continue to grow. Planners expect that most land use and development for future population growth will occur near the Yakima River mainstem and major tributary corridors. Water storage and delivery systems have major impacts on the Yakima River subbasin's hydrology. An extensive water supply system, run by the BOR's Yakima Irrigation Project, stores and delivers water for over 400,000 acres (~156 square miles) of irrigated agriculture and, to a lesser degree, industrial, domestic, and hydropower use. Management of water storage and delivery systems results in stream flows across the subbasin that are often out of phase (e.g., heavy flows at times when naturally there would be low flows) with the life history requirements of native salmonids (Fast et al. 1991) and riparian species such as cottonwoods (Braatne and Jamieson 2001).

Upper Columbia River Basin

The UCR Basin consists of six subbasins- Crab Creek, Wenatchee River, Entiat River, Lake Chelan, Methow River, and Okanogan River-extending from central Washington into British Columbia. Approximately 18,600 square miles lies within the U.S.

The Crab Creek subbasin is located in central Washington. Considered one of the longest ephemeral streams in North America, Crab Creek flows southwest for 140 miles, draining into the Columbia River about five miles downstream from Wanapum Dam. The subbasin consists of about 5,096 square miles, most of which are used to raise crops. Anadromous steelhead use only the lower portion of Crab Creek.

The Entiat River subbasin, located in north-central Washington, is relatively small at 466 square miles. Approximately 91% of the subbasin is in public ownership. The remaining 9% is privately owned and is primarily within the valley bottoms. The subbasin consists of two primary watersheds: the Entiat and Mad Rivers. Spring-run Chinook salmon, steelhead, and bull trout spawn and rear in the Entiat River subbasin.

The Wenatchee River subbasin covers an area of 1,334 square miles. Approximately 90% of the subbasin is in public ownership and the remaining 10% is within the valley bottoms and in private ownership.

The Lake Chelan subbasin is located in north-central Washington and consists of 937 square miles. Approximately 87% of the subbasin is publically owned with the remainder being privately owned. The most prominent feature of the subbasin is Lake Chelan, which occupies 50 miles of the 75-mile-long basin. The majority of inflow to Lake Chelan is from two major tributaries, the Stehekin River (65%) and Railroad Creek (10%). About 50 small streams provide the remaining 25% of the inflow to Lake Chelan. Because of the shape of the valley, most tributaries are relatively steep and short. Lake Chelan drains into the 4.1-mile-long Chelan River. Presently, nearly all the flow from Lake Chelan is diverted through a penstock, which passes the water through the Lake Chelan powerhouse located near the mouth of the river.

The Methow subbasin is located in north-central Washington and lies entirely within Okanogan County. The subbasin consists of approximately 1,825 square miles. Approximately 89% of the subbasin is in public ownership. The remaining 11% is privately owned and is primarily within the valley bottoms.

The Okanogan subbasin is the largest of the UCR subbasins. Originating in British Columbia, the Okanogan River enters the Columbia River between Wells Dam and Chief Joseph Dam. The subbasin is approximately 8,942 square miles in size. However, only about 26% of the subbasin lies within the U.S. (Washington). Of this portion, 41% is in public ownership, 21% is in Tribal ownership, and the remaining 38% is privately owned and is primarily within the valley bottoms. There are three major watersheds within the subbasin in Washington (Similkameen River, Omak Creek, and Salmon Creek). The Similkameen River, located primarily in Canada, contributes 75% of the flow to the Okanogan River.

Human activities acting in concert with natural occurrences (e.g., floods, drought, fires, wind, volcanism, and ocean cycles) within the UCR Basin have impacted habitat conditions and compromised ecological processes. Although habitat within many of the upper reaches of most subbasins is in relatively pristine condition (e.g., upper reaches of the Wenatchee River, Entiat River, and Methow River subbasins), human activities have reduced habitat complexity, connectivity, water quantity and quality, and riparian function in many lower stream reaches. Loss of large woody debris and floodplain connectivity have reduced rearing habitat for Chinook salmon, steelhead, and bull trout in larger rivers (e.g., Wenatchee, Entiat, Methow, and Okanogan Rivers). Fish management, including past introductions and persistence of non-native (exotic) fish species, continues to affect habitat conditions for listed species.

The implementation of several programs and projects that regulate land-use activities on public and private lands have improved habitat conditions over the last decade in the UCR Basin. For example, improved farm and ranch practices and numerous voluntary restoration and protection projects have occurred throughout the region. While difficult to quantify, the overall effect of improvements is important to salmon and trout recovery. Counties continue to protect and enhance critical areas, including salmon and trout habitat through Washington state law, and other local land-use regulations. The Forest Service, the largest landowner in the UCR Basin, manages spawning and rearing streams through several programs, including the Northwest Forest Plan and the PACFISH/INFISH Strategy (Henderson et al. 2005). WDFW and the Washington State Department of Natural Resources also own land in the UCR Basin and have modified and continue to modify land management practices to improve habitat conditions. However, habitat improvements are still needed to improve populations of listed species.

Snake River Basin

The Snake River Basin encompasses 107,000 square miles that extend across parts of Idaho, Nevada, Utah, Oregon, Washington, and Wyoming. The Snake River drains approximately one-half of the total area of the Columbia River Basin (219,000 square miles), and is the Columbia River's largest tributary. Historically, the Snake River Basin is believed to have been the most important drainage for production of anadromous fish in the entire Columbia River Basin. Once, the Snake River was estimated to have produced at least 40% of all Columbia River spring- and summer-run Chinook salmon, more than half of Columbia River steelhead, and substantial numbers of fall-run Chinook, sockeye, and coho salmon (Chapman et al. 1990; Good et al. 2005). Within the Snake River Basin, the Salmon River is the largest river system, followed by the Clearwater River, both in Idaho.

The topography and climates characteristic of the Snake River Basin are extremely diverse. Terrestrial habitats include high elevation interior deserts, alpine peaks, dense forests, and the deepest river canyon in North America (Hells Canyon: - 7,993 feet). Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas and warmer and drier climates in the lower elevations.

Land management and development within the Snake River Basin vary from wilderness to agriculture and rangeland to small towns and cities. The growth of towns and typically affects streams in numerous ways. As with logging roads, urban and rural roads built across or along streams introduce fines and toxic substances such as motor oil into the water. Improperly designed and constructed stream crossings block or impede fish passage. Paving of parking lots and roads increases the amount of impervious surface and reduces the infiltration of precipitation into the aquifer. As a consequence, streams draining watersheds with a high proportion of impervious surface area tend to be flashy, unstable and embedded with fine sediments. Pollutants also enter streams as a result of lawn and garden fertilization or cultivation, or from factories or other businesses. The Snake River Basin contains the largest contiguous wilderness in the lower 48 states. Of the 31,862 square miles of land in the Snake River recovery domain, 69.4% is federally owned, 24.3% is privately held, and 6.5% is state or tribally owned.

Currently, salmon and steelhead occupy only a portion of their former range in the Snake Basin. Starting in the 1800s, dams blocking anadromous fish from their historical habitat were constructed for irrigation, mining, milling, and hydropower. Construction of the Hells Canyon Complex of impassable dams along the Idaho-Oregon border in the 1960s completed the extirpation of anadromous species in the upper Snake River and its tributaries above Hells Canyon Dam. Major tributaries upstream from Hells Canyon Dam that once supported anadromous fish include the Wildhorse, Powder, Burnt, Weiser, Payette, Malheur, Owyhee, Boise, Bruneau, and Jarbidge Rivers, and Salmon Falls Creek. These tributaries supported most of the sockeye salmon and fall Chinook salmon populations in the basin and an estimated 15 steelhead populations and 25 spring/summer-run Chinook salmon populations (McClure et al. 2005).

Other dams besides the Hells Canyon complex have significantly reduced access to salmon and steelhead habitat. Dworshak Dam, completed in 1971, caused the extirpation of Chinook salmon and steelhead runs in the North Fork Clearwater River drainage. Lewiston Dam, built in 1927 and removed in 1973, is believed to have caused the extirpation of native Chinook salmon, but not steelhead, in the Clearwater drainage above the dam site. Harpster Dam, located on the South Fork Clearwater River at approximately RM 15, completely blocked both steelhead and Chinook salmon from reaching spawning habitat from 1949 to 1963. The dam was removed in 1963 and fish passage was restored to approximately 500 miles of suitable spawning and rearing habitat.

Idaho Tributaries

Spawning, rearing, and migration habitat quality in tributary streams in Idaho occupied by salmon and steelhead varies from excellent in wilderness and road less areas to poor in areas subject to intensive human land uses. Mining, agricultural practices, alteration of stream morphology, riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, and urbanization have degraded stream habitat throughout much of the Snake River Basin. Reduced summer stream flows, impaired water quality, and loss of habitat complexity are common problems for stream habitat in non-wilderness areas. Human land use practices throughout the Snake River Basin have modified streams reducing rearing habitat and increasing water temperature fluctuations.

In many stream reaches occupied by anadromous fish in Idaho, water diversions substantially reduce stream flows during summer months. Withdrawal of water, particularly during low flow periods, increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport. Reduced tributary streamflow is considered a major limiting factor for Snake River spring/summer-run Chinook salmon and Snake River Basin steelhead (NMFS 2011c).

Many streams occupied by salmon and steelhead are listed on the State of Idaho's Clean Water Act Section 303(d) list for impaired water quality, such as impairment for elevated water temperature (IDEQ 2014). High summer stream temperatures may currently restrict salmonid use of some historically suitable habitat areas, particularly rearing and migration habitat. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Water quality in spawning, rearing, and migration habitat has also been impaired by high levels of sedimentation, and by other pollutants such as heavy metal contamination from mine waste (e.g., IDEQ (2001); IDEQ (2003)).

The reduction in abundance of adult salmon and steelhead returning to Idaho streams has also reduced the transport of MDNs to freshwater spawning and rearing areas. The loss of these nutrients limits biogeochemical processes important to salmonid productivity in some streams by depriving rearing areas of some nutrient inputs (NMFS 2008h) and reducing the productivity of the food web. Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading (Helfield and Naiman 2001). In two IC watersheds, the Salmon and John Day Rivers, Bilby et al. (2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material, suggesting that salmon carcasses are important to aquatic productivity and the availability of food for rearing fish (NMFS 2008h). Kohler et al. (2008) also found a positive stream food web response to the addition of salmon carcass analogs (define what an analog is) in two Salmon River tributaries. These studies indicate that the loss of MDNs, due to a reduction in adult spawners, likely has contributed to reduced Chinook salmon and steelhead abundance and productivity in tributary areas.

Oregon Tributaries

The Northeast Oregon region of the Snake River Basins comprises 4,880 square miles in the Columbia River plateau of northeastern Oregon, and a small section of southeastern Washington. It is characterized by a rolling, semi-arid landscape that is bordered by the plush terrain of the Blue Mountains. The nearby Wallowa Mountains lie just east of the main Blue Mountain range and near the Oregon/Idaho border, which forms the eastern boundary of this region. Three major rivers, along with their tributaries, flow into the Snake River drainage: the Grande Ronde, Imnaha, and Wallowa Rivers. The Grande Ronde River in southeastern Washington also drains into the mainstem Snake River, marking the region’s northern boundary. To the south, the upper Grande Ronde River and the eastern portion of the John Day River basin form the region’s southern border.

Temperatures and precipitation in Northeast Oregon vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the eastern and western boundaries, and warmer and drier climates in the lower portions of the region. Mountainous regions are predominately coniferous forests, while arid regions are characterized by sagebrush steppe and grassland. Elevation in the region varies from mountain peaks that exceed 9,000 feet to grasslands ranging from 2,000 to 4,000 feet.

Public land constitute 54% of the area while 45% is privately held, and the remainder is partitioned for both state and tribal use. The region is dominated by agricultural and rangeland use, as well as forestlands used for recreational purposes. Northeast Oregon’s human population is growing at a slower pace than other areas in the Pacific Northwest, but development is nonetheless occurring, particularly along valley bottoms.

Numerous efforts have been made in recent years to protect and restore habitat conditions on public and private lands. Landowners and land managers have improved habitat management to restore healthy watershed conditions and support salmon and steelhead recovery. In some areas, actions to improve watershed conditions from the uplands to the floodplain are allowing natural ecosystem functions to recover. Still, habitat problems remain throughout the area. Many more habitat improvements are likely needed to achieve viability for Snake River spring/summer-run Chinook salmon and steelhead (Ford 2011).

Both current and historical management practices pose threats to the recovery of the spring/summer-run Chinook Salmon ESU and Steelhead DPS. Overall, the effects of development and land use activities over the last 200 years have altered watershed hydrology and reduced habitat quality and complexity, floodplain connectivity, and water quality. The alteration of tributary habitats has affected spring/summer-run Chinook salmon and steelhead population abundance, productivity, and spatial structure. To recover, the fish need streams with abundant cold water, plenty of clean gravel, pools where they can find food and shelter, and unhindered access to spawning and rearing areas. Thus, their health depends greatly on how lands and water are managed.

Several land use-related limiting factors and threats are common across the salmon ESU and steelhead DPS. Many of the threats have both historical, or legacy, and current components. Historical threats are those in which actions taken previously—such as road construction, and agricultural and timber harvest activities—continue to have lingering effects on tributary habitat. These common limiting factors and threats include agricultural practices, timber harvest, roads, water withdrawal, recreation activities, and noxious weed infestation.

Agricultural practices have improved over the years; however, habitat conditions still display the lingering effects of past practices and, in some cases, continue to be damaged from current practices. Agricultural practices have reduced habitat quality and complexity through stream channelization, levee and dike construction, wetland conversion, and removal of riparian vegetation. Such activities have restricted stream floodplain connectivity, resulted in downcutting of stream channels, and led to a reduction in pools and large woody debris. Agricultural practices have also affected habitat conditions by altering natural hydrologic regimes through conversion of native grasslands and other natural conditions that stored water and slowed surface runoff, and by increasing fine sediment (e.g., dirt and sand) input to streams. They have reduced water quality by removing large shade-producing trees and by the leaching of pesticides, herbicides, and fertilizers into streams.

Another key aspect of agriculture affecting habitat conditions is livestock. Livestock grazing practices threaten salmon and steelhead viability by damaging and/or compacting streambanks, increasing the input of fine sediments into streams, reducing riparian vegetation, and contributing harmful bacteria and excessive nutrients to streams. Current livestock management, compared to historical management practices, tends to have less impact on salmonid habitat because of improved practices and lower numbers of livestock than historical levels. Negative habitat effects, however, continue to exist when livestock have unrestricted access to stream channels, especially during hot summer and early fall months.

Timber harvest-related threats include lingering effects from historical detrimental timber harvest activities and some current practices. Historical activities reduced salmonid habitat quality and quantity by harvesting large trees from riparian areas, removing large wood from streams, skidding logs across and adjacent to streams, clear-cutting across intermittent or perennial streams, building roads in sensitive areas and/or without proper erosion control structures, and constructing stream crossings that impaired or completely blocked fish from reaching important spawning and rearing areas. Unregulated forest practices, along with livestock grazing and fire suppression, also modified vegetation patterns on forest lands, which led to the alteration of important ecosystem processes, such as wild fire burning, insect invasions, and ecological succession. Current timber harvest activities continue to threaten salmonid viability when they remove riparian area trees that provide shade and future large wood recruitment to streams and adjacent areas, do not adequately protect streams from sediment input, and/or construct roads in sensitive areas. Timber harvest activities have improved and are likely to result in improved conditions for fish, in the future.

Roads affect habitat conditions and salmon and steelhead viability by contributing fine sediment to streams, by channeling runoff and fine sediments, by being located across stream channels in riparian areas, or through other mechanisms to contribute sediment to streams. Roads can also intercept subsurface water drainage, disrupting natural drainage patterns and concentrating runoff flow. Roads can confine channels, preventing them from interacting with their floodplain. Most negative road-related effects are from roads built in the past.

The withdrawal of water from streams becomes a threat when habitat is dewatered, when fish are stranded, when eggs in the gravel are desiccated, when streamflows are too low for adult or juvenile fish passage, and when water temperature rise. Most streams in Northeast Oregon are over-allocated for irrigation water withdrawal purposes and streamflows reach low levels at critical times in fish life history. Low flows caused by withdrawals, in addition to providing less habitat because there is less water, can increase summer stream temperatures, increase sedimentation, and impair fish passage. Diversion structures can limit or prevent passage of juveniles and/or returning adults, and unscreened diversions can result in entrainment of fish in irrigation ditches. Push-up dams used for water diversion can restrict fish passage and contribute fine sediment to the channel.

Barriers to fish passage in Northeast Oregon include culverts, water withdrawal diversion structures, weirs at hatchery facilities, and any other human-made structure that impede fish passage. Barriers can prevent returning adults from accessing upstream spawning habitat, and juvenile fish from migrating up or down stream.

Recreation activities can affect habitat quality when campgrounds, trailheads, trails, and other facilities are located in riparian areas. Recreational access to and around streams can result in loss of riparian vegetation, sediment input, compaction of streambanks, and harassment of spawning fish.

New residential development in certain watersheds places higher demands on limited ground water sources. It can also lead to increases in the discharge of sewage and the leaching of chemicals used in residential applications. The change from porous to impervious surfaces can increase the amount of surface water runoff and pollutants that enters the stream system. Residential development along streams can also result in the loss of native riparian vegetation and streambank stability, and increased erosion.

Noxious weed infestations are a threat to Snake River spring/summer-run Chinook salmon and steelhead in specific watersheds. These invasive species often out-compete native vegetation located within riparian areas, resulting in loss of habitat diversity and riparian area degradation. Together, past land use practices across the region over the last 200 years contributed to causing many of the factors now limiting salmonid abundance and productivity. While some past land use practices were less destructive than other practices, the overall impact was a reduction in habitat quality and complexity, water quality, and a general disruption in the proper functioning of watershed processes in many parts of the Grande Ronde and Imnaha drainages.

Fortunately, habitat conditions in many areas are improving. While harmful land use practices still continue in some areas, many land management activities, including forestry and agricultural practices, now have much less impact to salmonid habitat because of raised awareness and less invasive techniques. For example, timber harvest on public land has declined drastically since the 1980s, and current harvest techniques (e.g., the use of mechanical harvesters and forwarders) and silvicultural prescriptions (i.e., thinning and cleaning) require little, if any, road construction and produce much less sediment. Riparian areas also receive more protection under current forest management. Agriculture activities have also improved to reduce the impact on habitat. Many landowners are implementing good conservation practices to farming and grazing so that important ecosystem processes and functions can recover, and are also protecting and restoring stream corridors. For example, they have protected many miles of stream adjacent to farmland in Union and Wallowa counties through easement programs, such as the Conservation Reserve Enhancement Program, that protect streambanks and riparian vegetation through land management contracts. Such changes are slowly improving habitat conditions for spring/summer-run Chinook salmon and steelhead and other fish and wildlife species, while also restoring overall watershed health.

A final effect to be considered is the reduction in supply of MDNs. The decrease in adult salmon and steelhead returning to Northeast Oregon streams has reduced the transport of MDNs to freshwater spawning and rearing areas. The loss of these nutrients limits biogeochemical processes important to salmonid productivity by depriving rearing areas of unique and important nutrient inputs (NMFS 2008h). Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading (Helfield and Naiman 2001). This and other studies indicate that the loss of MDNs due to a reduction in adult spawners may have affected habitat diversity and productivity.

Washington Tributaries

The Washington portion of the Snake River Basin (called the SEWMU) is located in the southeast corner of the state, generally bounded by the Washington/Oregon state line on the south, the Columbia River (to the confluence with the Snake River) on the west, and the Snake River (including southern flowing tributaries, such as the Palouse River below Palouse Falls, Alkali Flats Creek, Penawawa Creek, and Almota Creek) on the north and the east. The region is generally characterized by rolling, semi-arid lands flanked by the forested Blue Mountains in the south. The major rivers draining the area are the Snake, the Grande Ronde, the Tucannon, and the Walla Walla[22] Rivers and Asotin Creek. Elevations along the Snake River range from approximately 400 to 500 feet near its confluence with the Columbia River to 750 feet near Clarkston.

The region's climate is influenced by the Cascade Mountains, the Pacific Ocean, and the prevailing westerly winds. The Cascades intercept the maritime air masses as they move eastward, creating a rain shadow effect that reaches as far as the Blue Mountains. The results are warm and semi-arid conditions in the lower elevations of the SEWMU, and cool and relatively wet conditions in the higher elevations. In the semi-arid portions of the region, the annual precipitation is less than 15 inches per year, varying by area from 5 to more than 45 inches (Whiteman et al. 1994). Temperatures can range from -20°F in the winter to 105°F in the summer.

The SEWMU has experienced a variety of changes that impacted salmonids and their habitat since the arrival of Euro-American settlers in the 19th century. The decimation of the beaver population in the 1830s and 1840s reduced an important source of large woody debris and pools in streams. Settlers, who began arriving in the late 1840s and 1850s, were attracted by the agricultural possibilities, and agriculture remains an important land use today. Logging and urbanization have also affected salmonids and their habitat, as have construction and operation of hydroelectric dams on the Snake and Columbia Rivers and their tributaries. General causes of salmonid population declines include irrigation diversion dams, hydroelectric generation, hatcheries, agriculture, logging, urbanization (including residential and industrial development), recreation, and harvest. Activities associated with these endeavors have dewatered streams, removed riparian vegetation, increased stream water temperatures and effects of parasites and diseases, altered and/or dewatered stream courses, introduced pollutants into streams and wetlands, and blocked or impeded fish passage both up- and downstream. Fish populations have been depleted by over-harvest in the late 19th and early 20th centuries. Hatcheries have introduced fish with different run timing and fish that prey upon or compete with non-hatchery fish. Diseases carried by hatchery fish are also a concern.

Agriculture has had a large impact on habitat. Water needed for irrigations was historically diverted from streams by dams or other structures that often present partial or total passage barriers to adults and juvenile fishes and/or entrainment hazards to emigrating juveniles. Some historical irrigation diversions totally dewatered downstream stream reaches; in others, the temperature in small quantities of water that was left in the natural stream channel can easily reach unhealthy or lethal levels. Cropping practices in upland areas, the roads, stream crossings, and drainage systems have increased erosion and contributed large quantities of fine sediment to spawning riffles. Chemicals and pesticides have entered the stream as pollutants harmful to fish.

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[22] For recovery planning purposes, the Washington portion of the Walla Walla River Basin is considered part of the Snake River Basin, even though the Walla Walla River is a tributary to the Columbia River. The Walla Walla Basin is also considered in mid-Columbia recovery planning, as part of the MCR Steelhead DPS.

Livestock grazing has negatively affected salmonid habitat in a variety of ways, such as by removing riparian vegetation and eliminating natural shade. The lack of shade frequently results in increased water temperatures. The reduced input of leaves, insects, and other organic material limits food available to fish and their prey. Trampling of stream banks by grazing livestock causes the banks to collapse, increasing sedimentation. Livestock feces introduces excessive concentrations of nutrients which, in warm, slow-moving streams, results in low levels of dissolved oxygen (eutrophication). Grazing encourages channel incision as grasses and shrubs are removed from the riparian zone. Channel incision causes the riparian corridor to narrow and the water table to recede. Conversion of bunch grass prairie to production of annual crops has led to erosion of fine sediments into streams and increased intensity of runoff events, and increased channel bank erosion from runoff.

Logging can involve a number of practices harmful to salmonids and their habitats. When trees along stream courses are removed, water temperatures increase. Logging access roads often parallel or cross streams. Improperly sized and placed stream crossings can fail and dramatically increase the introduction of sediment into streams as well as block fish passage. Runoff from roads that parallel streams may allow sediment and road oils to enter the stream. Removal of riparian vegetation also reduces plant and animal inputs into the stream as food sources, root structure that maintains bank stability, and the source of large woody debris important to maintenance of suitable in-stream conditions. Harvest of trees can affect hydrology and stream discharge dynamics. Past logging practices in the Pacific Northwest were devastating to salmonid streams, such as splash dams and associated removal of large boulders and logs to improve transportation of the stored logs. Even with new regulations and improved practices, these effects will persist for many decades, for example, until trees in riparian areas grow to maturity, fall into streams and rivers and are replaced and roads are decommissioned and the area returned to natural conditions

Although heavy urban development has been confined to a relatively small portion of SEWMU, it has had a disproportionately large impact. The development-related impacts summarized in Subsection ‘Snake River Basin’ occur to one degree or another in various portions of the SEWMU. The most damaging activity associated with urban development has been flood control projects and associated structures. Large portions of the Tucannon, Touchet and Walla Walla Rivers have been channelized and confined by levees and dikes intended to protect nearby roads, buildings, fields, and farms. The overall impact of these projects destabilized the rivers by increasing their erosive power (Hecht et al. 1982). As a consequence, the Tucannon River is now actively degrading its banks and bed and causing serious problems with regard to fine sediment deposition and habitat complexity. The Walla Walla River, and especially its Mill Creek tributary, has also been severely impacted by flood control projects. Fish passage is obstructed to varying degrees at numerous points, habitat complexity is virtually non-existent through the channelized section, and portions of Mill Creek are partially dewatered and subjected to excessive temperatures on an annual basis.

Habitat condition in the SEWMU for eight key limiting factors has been analyzed using the Ecosystem Diagnosis and Treatment (EDT) model (Mobrand et al. 1997). For this purpose, the streams in the management unit were divided into stream reaches. The percentage of stream reaches limited by each factor was as follows (SRSRB 2011, Table 5.2):

- Pools 100%
- Riparian function 96%
- Large wood 89%
- Confinement 86%
- Sedimentation 67%
- Flow 61%
- Temperature 61%
- Scour 46%

Typically, several factors were listed as limiting salmon and steelhead recovery in a particular stream reach and nineteen reaches were limited by six or more factors.

2.3.3.2 Mainstem (Exclusive of Estuary)

The mainstem habitat of the Columbia and Snake Rivers serves as a migration corridor for salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Important features of migration habitat include substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage. For fall-run Chinook salmon and, to a lesser extent chum salmon, mainstem habitat also serves as important spawning and rearing habitat. Important features of spawning and rearing habitat include accessibility, spawning gravel, water quality, water quantity, water temperature, food, and riparian vegetation.

Current conditions within much of the mainstem Columbia and Snake Rivers are greatly different and disadvantage salmon and steelhead compared to historical conditions. The development of hydropower and water storage projects within the Columbia River Basin have resulted in the inundation of many mainstem spawning and shallow-water rearing areas, leading to loss of spawning gravels and access to spawning and rearing areas; altered water quality, leading to reduced spring turbidity levels; altered water quantity caused by seasonal changes in flows and consumptive losses from use of stored water for agricultural, industrial, or municipal purposes; altered water temperature, including generally warmer minimum winter temperatures and cooler maximum summer temperatures; altered water velocity, with reduced spring flows and increased cross-sectional areas of the river channel; altered food webs, including the type and availability of prey species; and lack of safe passage, with increased mortality rates of migrating juveniles (Ferguson et al. 2005; Williams et al. 2005).

As discussed in more details below, dams and their associated reservoirs influence the current status of Columbia River Basin salmon, steelhead, and eulachon within the migratory corridor. The dams 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.

Smolt Passage

Delay

Before development of dams on the mainstem (which were built between 1938 and 1978), the mainstem migratory corridor was free-flowing with high velocities and a broad complex of habitats including rapids, short chutes, falls, riffles, side channels, wetland areas, and pools. It is not known how long juvenile salmon and steelhead took to traverse the free-flowing river, but in 1966, when Snake River salmon encountered only four mainstem dams, Raymond (1968) estimated that migrating smolts traveled about one-third to one-half as fast through the impounded reaches as through the free-flowing reaches.

Dams within the migratory corridor converted much of the once free-flowing river into a stair-step series of slow pools. Today, median travel times for yearling Chinook salmon from the Snake River to Bonneville Dam range from 14 days to 31 days depending on flow conditions, which is an increase of 40 to 50% over travel times measured in 1966 when fish encountered only the four mainstem dams (Williams et al. 2005).

This increased travel time presents an array of potential survival hazards to migrating juvenile salmon and steelhead: increasing their exposure to mortality vectors in the reservoirs (e.g. predation, disease, thermal stress), disrupting arrival timing to the estuary (which likely affects predator/prey relationships), depleting energy reserves, potentially causing metabolic problems associated with smoltification (i.e., the process of metabolic changes required to allow juvenile fish to convert from freshwater to saltwater environments), and contributing to residualism (i.e., a loss of migratory behavior).

A substantial fraction of the mortality experienced by juvenile outmigrants through the portion of the migratory corridor affected by the hydrosystem occurs in the reservoirs (e.g., about half of the mortality of in-river migrating juvenile spring-run Chinook salmon and steelhead), and therefore, reducing migration delays has been a focus of recent changes in dam operation to improve juvenile outmigrant survival through the hydrosystem. For example, Federal storage reservoirs have, compared to historical operations, been operated to increase spring and summer flows to accelerate smolt migrations, spill (and most recently, the addition of surface passage routes) has been implemented to reduce forebay delay, and a large fraction of the annual salmon and steelhead smolt outmigration has been collected and transported via barge downstream past the reservoirs and projects themselves, greatly accelerating passage.

Dam Passage

A substantial proportion of juvenile salmon and steelhead can be killed while migrating through dams, directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly through injury and disorientation, which leave fish more susceptible to predation and disease. Some level of juvenile mortality and injury is associated with all routes of dam passage, but turbines generally cause the highest direct mortality rates—generally ranging between 8% and 19%. Juveniles passing through project spillways, sluiceways, and other surface routes generally suffer the lowest direct mortality rates, typically 2% or less. However, substantially higher spillway mortalities have been measured through spillways at several mainstem projects (Ferguson et al. 2005). Juvenile mortality of approximately 3 to 5 % can occur in project forebays, (Axel et al. 2003; Ferguson et al. 2005;

Hockersmith 2007), where fish can be substantially delayed (median of 15 to 20 hours) before passing through the dam (Perry et al. 2007). Forebay delay increases juvenile fish exposure to fish and avian predators and the exposure time to adverse water quality conditions (e.g., elevated total dissolved gas levels and high water temperatures).

In the 1980s and 1990s, seven of the eight FCRPS dams in the migratory path of Snake River juvenile salmon and steelhead were retrofitted with turbine intake screen systems that divert 45 to 90% of the fish away from turbine entry and into bypass system channels, allowing migrants to be collected for transport downstream to below Bonneville Dam or released back to the river. Contemporary mechanical screen bypass systems are vastly improved compared to earlier systems that operated during the 1970s and early 1980s. At present, estimates of mortality through these passage routes are typically less than 2% (Ferguson et al. 2005). Ferguson et al. (2007) found that the new bypass system had high survival rates, virtually no injuries, little delay (compared to water particle travel times), and only mild indications of stress, compared to the older systems. However, outfall locations and dam configuration and operations remain important considerations for maximizing the survival of juvenile salmonids that are bypassed back to the river below dams.

In recent years, operational improvements and passage route configuration changes at several dams have also reduced juvenile mortality and injury rates. The proportion of water released through spillways has increased at most of the dams, resulting in a higher proportion of the migrants passing through these routes. Spilling water for fish has been increasingly provided on a 24-hour basis during the period of juvenile migration at most FCRPS dams in the migratory corridor. Water is also spilled when flows are higher than needed for turbine operation, an added survival benefit.

All dams in the mainstem migratory corridor have multi-gated spillways that use either vertical lift or radial gates that open 15 to 18 meters below the usual reservoir surface. To pass via the spillway, smolts must dive lower into the water to locate spillway entrances. A reluctance to swim to lower depths during daylight hours tends to increase juvenile delay in the forebays. Surface passage routes increase spill effectiveness (the proportion of fish passing a project via spillways divided by the proportion of total spilled project flow). Surface bypass structures are currently used at five of the eight FCRPS dams on the lower Columbia and Snake Rivers.

In 1975, large-scale juvenile fish transportation began, following a decade of research that led to the conclusion that generally the adult return rates of predominantly stream-type salmonids (spring/summer-run Chinook salmon and steelhead) that were transported as juveniles exceeded the return rates of fish that migrated in-river (Ebel et al. 1973; Ebel 1980; Mighetto and Ebel 1994). Currently, fish collection and transportation systems are operated seasonally at LGR, Little Goose Dam, and Lower Monumental Dam. Transportation at McNary Dam was terminated in 2012 (NMFS 2014b). Most transported fish are barged to release points downstream from Bonneville Dam. When collection numbers become too small for barging to be cost-effective, fish are transported via truck. Historically, approximately 60 to 90% of spring migrating smolts (spring/summer-run Chinook salmon and steelhead) in the Snake River Basin were transported annually, although almost all fish (99%) were transported during low water year conditions like 2001 (Williams et al. 2005). With the advent of a later May 1 start date for transport, the adoption of 24-hour spill and the installation of surface passage weirs at the Snake River collector projects, recent (2007-2015) transportation rates of juvenile yearling Chinook salmon and steelhead have ranged from approximately 15 to 50% annually (Faulkner et al. 2016). Operational and structural improvements at the dams have generally improved survival rates of juveniles through the mainstem migration corridor. These higher survival rates for in-river migrating fish have resulted in substantially reduced estimates of the relative benefit of transport.

Adult Passage

Unlike the situation with downstream migrating juveniles, there is no indication that reservoirs substantially delay adult upstream migration (Ferguson et al. 2005). Therefore, the discussion here is limited to fish passage facilities.

The eight mainstem FCRPS projects in the lower Snake and Columbia rivers and the five mainstem FERC-licensed projects in the mid-Columbia River are outfitted with adult fish ladders. In general, adult passage facilities are highly effective. Nonetheless, salmon may have difficulty finding ladder entrances, and fish also may fall back over the dam, either voluntarily (e.g., adults that "overshoot" their natal stream and attempt to migrate downstream through a dam on their own volition) or involuntarily (e.g., being entrained in spillways after exiting a fish ladder). Adults that fall back through project turbines and juvenile bypass systems have mortality rates estimated at between 22% and 59%, depending on the species and size of the individual fish (Ferguson et al. 2005). The survival of adults through juvenile bypass systems is less well known, but it is likely that survival rates are higher through these systems than through turbine units.

Mainstem Hydrologic Conditions

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow, altered its seasonality, and reduced sediment discharge and turbidity (Simenstad et al. 1982; Sherwood et al. 1990; Simenstad et al. 1990; Weitkamp 1994; NRC 1996). Annual spring freshet flows through the Columbia River estuary are about one-half of pre-development levels. Total sediment discharge is about one-third of nineteenth-century levels.

Flow affects juvenile migrant travel time and the distribution of fish among the various routes of dam passage. In general, the lower the flow through the series of reservoirs, the longer the travel time of outmigration. The longer juveniles remain in project reservoirs, the greater their exposure to predation, elevated temperatures, disease, and other sources of mortality and injury. Recognizing that the flow-survival relationships for some ESUs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995), there has been an attempt to manage Columbia and Snake River water resources to maintain seasonal flows above those thresholds. This has been accomplished by avoiding excessive drafts going into the spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during the summer to augment flows.

In summary, combined with the influence of reservoirs behind the dams, reductions in spring and early summer flows slow juvenile fish emigration, increase their exposure to injury and mortality factors within the reservoirs, and changes ocean-entry timing. These flow reductions also reduce turbidity, which has also been shown to reduce juvenile survival.

Mainstem Effects of Bureau of Reclamation Irrigation Projects in the Columbia River Basin

In total, BOR's 23 irrigation projects in the Columbia River Basin reduce the annual runoff volume at Bonneville Dam by about 5.5 million acre feet. These depletions occur primarily during the spring and summer as the reservoirs are refilled and as water is diverted for irrigation purposes.

Spring flow reductions have both beneficial and adverse effects on fish survival. During above average water years, flow reduction during reservoir refill reduces involuntary spills, which are known to cause undesirable total dissolved gas conditions in the migratory corridor. However, this beneficial effect is small because the amount of flow attenuation provided by Reclamation is generally too small to greatly affect involuntary spill events below Hells Canyon and Chief Joseph Dams. Flow depletions associated with Reclamation's projects contribute to juvenile migration delay and decrease juvenile migrant survival. In addition to these mainstem flow effects, several of the projects below Hells Canyon and Chief Joseph Dams affect listed salmonids in the tributary streams where the project is located or where Reclamation's irrigation return flows occur.

Mainstem Water Quality

Water quality in the mainstem Snake and Columbia Rivers is affected by an array of land and water use development activities. Water quality characteristics of particular concern are temperature, turbidity, total dissolved gas, and pollutants.

Temperature

Water management influences water temperatures through storage, diversion, and irrigation return flows. Changes in water temperatures can have significant implications for anadromous fish survival. Using historical flows and environmental records from 1960 to 1995, one recent study compared water temperature records in the Lower Snake River with and without the lower Snake River dams (Perkins and Richmond 2001). There are three notable differences when comparing the current river conditions to the unimpounded river conditions: the maximum summer water temperature has been slightly reduced, water temperature variability has decreased, and post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall (i.e., thermal inertia). Thermal inertia is of particular biological significance, as it may affect adult migrations, spawn timing, and juvenile emergence, rearing, and outmigration timing, as described below.

The effects of thermal inertia on salmon depend on the coincidence of sensitive life stages with the time shifts in water temperature. The Snake River fall-run Chinook Salmon ESU may be the most vulnerable ESU/DPS as they spawn, incubate, and rear in mainstem habitats. In some years, adult arrival at spawning sites in the Snake River system is delayed by high water temperatures

(Bennett and Peery 2003). The migration is slowed or stopped when the fish take refuge in cooler areas (e.g., tributary mouths) and resumes when the general river temperature declines. Delayed adult migration combined with delayed onset of water temperatures conducive to spawning delays the onset of spawning. In turn, incubation, hatching, and rearing occur under less than ideal thermal conditions, resulting in delayed juvenile emigration. Delayed downstream migration places juveniles in the migration corridor later in the spring, when water temperatures are rising, which in turn decreases the likelihood of juvenile survival.

High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmonids to stop or delay their migrations. High temperatures also increase the metabolism and foraging by predatory fish. The impacts of high summer water temperatures on juvenile salmonid health may be reduced by the availability of thermal refugia, areas where localized shade, springs, or tributary inflows provide lower water temperatures (Kock et al. 2007).

Coincidently, and perhaps due to climate change, average annual Columbia Basin air temperatures have increased by about 1° C over the past century, and water temperatures in the mainstem Snake and Columbia Rivers have been affected similarly (ISAB 2007a).

Turbidity

Flow regulation and reservoir existence reduces turbidity in the Columbia and Snake Rivers, in the estuary, and in the Columbia River plume. Reduced turbidity increases predator success through improved prey detection, increasing the susceptibility of smolts to predation. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia River and Snake River migratory corridors.

Total Dissolved Gas

Spill at mainstem dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses, notably nitrogen. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury or death (this is also known as decompression sickness, or the bends, which is a condition arising from dissolved gases coming out of solution into bubbles inside the body on depressurisation). The incidence of GBT in both migrating smolts and adults remains low (1-2%) when TDG concentrations in the upper water column do not exceed 120% of saturation in FCRPS project tailraces and 115% in project forebays. When those levels are exceeded, the incidence of GBT increases. However, the effects of TDG supersaturation are moderated by depth, where each meter of depth compensates for 10% of gas supersaturation at the water surface. That is, water that is at 120% of saturation at the surface would be at 110% of saturation one meter below surface, at 100% of saturation two meters below the surface, and so on.

Current reservoir operations typically limit gas-generating, high-spill events to a few days or weeks during high-flow years. Historically, TDG supersaturation was a major contributor to juvenile salmon mortality, and TDG abatement is a focus of efforts to improve salmon survival. The 115-120% guideline is generally exceeded only during the peak of the annual runoff hydrograph. The COE has invested heavily in controlling TDG at its projects in the migratory corridor.

Toxic Contaminants

Toxic contaminants in inflows carry cumulative loads from upstream areas in variable and generally unknown amounts. Growing population centers throughout the Columbia and Snake River Basins, and numerous smaller communities contribute municipal and industrial waste discharges to the rivers. Industrial and municipal wastes from the Portland-Vancouver metropolitan areas affect the LCR and estuary. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Toxic contaminants are especially a concern in the estuary.

2.3.3.3 Columbia River Estuary and Plume

The estuary and plume of the Columbia River do not have unambiguous, agreed-upon boundaries. For purposes of this document, we define estuary and plume as they are described in Section 1.4, Action Area, which is consistent with current recovery planning documents (e.g., NMFS 2011c). The Columbia River estuary is the tidally influenced portion of the river and tributary reaches upstream from the Columbia mouth, which extends upstream 146 miles to Bonneville Dam and up the Willamette River to Willamette Falls. During low flows, reversal of river flow has been measured as far upstream as Oak Point at RM 53. The intrusion of saltwater is generally limited to Harrington Point at RM 23, but saltwater intrusion can extend past Pillar Rock at RM 28.

The Columbia River plume is generally defined by a reduced-salinity contour near the ocean surface of approximately 31 parts per thousand (Fresh et al. 2005). The plume's location varies seasonally with discharge, winds, and currents. In summer, it extends far to the south and offshore along the Oregon coast. During the winter, it shifts northward and inshore along the Washington coast. Strong density gradients between ocean and plume waters create stable habitat features where organic matter and organisms are concentrated (Fresh et al. 2005). The plume can extend beyond Cape Mendocino, California, and influences salinity in marine waters as far away as San Francisco.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about 4 miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Strong density gradients between ocean and plume waters create stable habitat features where organic matter and organisms are concentrated (Fresh et al. 2005), and the estuary and plume served as a physical and biological engine for salmonids and eulachon. Juveniles from hundreds of populations of steelhead, chum, Chinook, and coho salmon entered the estuary and plume every month of the year, with their timing honed over evolutionary history to make use of habitats rich with food. This genetic variation in behavior was an important trait that allowed salmonids and eulachon to occupy many habitat niches in time and space.

Today, the estuary and plume are much different. Notably, jetties at the mouth of the river restrict the marine flow of nutrients into the estuary. Dikes and levees lining the Washington and Oregon shores prevent access to areas that once were wetlands. New islands have been formed by dredged materials, and pile dike fields redirect flows. Less visible, but arguably equally important, are changes in the size, timing, and magnitude of flows that regularly allowed the river to top its banks 200 years ago and provided salmonids and eulachon with important access to habitats and food sources. Flow factors, along with ocean tides, are key determinants of habitat opportunity and capacity in the estuary and plume. It is unknown what effect these changes in hydrology may have on eulachon habitat.

More than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres (about five square miles) of intertidal marsh and spruce swamps have been converted to other uses since 1948 (LCREP 1999). Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. As a result, the peaks of spring/summer floods have been reduced, and the amount of water discharged during the winter has increased.

The estuary and plume provide salmonids and eulachon with a food-rich environment where they can undergo the physiological changes needed to make the transition from freshwater to saltwater habitats, and vice versa. Every anadromous fish that spawns in the Columbia River Basin undergoes such a transformation at least twice in its lifetime—the first time during its first year of life (or soon after) when migrating out to sea, and the second time 1 to 3 years later as an adult returning to spawn. The transition zone where juvenile salmonids undergo these transformations is thought to extend from the estuary itself to the near-shore ocean, plume habitats, and rich upwelling areas near the continental shelf (Casillas 1999).

More detail about the current state of the estuary and plume is discussed below, but it is essential to understand beforehand that utilization of the estuary and plume, and thus the impacts on salmonids and eulachon because of changes to these areas, vary considerably according to major life history types of the salmonids/eulachon experiencing the changes. As discussed in Subsection 2.2.1, Status of Listed Species, anadromous salmonids fall into two major life history classes, according to freshwater rearing strategy: ocean-type and stream-type (Fresh et al. 2005). Ocean types may rear in the estuary for weeks or months, making extensive use of shallow, vegetated habitats such as marshes and swamps, where significant changes in flow and habitat have occurred (Fresh et al. 2005). Conversely, stream-type salmonids rear in the estuary for an extended period of time, usually at least one year, and then migrate to sea (Fresh et al. 2005). In terms of ESA-listed fish, the LCR Coho Salmon ESU, all DPSs of steelhead, Snake River Sockeye Salmon ESU, UCR spring-run Chinook Salmon ESU, and Snake River spring/summer-run Chinook Salmon ESU are stream-type fish. Fall-run populations of the LCR Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, and CR Chum Salmon ESU are ocean-type fish. Spring-run populations of the LCR Chinook Salmon ESU and UWR spring-run

Chinook ESU are technically ocean-type fish but naturally represent a mixture of the two types. Within these major types, historically, there was a considerable diversity of estuary use, especially in ocean-type Chinook salmon, with fish utilizing the estuary at various fry, fingerling, subyearling, and yearling stages (Fresh et al. 2005); however, many previously common patterns are now considered rare.

Both ocean- and stream-type salmonids experience significant mortality in the estuary. However, as just mentioned, because the two types typically spend different amounts of time in the estuary and plume environments and use different habitats, they are subject to somewhat different combinations of threats and opportunities. For ocean-type juveniles, mortality is believed to be related most closely to lack of habitat, changes in food availability, and the presence of contaminants, including persistent, bio accumulative contaminants present in sediments in the shallow-water habitats where ocean-type juveniles rear in the estuary. Stream-types are affected by these same factors, although presumably to a lesser degree because of their shorter residency times in the estuary. However, stream-types are particularly vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid channel areas located near habitat preferred by piscivorous birds (Fresh et al. 2005). Table 83 compares the relative importance of major limiting factors to the two life-history types. The factors are explained in the following Sections.

Table 83. Relative importance to ocean- and stream-type salmonids of limiting factors in the Columbia River estuary, for factors rated as significant or higher in one of the two life-history types. Adapted from Table 3-1 of NMFS (2011c).

Factor	**Level of Impact**[1]	
	Ocean-type	**Stream-type**
Flow-related habitat changes	Major	Moderate
Sediment-related habitat changes	Significant	Moderate
Flow-related changes to access to off-channel habitat	Major	Moderate
Bankful elevation changes	Major	Minor
Flow-related plume changes	Moderate	Major
Water temperature	Major	Moderate
Reduced macrodetrital inputs	Major	Moderate
Avian and pinniped predation	Minor	Major
Toxicants	Significant	Minor-Moderate

[1] Level of impact ratings: No likely effects, minor effects, moderate effects, significant effects, and major effects on populations.

Limiting Factors Related to Changes in Physical Habitat

Mean flow into the estuary has been reduced 16% from historical levels and the pattern of flow has changed considerably. Spring freshets, important for downstream migration, have been reduced 44% and occur earlier in the year, and flow is higher than it was historically at other times of the year. This decreased flow, coupled with overall effects of climate change, has increased mean water temperatures at Bonneville Dam by 4° C since 1938; temperature levels of 20°C, considered the upper tolerance level for salmon (NRC 2004) occur earlier in the year and more frequently than they did historically. Variation in flow has been reduced, particularly the frequency of bank overflows, which historically was a key element in sustaining the food web.

Land-use development and decreased flow has decreased the size of the estuary by about 20%. Much of the decrease is due to reduction in channel complexity and increased in diking. By some estimates, over 70% of the historical tidal marsh habitat is now inaccessible and levee construction has reduced the frequency of overbank flows (Jay and Kukulka 2003). The reduction in overbank events reduces the availability of food and refugia for ocean-type juveniles rearing in the estuary. Smaller stream-type juveniles are affected the same way.

The combination of decreased flows and upstream impoundments have reduced sediment inputs by 60%, which has reduced the ability of the estuary to build habitat, and has also had food web consequences in the estuary and plume.

The plume supports ocean productivity by increasing primary plant production during the spring freshet period, distributing juvenile salmonids in the coastal environment, concentrating food sources and providing refugia from predators in the more turbid, low-salinity plume waters (Fresh et al. 2005). Changes in the volume and timing of Columbia River flows have altered both the size and structure of the plume during the critical spring and summer months (NMFS 2011c). Reductions in spring freshets and associated sediment transport processes may now be suboptimal for juvenile salmonids (Casillas 1999). Changes in the plume include surface area, volume, extent and intensity of frontal features, and the extent and distance offshore (Fresh et al. 2005).

Limiting Factors Related to Changes in the Food Web

The estuarine food web historically was based on macrodetrital inputs (i.e., input of decaying plants) that originated from emergent, forested, and other wetland rearing areas in the estuary (NPCC 2004b; Sagar et al. 2015). Today, detrital sources from emergent wetlands in the estuary are approximately 84% less than they were historically (Bottom et al. 2005). The reduction of macrodetritus in the estuary reduces the food sources for juvenile salmonids. As a result, juveniles may have reduced growth, lipid content, and fitness prior to ocean migration or may need to reside longer in the estuary to achieve the necessary growth and development for ocean entrance.

Macrodetrital plant production has declined because of revetment construction, disposal of dredged material in areas where plant materials or insects could drop into the water, simplification of habitat through the removal of large wood, and reductions in flow. Historically, much of the detrital inputs occurred during overbank events, which provided additional shallow-water habitat for juvenile salmonids and resulted in significant detrital inputs to the estuary. The current food web is based on decaying phytoplankton delivered from upstream reservoirs.

The switch in the estuarine food web from a macrodetritus-based source to a microdetritus-based source (i.e., input of phytoplankton) has altered the productivity of the estuary (Bottom et al. 2005; Sagar et al. 2015). The substitution of detrital sources in the estuary also has contributed to changes in the spatial distribution of the food web (Bottom et al. 2005). Historically, the macrodetritus based food web was distributed evenly throughout the estuary, including in the many shallow-water habitats favored by ocean-type salmonids. But the contemporary microdetrital food web is concentrated within the estuarine turbidity maximum in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type fish that use peripheral habitats and more accessible to species, such as American shad, that feed in deeper-water areas. Pelagic fish such as shad may also benefit from the fact that the estuarine turbidity maximum traps particles and delays their transport to the ocean up to 4 weeks, compared to normal transport of around 2 days (NPCC 2004b).

Another aspect of the food web change is predation and competition. Predation and competition for habitat and prey resources limit the success of juvenile salmonids entering the estuary and plume. Competition among salmonids and between salmonids and other fish may be occurring in the estuary (LCFRB 2004), with the estuary possibly becoming overgrazed when large numbers of ocean-type salmonids enter the area. Food availability may be reduced as a result of the temporal and spatial overlap of juveniles from different locations (Bisbal and McConnaha 1998). Ecosystem-scale changes in the estuary have altered the relationships between salmonids and other fish, birds, and mammal species, both native and exotic. Some native species' abundance levels have decreased from historical levels, while others have increased to levels far exceeding those in recorded history, with associated changes in predation of salmon and steelhead juveniles. Changes in physical habitat have increased feeding opportunities for piscivorous birds, such as terns and cormorants, to which stream-type smolts are especially vulnerable. Predation on juvenile salmonids, both stream- and ocean-types, by northern pikeminnows has likely increased as well due to lower turbidity. Predation by pinnipeds has also increased over historical levels.

The introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitism, and alterations in the food web. At least 37 fish species, 27 invertebrate species, and 18 plant species have been introduced into the estuary (NPCC 2004b; Sytsma et al. 2004). Introduced species affect ocean-type ESUs more than they do stream-type ESUs because ocean types' depend on the estuary for longer periods and use shallow-water habitats.

One of these introduced species, the American shad, has had especially profound consequences. American shad adult returns now exceed 4 million annually (NPCC 2004b). Shad do not eat salmonids, but they exert tremendous pressure on the estuary food web because of the sheer weight of their biomass. Some evidence suggests that planktivorous American shad have an impact on the abundance and size of *Daphnia* in Columbia River mainstem reservoirs (Haskell et al. 1996 in ISAB 2008), thereby reducing this important food source for subyearling fall-run Chinook salmon that also eats *Daphnia*.

Limiting Factors Related to Toxic Contaminants

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007), from both estuary and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoffs (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare. However, recent research has revealed some notable exceptions in which toxic contaminants may lead to the direct mortality of salmonids, such as high levels of prespawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2007), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2005).

Sublethal effects are a significant threat to juvenile salmon in the Columbia River. In juvenile salmonids, contaminant exposure can result in decreased immune function and generally reduced fitness (Arkoosh and Collier 2002; NPCC 2004b). Exposure can also impair growth, development, and reproduction and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects likely indirectly increase mortality from other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

In particular, contaminants that affect growth can have significant effects. Juvenile growth is necessary for ocean survival (Zabel and Williams 2002), and adult fish size has been correlated to reproductive success and egg size (Healey and Heard 1984; Beacham and Murray 1987). Low lipid content observed in outmigrating juvenile Chinook salmon in the estuary (Johnson et al. 2007a; LCREP 2007), is a sign of poor growth that is correlated with an increased risk of juvenile mortality (Biro et al. 2004). Thus, contaminants that impair salmonid growth can reduce juvenile survival, adult returns, and individual reproduction.

Although many effects of contaminants require an exposure period of weeks to months, some impacts, especially those on behavior, can occur very quickly. For example, effects of pesticides and copper on the salmon olfaction system can be seen after exposure periods of only a few hours (Sandahl et al. 2004; Hecht et al. 2007; Sandahl et al. 2007).

Toxic contaminants can also indirectly affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources.

Loge et al. (2005) estimated disease-induced mortalities in Chinook salmon related to exposure to contaminants at 1.5% and 9% for estuary residence times of 30 and 120 days, respectively. Other contaminants beginning to be characterized in the estuary, such as endocrine-disrupting substances like synthetic hormones, could have substantial effects on salmon and steelhead (Fresh et al. 2005). Emerging contaminants, such as caffeine, acetaminophen, and human and veterinary antibiotics, in the water column of the estuary and evidence of exposure to estrogenic compounds have been found in the blood of juvenile Chinook salmon (LCREP 2007). Several suspected hormone disruptors were detected, including bisphenol A (plasticizer), HHCB (artificial musk), and PBDEs (flame retardants). In particular, PBDE concentrations in the environment have increased exponentially during recent decades; in the estuary, they have been found in the water column, on suspended sediment, and in the tissue and stomach contents of juvenile Chinook salmon, which indicates that salmon prey also are contaminated (LCREP 2007). PBDEs are similar to PCBs in their chemical structure and sublethal effects, such as neurotoxicity and hormone disruption.

Stream-type salmon are apt to have contaminant loads that reflect conditions in the UCR and its tributaries, while ocean-type salmon are apt to have loads that reflect conditions in the lower river and estuary (Dietrich et al. 2005; Leary et al. 2005; Johnson et al. in prep). Both stream-type and ocean-type juvenile salmonids are likely affected by exposure to waterborne contaminants, such as organophosphate pesticides and dissolved metals, that can have acute effects on salmon olfaction and behavior (Fresh et al. 2005; Johnson et al. in prep), and both types could be affected by bioaccumulative legacy pesticides, such as DDTs, that are present throughout the basin. Additionally, ocean-type juveniles likely experience adverse effects and possibly mortality from urban and industrial bioaccumulative toxics, such as PCBs and PBDEs, that are absorbed during longer estuarine residence times (Fresh et al. 2005). Both life history types could be affected by contaminant impacts on prey resources (Johnson et al. in prep). Preliminary data tend to show that contaminant body burdens are generally higher in ocean-type stocks than in stream-type populations (Johnson et al. 2007b). Contaminant body burdens are also generally higher in outmigrating subyearling UCR, MCR, and LCR Chinook salmon than in yearlings, especially for industrial contaminants such PCBs and PBDEs that are present at higher concentrations in the estuary (Dietrich et al. 2011). Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life history types.

Limiting Factors Related to Avian, Pinniped, and Piscivorous Fish Predation

Avian Predation

Colonial water birds including Caspian terns (*Hydroprogne caspia*), double-crested cormorants (*Phalarcrocorax auritus*), and gulls (*Larus* spp.) may comprise the majority of avian predators on salmonid smolts in the estuary and mainstem of the Columbia River (Roby and Craig 1998; Collis et al. 2002; Evans et al. 2012; ISAB 2015). Because steelhead smolts are larger in size, multiple studies have shown that they are particularly susceptible to predation by terns and cormorants. For instance, a study by Collis et al. (2001) determined that over 15% of the tags from PIT-tagged steelhead detected at Bonneville Dam in 1998 were later found on estuarine bird colonies compared with only 2% of the tags from PIT-tagged yearling Chinook salmon (ISAB 2015). Similarly, Faulkner et al. (2007) showed that the percentage of tagged smolts recovered from bird colonies upstream of McNary Dam was higher for steelhead than for Chinook salmon (ISAB 2015). A reduction in steelhead mortality and an increase in in-river abundance downstream of Lower Monumental Dam was observed between 1998 and 2007, negatively correlated with a decrease in PIT tags recovered from bird colonies near McNary pool, indicating that predation by bird colonies was depensatory (ISAB 2015). Furthermore, this correlation coincided with a period of increased spill (Faulkner et al. 2008), which increases the number of in-river migrants, temporarily buffering all potential prey species inhabiting the river from predation risk (ISAB 2015).

Piscivorous Fish Predation on Outmigrants

Like avian predation, predation on juvenile salmonids by piscivorous fish may be depensatory. Although the ISAB (2015) states that no data are available for the Columbia River to confirm this hypothesis, native pikeminnow are significant predators of both juvenile salmonids in the Columbia River Basin, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011; ISAB 2015). The Northern Pikeminnow Management Program (NPMP) began in 1990 and has since reduced predation-related juvenile salmonid mortality (NMFS 2008d). Prior to this control program, pikeminnow were estimated to eat roughly 8% of the 200 million juvenile salmonids that migrated downstream in the Columbia River Basin yearly, however, the NPMP appears to have reduced that rate to about 5% (CBFWA 2010; ISAB 2015).

Predation on Returning Adult Salmonids

By the time adult salmon enter the Columbia River estuary, they have already survived multiple threats in both saltwater and freshwater environments. Additionally, predation on salmonids in their early life history can be offset by compensatory mortality during later life stages, particularly if predators selectively remove the most vulnerable individuals. Therefore the remaining returning salmonids are likely valuable for spawning or harvest (ISAB 2015).

One of the largest predators of adult salmonids in the LCR are pinnipeds (seals and sea lions). Pinnipeds are capable of consuming large quantities of adult salmonids and other fishes (ISAB 2015). For example, as of 2008, sea lion predation of adult spring-run LCR Chinook salmon and adult winter steelhead in the Bonneville tailrace had increased from 0%, or sufficiently low that it was rarely observed, to about 8.5% and 21.8%, respectively (Marine Mammal Appendix in NMFS 2008d; 2008h). Additionally, a study by Stansell et al. (2014) showed that the minimum number of pinnipeds estimated from visual observations at Bonneville Dam increased from 31 to 166 from 2002 to 2010, with 137 observed during 2014 (ISAB 2015).

A telemetry study by Wright et al. (2010) showed a decrease in pinniped wounds in spring, summer, and fall Chinook salmon and steelhead between 1996 and 2004 as run sizes increased, signaling depensation due to predator satiation (ISAB 2015). Finally, Rub (2014) as referenced in ISAB (2015), reported that recent tagging studies by NOAA indicated that the weighted mean annual survival of spring Chinook migrating upstream from the Lower Columbia estuary past Bonneville Dam has declined from 90% in 2010 to 69% in 2013, after accounting for impacts from sampling gear and fishing mortalities.

Rub (2014) suggested predation by pinnipeds would have been more intense for the Chinook salmon arriving early in the run, which supported data showing that survival was higher for Chinook salmon arriving late (ISAB 2015). Additionally, the declining survival rates from 2010 to 2013 correlate closely with an increasing presence of sea lions and seals in the estuary (Rub 2014; ISAB 2015). However, even though the number of sea lions in Astoria (at the mouth of the Columbia) has increased dramatically in the last few years, the number of spring Chinook salmon counted at Bonneville Dam has been continually increasing since 2008. However, it is difficult to estimate the overall impact of pinniped predation on salmonids in the Columbia River and estuary, due to limited estimates of total pinniped abundances (ISAB 2015).

Ongoing actions to reduce predation include redistribution of avian predator nesting areas, a sport reward fishery to harvest pikeminnow, and the exclusion and hazing of marine mammals near Bonneville Dam (NMFS 2008d).

2.3.4 Hatchery Effects

This Section includes the effects of hatchery operations in the Columbia River Basin for the operation of hatcheries prior to this consultation, as well as the continued operation of hatchery programs that have already undergone a separate ESA Section 7 consultation. The effects of future operations of hatchery programs with expired ESA Section 7 consultation and those programs yet to undergo ESA Section 7 consultation cannot be included in the environmental baseline, except when effects are ongoing (e.g., returning adults from past hatchery releases for programs with expired ESA permits).

A more detailed description of the specific effects of hatchery programs NMFS analyzes can be found in Section 2.4.1, Factors Analyzed when Assessing Hatchery Programs. For example, these include competition with natural-origin fish for spawning sites and food, outbreeding depression, and hatchery-influenced selection. Because most programs are ongoing, the effects of each are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015) and was summarized in Section 2.2.1 of this Opinion. We also incorporate some analysis of baseline effects of the programs included in our Proposed Action when necessary to evaluate effects of the program into the future (i.e., past pHOS values, past broodstocking practices). The information below provides context on the number, size and purpose of hatchery programs throughout the Columbia River Basin.

The history and evolution of hatcheries are important factors in analyzing their past and present effects. From their origin more than 100 years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability. The first hatcheries, beginning in the late 19th century, provided fish to supplement harvest levels, as human development and harvest impacted naturally produced salmon and steelhead populations. As development of the Columbia River Basin proceeded (e.g., dam construction as part of the FCRPS between 1939 and 1975), hatcheries were used to mitigate for lost salmon and steelhead harvest attributable to reduced salmon and steelhead survival and habitat degradation. Since that time, most hatchery programs have been tasked to maintain fishable returns of adult salmon and steelhead, usually for cultural, social, recreational, or economic purposes, as the capacity of natural habitat to produce salmon and steelhead has been reduced.

A new role for hatcheries emerged during the 1980s and 1990s after naturally produced salmon and steelhead populations declined to unprecedented low levels. Genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery, as well as in fish that spawn in the wild (Hard et al. 1992; NMFS 2008b; Jones Jr. 2015). Hatchery programs have been used as a tool to conserve the genetic resources of depressed natural populations and to reduce extinction risk, at least in the short-term (e.g., Snake River sockeye salmon). Such hatchery programs are designed to preserve the salmonid genetic resources until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs reduce the risk of extinction (NMFS 2005c; Ford 2011). Hatchery programs that only conserve genetic resources, however, "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or long-term (NMFS 2005c). Furthermore, hatchery programs that conserve vital genetic resources are not without risk to the natural salmonid populations because the manner in which these programs are implemented can affect the genetic structure and evolutionary trajectory of the target population (i.e., natural population that the hatchery program aims to conserve) by reducing genetic and phenotypic variability and patterns of local adaptation (HSRG 2014; NMFS 2014f).

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. Hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival or when access to spawning and rearing habitat is blocked. Under circumstances like these, and in the short-term, the demographic risks of extinction of such populations likely exceed genetic and ecological risks to natural-origin fish that would result from supplementing the natural population through hatchery actions. Benefits like this should be considered *transitory*, or short-term, and these benefits do not contribute to survival rate changes necessary to meet recovery plan abundance and productivity viability criteria. These hatchery programs help "to preserve remaining genetic diversity, and likely have prevented the loss of several populations" (NMFS 2005c; Ford 2011). However, until the factors limiting salmon and steelhead productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon and steelhead viability may not be realized. Therefore, fixing the factors limiting viability is the key to long-term viability. "The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery" (HSRG 2004). Salmon and steelhead populations that rely on hatchery production are not viable (McElhany et al. 2000; NMFS 2013e), and increased dependence on hatchery intervention results in decreasing benefits and increasing risks (ICTRT 2007; NMFS 2014e).

Population viability and reductions in threats are key measures for salmon and steelhead recovery (NMFS 2013e). Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., supplementation of natural population abundance through hatchery production). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish by increasing the natural production with returning hatchery adults. These programs are not, however, a proven technology for achieving sustained increases in adult production (ISAB 2003), and the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014). The LCR in particular is currently very dependent on hatchery production, with concurrent risks. In particular, many listed natural Chinook and coho salmon have high percentages of hatchery-origin fish on the spawning grounds. In addition the hatchery fish released in some cases originate from nonlocal sources, creating an added risk to diversity. Examples are long-time use of a steelhead stock that originated in Puget Sound and more recently a Chinook salmon stock that originated in the Rogue River.

Regarding hatchery consultations in the Action Area, NMFS describes the progression of consultations that have been performed in Section 1.2, Consultation History. Here we incorporate those by reference and update the environmental baseline for contemporary effects that result from those consultation conclusions.

In 2008, an agreement was reached by all of the parties to the *U.S. v. Oregon* CRFMA that set production goals for 89% of the hatchery production above Bonneville Dam (*U.S. v. Oregon* 2009). The remaining production includes hatchery programs that are operated and/or funded by non-*U.S. v. Oregon* parties, and hatchery production that was not agreed to at the time of signing (*U.S. v. Oregon* 2009).

More than 80 hatchery facilities (including ancillary facilities) for salmon and steelhead in the Columbia River Basin are operated by Federal and state agencies, tribes, and private entities (Figure 26 and Figure 27) (NMFS 2014f).

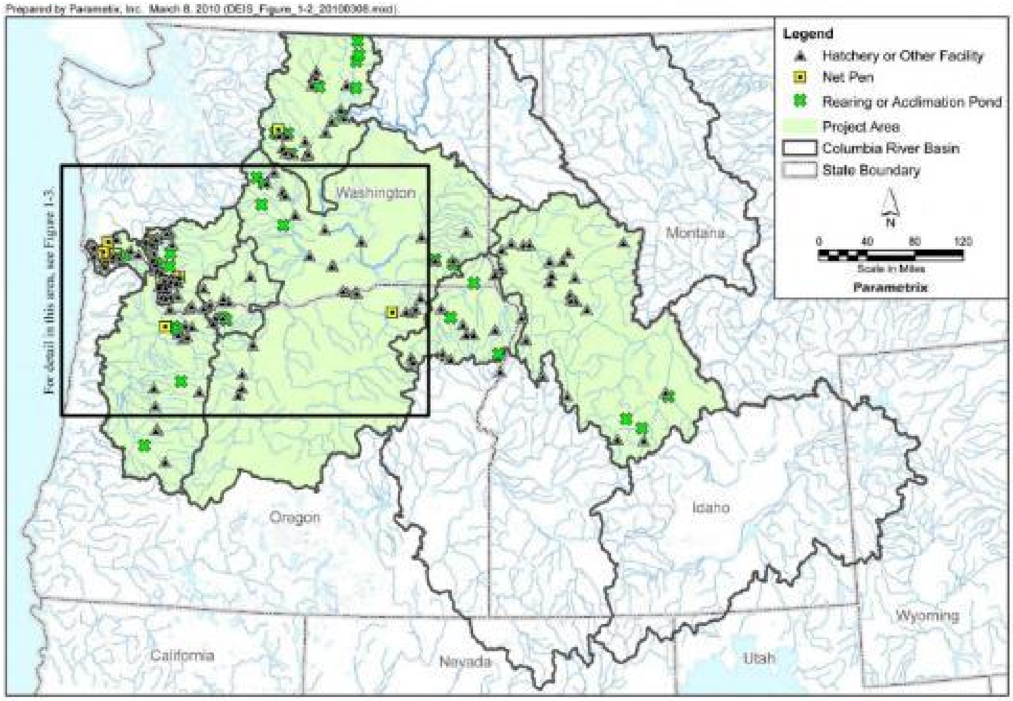

Figure 26. Hatchery facilities in the project area (NMFS 2014f).

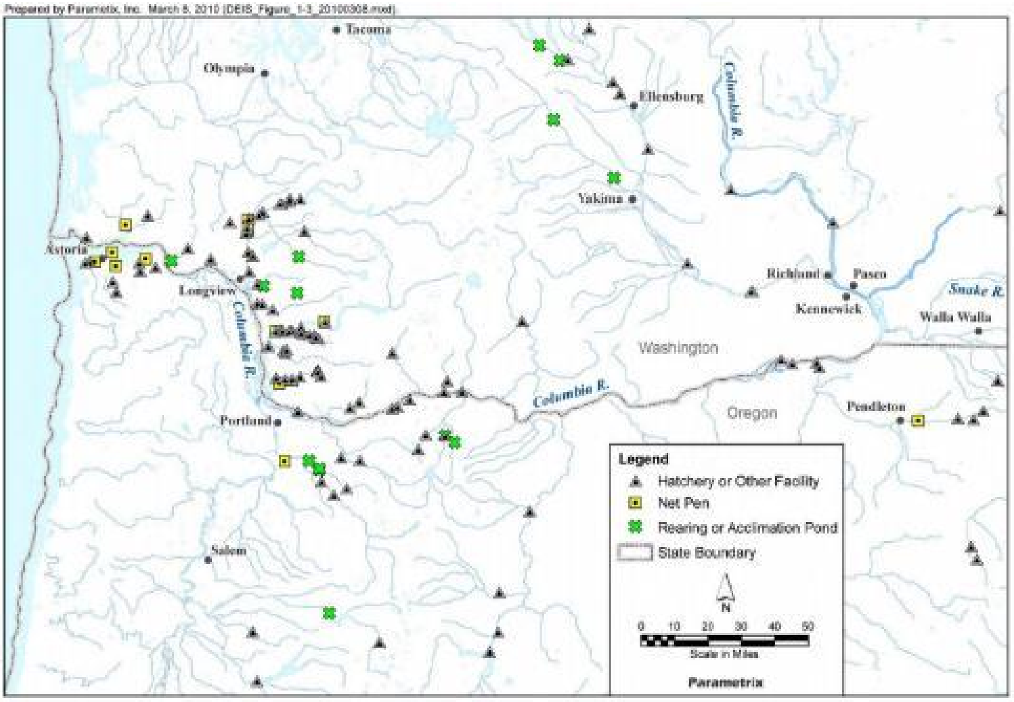

Figure 27. Hatchery facilities in the project area (detail area) (NMFS 2014f).

Currently, these Columbia River hatchery facilities support approximately 160 individual hatchery programs (Table 84). Many of the hatchery facilities support one or more hatchery programs, and funding for these facilities can come from multiple entities, including NMFS (through the Mitchell Act) and other Federal agencies. Hatchery facilities funded under the Lower Snake River Compensation Program are also supported by Federal funds. These hatchery facilities were built to mitigate for the effect of Federal dams on the lower Snake River (USACE 1975). The BOR funds hatchery production to mitigate for the effects of the Grand Coulee Dam. The COE funds substantial hatchery production as mitigation for dams in the mainstem Columbia River and Snake River. Furthermore, the NPCC's Columbia River Basin Fish and Wildlife Program allocates BPA funding to finance artificial production programs authorized by the Northwest Power Planning and Conservation Act of 1980 (PL 96-501, December 5, 1980). Other hatchery facilities in the Columbia River Basin are funded by private power companies or public utility districts and do not receive Federal funds.

The total number of hatchery facilities and hatchery programs normally remains fairly constant, but individual programs can change from year to year depending environmental conditions, broodstock collection, juvenile survival, fisheries management changes, ESA concerns, and funding. For example, the spring Chinook salmon hatchery program at Entiat National Fish Hatchery was terminated in 2007 because of ESA concerns over the effects of the program on the conservation of UCR spring Chinook salmon, and the Tule Fall Chinook Salmon Program at the Little White Salmon NFH was terminated in 2013 due to management and funding source changes. Even when a hatchery program is terminated, the effects of that program on listed species can continue for a number of years depending on the species released. In this example, the tule fall-run Chinook salmon last released in 2013 from the Little White Salmon NFH will continue to return as hatchery-origin adults through 2017as 5-year old fish. The next generation of hatchery practices are expected for hatchery programs that are funded though the Mitchell Act, as described under Phase 2 and Phase 3 of the Proposed Action (Section 1.3).

The 160 hatchery programs released an estimated 144 million juvenile salmonids into the Columbia River Basin in 2016 (Table 84). This total is a 27% decrease from the annual release of approximately 197.1 million that was evaluated in the 1999 Hatchery Opinion (NMFS 1999a). The release of salmon and steelhead into the Columbia River Basin varies annually and in recent years has averaged between 140 and 145 million smolts. This does not mean that 140 to 145 million hatchery-origin juveniles pass down the mainstem, through the estuary, and into the ocean. There is a high level of mortality immediately after release greatly reducing the number of juveniles outmigrating to the estuary and then into the ocean. Survival from release at the hatchery facility to the ocean is highly variable depending on the species, size at release, timing of release, release location, the distance traveled within the tributaries, the number of dams encountered, whether the fish are collected and transported downstream, and in-river environmental conditions. All of these factors affect the survival of hatchery-origin juveniles. For example, Faulkner et al. (2015), using the mean migrant survival estimate for the 2002-2014 outmigration years, estimated that the survival of hatchery-origin spring-run Chinook salmon juveniles from release in the upper Snake River Basin to Lower Granite Dam was 64.2%. That is, out of all of the hatchery-origin spring-run Chinook yearlings released into the Snake River, less than two-thirds reached the first dam. Similarly, Neeley (2012) estimated juvenile survival from the acclimation and release locations in the Yakima River Basin to McNary Dam (distances ranging from 90 to 229 river miles) for spring-run Chinook salmon, coho salmon, summer-run Chinook salmon, and fall-run Chinook salmon has been less than 30% over that distance. Estimates of juvenile survival from acclimation and release locations in the Umatilla River Basin to Three Mile Dam (at approximately RM 4 of the Umatilla River) have averaged less than 50% in recent years, and survival to John Day Dam (a distance of 77 miles) has averaged less than 40% (Clarke et al. 2014). Faulkner et al. (2015), when estimating the number of juvenile fish that could be encountered at each of the mainstem dams, assumed that there is approximately a 10% loss for each dam that the juvenile salmon and steelhead must cross. Applying this information, less than one-half of the annual release of over 88 million above Bonneville Dam would survive to below Bonneville Dam.

This Opinion includes, in the baseline, the effects of hatchery operations in the Columbia River Basin. These effects constitute factors that may increase risk to the recovery of the ESA-listed ESUs and DPSs, which result from the operation of hatcheries prior to this consultation, as well as the continued operation of hatcheries into the future for those hatchery programs that have already undergone a separate ESA Section 7 consultation as listed in Table 84. The effects of future operations of those hatchery consultations with expired ESA Section 7 consultation and those programs yet to undergo ESA Section 7 consultation (Table 84) cannot be included in the environmental baseline but the effects of these programs on ESA-listed species will be considered under cummulative effects. In some instances, effects are ongoing (e.g., returning adults from past hatchery releases for programs with expired ESA permits) and are included in the analysis, even for those future operations that are excluded from the baseline.

Table 84. Columbia River Basin hatchery releases by region, program, species, run, release goal, and applicants/operators (URB – Upriver Bright[23]; RSI – remote site incubators[24]).

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Columbia River Bain Hatchery Programs Evaluated in this Opinion					
Lower Col	Beaver Creek Summer Steelhead	Steelhead	Summer	30,000	NMFS/WDFW
Lower Col	Beaver Creek Winter Steelhead	Steelhead	Winter	130,000	NMFS/WDFW
Lower Col	South Toutle Summer Steelhead	Steelhead	Summer	20,000	NMFS/WDFW
Lower Col	Coweeman Winter Steelhead	Steelhead	Winter	12,000	NMFS/WDFW
Lower Col	Cathlamet Channel Net-pen Spring Chinook	Chinook	Spring	250,000	NMFS/WDFW
Lower Col	Deep River (SAFE) Fall Chinook	Chinook	Fall	1,000,000	NMFS/WDFW
Lower Col	Deep River (SAFE) Coho	Coho	Fall	950,000	NMFS/WDFW
Lower Col	Klineline Winter Steelhead (Salmon Cr)	Steelhead	Winter	40,000	NMFS/WDFW
Lower Col	Washougal Summer Steelhead	Steelhead	Summer	70,000	NMFS/WDFW
Lower Col	Washougal Winter Steelhead	Steelhead	Winter	85,000	NMFS/WDFW
Lower Col	Kalama River Early Winter Steelhead	Steelhead	Winter	45,000	NMFS/WDFW
Lower Col	Kalama River Skamania Summer Steelhead	Steelhead	Summer	30,000	NMFS/WDFW
Lower Col	Rock Creek Winter Steelhead	Steelhead	Winter	20,000	NMFS/WDFW
Lower Col	Kalama Spring Chinook	Chinook	Spring	500,000	NMFS/WDFW
Lower Col	Bonneville Coho	Coho	Fall	1,000,000	NMFS/ODFW
Lower Col	Bonneville Tule Fall Chinook	Chinook	Fall	5,000,000	NMFS/ODFW
Lower Col	Big Creek tule Chinook	Chinook	Fall	3,100,000	NMFS/ODFW

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[23] URB stocks are derived from fall Chinook stocks that spawned above Celilo Falls. They are not considered a part of listed ESUs in the LCR and they have a later return time compared to tules. URB stocks are primarily wild fish destined for the Hanford Reach section of the Columbia River. Smaller URB components are destined for the Deschutes, Snake, and Yakima rivers (TAC 2008).

[24] RSIs are portable incubation units. They can be made from a variety of materials (e.g., wood, plastic, and metal) and attempt to minimize natural mortality of incubating salmonid eggs. By providing a vessel that is directly located next to a spawning site, but diverts water flow to a chamber (generally a 50 gallon sized barrel) where salmon eggs are housed, incubating eggs are protected from predators and silt suffocation. This increases their survival rate to fry stage, at which point they exit the RSI through a downstream tube, which returns the diverted stream flow back to the natural spawning channel.

Lower Col	Big Creek coho	Coho	Fall	535,000	NMFS/ODFW
Lower Col	Big Creek chum	Chum	Fall	200,000	NMFS/ODFW
Lower Col	Big Creek Winter Steelhead	Steelhead	Winter	60,000	NMFS/ODFW
Lower Col	Gnat Creek Winter Steelhead	Steelhead	Winter	40,000	NMFS/ODFW
Lower Col	SAFE Coho (Youngs Bay, Tongue Point, Blind Slough, SF Klaskanine)	Coho	Fall	2,565,000	NMFS/ODFW
Lower Col	Klaskanine Winter Steelhead	Steelhead	Winter	40,000	NMFS/ODFW
Lower Col	Klaskanine Fall Chinook	Chinook	Fall	2,100,000	NMFS/ODFW
Lower Col	Klaskanine Coho	Coho	Fall	1,750,000	NMFS/ODFW
Lower Col	Astoria High School STEP Coho	Coho	Fall	4,000	NMFS/ODFW
Lower Col	Astoria High School STEP Tule FC	Chinook	Fall	25,000	NMFS/ODFW
Lower Col	Warrenton High School STEP Coho	Coho	Fall	5,000	NMFS/ODFW
Lower Col	Warrenton High School STEP Tule FC	Chinook	Fall	16,500	NMFS/ODFW
Lower Col	Clackamas Summer Steelhead	Steelhead	Summer	175,000	NMFS/ODFW
Lower Col	Clackamas Winter Steelhead	Steelhead	Winter	160,000	NMFS/ODFW
Lower Col	Grays River coho	Coho	Fall	150,000	NMFS/WDFW
Lower Col	North Toutle Fall Chinook	Chinook	Fall	1,400,000	NMFS/WDFW
Lower Col	North Toutle Coho	Coho	Fall	150,000	NMFS/WDFW
Lower Col	Kalama Fall Chinook	Chinook	Fall	7,000,000	NMFS/WDFW
Lower Col	Kalama coho- Type N	Coho	Fall	600,000	NMFS/WDFW
Lower Col	Kalama Summer Steelhead (integrated)	Steelhead	Summer	60,000	NMFS/WDFW
Lower Col	Kalama Winter Steelhead (integrated)	Steelhead	Winter	45,000	NMFS/WDFW
Lower Col	Washougal Fall Chinook	Chinook	Fall	3,000,000	NMFS/WDFW
Lower Col	Washougal coho	Coho	Fall	150,000	NMFS/WDFW
Mid Col	Klickitat Coho	Coho	Fall	3,500,000	NMFS/Yakama Nation/WDFW
Mid Col	Klickitat URB Chinook	Chinook	Fall (URB)	4,050,000	NMFS/Yakama Nation
Mid Col	Klickitat Spring Chinook	Chinook	Spring	600,000	NMFS/Yakama Nation
Mid Col	Klickitat Skamania Summer Steelhead	Steelhead	Summer	90,000	NMFS/Yakama Nation/WDFW
Mid Col	Walla Walla Spring Chinook	Chinook	Spring	250,000	BPA/CTUIR/NMFS

Upper Col	Ringold Summer Steelhead	Steelhead	Summer	180,000	NMFS/WDFW
Snake	Nez Perce Coho	Coho	Fall	1,050,000	BPA/NPT
Willamette	Clackamas Spring Chinook	Chinook	Spring	861,000	NMFS/ODFW/PGE/USFWS
Columbia River Basin Hatchery Programs that currently have ESA authorization.					
Lower Col	Sandy River Spring Chinook	Chinook	Spring	300,000	NMFS/ODFW
Lower Col	Sandy River Winter Steelhead	Steelhead	Winter	160,000	NMFS/ODFW
Lower Col	Sandy River Summer Steelhead	Steelhead	Summer	75,000	NMFS/ODFW
Lower Col	Sandy River Coho	Coho	Fall	300,000	NMFS/ODFW
Lower Col	Carson NFH Spring Chinook	Chinook	Spring	1,170,000	USFWS/NMFS
Lower Col	Little White Salmon NFH URB Chinook	Chinook	Fall (URB	2,000,000	USFWS/NMFS
Lower Col	Little White Salmon NFH Spring Chinook	Chinook	Spring	100,000	USFWS/NMFS
Lower Col	Eagle Creek NFH Winter Steelhead	Steelhead	Winter	100,000	USFWS/NMFS/ODFW
Lower Col	Eagle Creek NFH Coho	Coho	Fall	350,000	USFWS/NMFS
Lower Col	Spring Creek NFH Tule Chinook	Chinook	Fall	10,500,000	USFWS/COE
Mid Col	Umatilla Coho	Coho	Fall	1,000,000	BPA/CTUIR/NMFS/ODFW
Mid Col	Yakima River coho	Coho	Fall	500,000	NMFS/Yakama Nation
Mid Col	Yakima River Summer/fall Chinook (Prosser Release)	Chinook	Fall (URB)	1,700,000	COE/NMFS
Mid Col	Warm Springs NFH Spring Chinook	Chinook	Spring	750,000	USFWS/COE
Mid Col	Walla Walla/Lyons Ferry steelhead	Steelhead	Summer	100,000	USFWS/WDFW
Mid Col	Umatilla Spring Chinook	Chinook	Spring	810,000	BPA/CTUIR/ODFW
Mid Col	Umatilla Fall Chinook	Chinook	Fall (URB)	1,200,000	BPA/CTUIR/ODFW/COE
Mid Col	Yakima River Spring Chinook	Chinook	Spring	810,000	BPA/Yakama Nation
Mid Col	Yakima River Summer/fall Chinook	Chinook	Fall (URB) (Summer/Fall)	1,000,000	BPA/Yakama Nation
Snake	Lyons Ferry/FCAP/IPC Fall Chinook	Chinook	Snake (Fall)	4,100,000	BPA/USFWS/NPT/WDFW/IDFG/IPC
Snake	Nez Perce Fall Chinook	Chinook	Snake (Fall)	1,400,000	BPA/NPT
Snake	Snake River Sockeye	Sockeye	Fall	1,000,000	BPA/IDFG

Snake	Imnaha Spring Chinook	Chinook	Spring	490,000	USFWS/ODFW/BIA
Snake	Wallowa/Lostine Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/BIA
Snake	Catherine Creek Spring Chinook	Chinook	Spring	150,000	USFWS/ODFW/BIA
Snake	Upper Grande Ronde Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/BIA/CTUIR
Snake	Lookingglass Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/BIA
Snake	Tucannon Spring Chinook	Chinook	Spring	225,000	USFWS/WDFW/BIA
Upper Col	Methow & Wenatchee Coho	Coho	Fall	700,000	BPA/Yakama Nation
Upper Col	Nason Creek Spring Chinook	Chinook	Spring	223,670	Grant PUD/WDFW
Upper Col	Chiwawa Spring Chinook	Chinook	Spring	144,000	Chelan PUD/WDFW
Upper Col	Wenatchee Steelhead	Steelhead	Summer	25,000	Chelan PUD/WDFW
Willamette	Molalla River Spring Chinook	Chinook	Spring	100,000	COE/ODFW
Willamette	McKenzie River Spring Chinook	Chinook	Spring	787,000	COE/ODFW
Willamette	North Santiam Spring Chinook	Chinook	Spring	685,000	COE/ODFW
Willamette	South Santiam Spring Chinook	Chinook	Spring	721,000	COE/ODFW
Willamette	Middle Fork Willamette Spring Chinook	Chinook	Spring	1,939,000	COE/ODFW
Willamette	South Santiam Summer Steelhead	Steelhead	Summer	509,500	COE/ODFW
Columbia River Basin Hatchery Programs that have not completed ESA consultation.					
Lower Col	Grays River Chum Salmon	Chum	Fall	250,000	BPA/WDFW
Lower Col	Salmon Creek Type-N Coho	Coho	Fall	60,000	WDFW/Clark PUD
Lower Col	Lewis River Spring Chinook	Chinook	Spring	1,350,000	WDFW/Pacificorp
Lower Col	Lewis River Late Winter Steelhead	Steelhead	Winter	50,000	WDFW/Pacificorp
Lower Col	Lewis River Type-N Coho Salmon	Coho	Fall	900,000	WDFW/Pacificorp
Lower Col	Lewis River Type-S Coho Salmon	Coho	Fall	1,100,000	WDFW/Pacificorp
Lower Col	Lewis River Early Winter Steelhead	Steelhead	Winter	100,000	WDFW/Pacificorp
Lower Col	Lewis River Summer Steelhead	Steelhead	Summer	235,000	WDFW/Pacificorp
Lower Col	Lewis River Chum Salmon	Chum	Fall	100,000	WDFW/Pacificorp
Lower Col	Lewis River Co-op	Coho	Fall	RSI	WDFW/NGOs

Lower Col	Little White Salmon NFH URB Chinook	Chinook	Fall (URB)	4,500,000	USFWS/COE
Lower Col	Duncan Creek/Washougal Chum	Chum	Fall	400,000	BPA/WDFW
Lower Col	SAFE Spring Chinook	Chinook	Spring	1,700,000	BPA/ODFW/CCF
Lower Col	SAFE SAB Chinook	Chinook	Fall	2,200,000	BPA/CCF/ODFW
Lower Col	Hood River Spring Chinook	Chinook	Spring	150,000	BPA/Warm Springs Tribe
Lower Col	Hood River Winter Steelhead	Steelhead	Winter	50,000	BPA/Warm Springs Tribe/ODFW
Lower Col	Hood River Summer Steelhead	Steelhead	Summer	On Hold[25]	BPA/Warm Springs Tribe/ODFW
Lower Col	Cowlitz Spring Chinook	Chinook	Spring	1,038,529	WDFW/Tacoma Power
Lower Col	Cowlitz Fall Chinook	Chinook	Fall	2,400,000	WDFW/Tacoma Power
Lower Col	Cowlitz Coho Salmon	Coho	Fall	2,178,000	WDFW/Tacoma Power
Lower Col	Cowlitz Late Winter Steelhead	Steelhead	Winter	645,000	WDFW/Tacoma Power
Lower Col	Cowlitz Summer Steelhead	Steelhead	Summer	626,000	WDFW/Tacoma Power
Mid Col	Touchet (integrated) Steelhead	Steelhead	Summer	50,000	USFWS/WDFW
Mid Col	Umatilla Steelhead	Steelhead	Summer	150,000	BPA/ODFW/CTUIR
Mid Col	Round Butte Spring Chinook	Chinook	Spring	240,000	ODFW/PGE
Mid Col	Round Butte Steelhead	Steelhead	Summer	1,092,000	ODFW/PGE
Snake	Little Sheep Steelhead	Steelhead	Summer	215,000	USFWS/WDFW
Snake	Wallowa Steelhead	Steelhead	Summer	800,000	USFWS/ODFW
Snake	Upper Tucannon Steelhead (endemic)	Steelhead	Summer	100,000	USFWS/WDFW
Snake	Lyons Ferry Steelhead Wallowa Stock	Steelhead	Summer	320,000	USFWS/WDFW
Snake	Dworshak NFH Spring Chinook	Chinook	Spring	1,500,000	USFWS/COE
Snake	Kooskia Spring Chinook	Chinook	Spring	600,000	BPA/USFWS
Snake	Clearwater NFH Summer Chinook	Chinook	Summer	600,000	IDFG
Snake	Clearwater NFH Spring Chinook	Chinook	Spring	3,400,000	IDFG
Snake	NPTH Spring Chinook	Chinook	Spring	400,000	BPA/NPT
Snake	Rapid River Spring Chinook	Chinook	Spring	2,500,000	IDFG/IPC
Snake	Hells Canyon Spring Chinook	Chinook	Spring	350,000	IDFG/IPC

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[25] Program currently not releasing fish, but planning to in the future.

Snake	Sawtooth Spring Chinook	Chinook	Spring	1,600,000	IDFG
Snake	Pahsimeroi Summer Chinook	Chinook	Summer	1,000,000	IDFG
Snake	Yankee Fork Spring Chinook	Chinook	Spring	200,000	BPA/ShoBan Tribe
Snake	Panther Creek Spring Chinook	Chinook	Spring	RSI	BPA/ShoBan Tribe
Snake	Johnson Creek Spring Chinook	Chinook	Summer	100,000	BIA
Snake	SF Salmon Spring Chinook	Chinook	Summer	1,000,000	IDFG
Snake	Dollar Creek Spring Chinook (boxes)	Chinook	Summer	RSI	BPA/ShoBan Tribe
Snake	Dworshak B Steelhead	Steelhead	Summer	2,100,000	USFWS/COE
Snake	SF Clearwater B Steelhead	Steelhead	Summer	843,000	IDFG
Snake	Up Salmon A Steelhead	Steelhead	Summer	279,000	IDFG/IPC
Snake	Pahsimeroi A Steelhead	Steelhead	Summer	800,000	IDFG
Snake	Upper Salmon Steelhead (boxes)	Steelhead	Summer	RSI	BPA/ ShoBan Tribe (LSRCP)
Snake	Yankee Fork B Steelhead	Steelhead	Summer	496,000	BPA/ ShoBan Tribe (LSRCP)
Snake	Upper Salmon B Steelhead	Steelhead	Summer	372,000	IDFG
Snake	Sawtooth A Steelhead	Steelhead	Summer	1,500,000	IDFG
Snake	EF Salmon Steelhead	Steelhead	Summer	60,000	IDFG
Snake	Little Salmon Steelhead	Steelhead	Summer	636,000	IDFG/IPC
Snake	Hells Canyon Steelhead	Steelhead	Summer	550,000	IDFG/IPC
Upper Col	Chief Joseph Summer Chinook	Chinook	Summer	2,000,000	BPA/Coville Tribe
Upper Col	Chief Joseph Spring Chinook (Carson)	Chinook	Spring	700,000	BPA/Coville Tribe
Upper Col	Chief Joseph Spring Chinook (Composite)	Chinook	Spring	200,000	USFWS/Coville Tribe
Upper Col	Entiat Summer Chinook	Chinook	Summer	400,000	USFWS/BOR
Upper Col	Twisp River Acclimation	Chinook	Spring	30,000	Douglas PUD/WDFW
Upper Col	Leavenworth NFH Spring Chinook	Chinook	Spring	1,200,000	USFWS/BOR
Upper Col	Winthrop NFH Spring Chinook	Chinook	Spring	400,000	USFWS/BOR
Upper Col	Winthrop NFH Steelhead	Steelhead	Summer	200,000	USFWS/BOR
Upper Col	Methow/Wells Steelhead	Steelhead	Summer	148,000	Douglas PUD/WDFW
Upper Col	Methow Spring Chinook	Chinook	Spring	135,000	Douglas PUD/Grant PUD/WDFW

Upper Col	Methow Spring Chinook-Chelan	Chinook	Spring	60,516	Chelan PUD/WDFW
Upper Col	Okanogan Steelhead	Steelhead	Summer	100,000	Grant PUD/Coville Tribe
Upper Col	Skaha Lake Sockeye	Sockeye	Fall	2,000,000	Chelan/Grant PUD/ONA
Upper Col	Priest Rapids Fall Chinook	Chinook	Fall (URB)	7,300,000	Grant PUD/COE/WDFW
Upper Col	Ringold Springs Fall Chinook	Chinook	Fall (URB)	3,500,000	COE/ODFW
Upper Col	Wenatchee Summer Chinook	Chinook	Summer	500,000	Chelan PUD/WDFW
Upper Col	Chelan Falls Summer Chinook	Chinook	Summer	576,000	Chelan PUD/WDFW
Upper Col	Wells Summer Chinook	Chinook	Summer	804,000	Douglas PUD/WDFW
Upper Col	Methow Summer Chinook	Chinook	Summer	200,000	Douglas PUD/WDFW
			Total	144,006,715	

2.3.5 Harvest Effects

The following Section describes the effects under the environmental baseline for harvest actions. While, by definition, the environmental baseline includes the past and present impacts of all Federal, state, and private actions and other human activities in the Action Area (Section 1.4), many of the salmon ESUs in Table 9 are subject to harvest outside of the Action Area, which is reviewed below.

2.3.5.1 Ocean Harvest

NMFS has previously considered the effects of ocean salmon fisheries on ESA-listed species under its jurisdiction for ESA compliance through completion of biological opinions and the ESA 4(d) Rule evaluation and determination processes. In general, each Opinion provides a review of the record of harvest effects on natural-origin salmon species in the Columbia River Basin (Table 85). Those environmental baseline discussions are hereby incorporated by reference; these Opinions and determinations are still in effect and address harvest effects to species that are affected by the Proposed Action considered in this Opinion (see Table 9 for the species list).

Since 1991, twenty eight salmon ESUs and steelhead DPSs have been listed under the ESA on the west coast of the United States. Beginning in 1991, NMFS considered the effects of Pacific Fishery Management Council fisheries, hereafter "PFMC Fisheries", on salmon and other species listed under the ESA and issued Opinions based on the regulations implemented each year or on the underlying Pacific Coast Salmon Fishery Management Plan (FMP) itself. In an Opinion dated March 8, 1996, NMFS considered the impacts of implementing the FMP on all salmon species then listed under the ESA, including spring/summer Chinook salmon, fall Chinook salmon, sockeye salmon from the Snake River, and Sacramento River winter Chinook salmon (NMFS 1996b). Subsequent Opinions, beginning in 1997, considered the effects of PFMC Fisheries on the growing catalogue of ESA-listed species (Table 85). NMFS has developed new consultations or reinitiated consultation when new information became available on the status of the ESUs or the impacts of the FMP on the ESUs, or when new ESUs were listed.

Table 85. NMFS ESA determinations regarding ESUs and DPS affected by PFMC Fisheries and the duration of the Opinion. (Only those decisions currently in effect are included).

Date (Decision type)	Duration	Citation	Species Considered
Salmonid Species			
March 8, 1996 (Opinion)	until reinitiated	(NMFS 1996b)	Snake River spring/summer-run and fall-run Chinook Salmon, and Sockeye Salmon
April 30, 2001 (Opinion)	until reinitiated	(NMFS 2001b)	UWR spring-run Chinook Salmon CR Chum Salmon Ozette Lake Sockeye Salmon UCR spring-run Chinook Salmon Southern California Steelhead

			South-Central California Steelhead Central California Coast Steelhead Northern California Steelhead UCR Steelhead Snake River Basin Steelhead LCR Steelhead California Central Valley Steelhead UWR Steelhead MCR Steelhead
April 27, 2012 (Opinion)	until reinitiated	(NMFS 2012d)	LCR Chinook Salmon
April 9, 2014 (Opinion)	until reinitiated	(NMFS 2014d)	LCR Coho Salmon
Non Salmonid species			
April 30, 2011 (Opinion)	until reinitiated	(NMFS 2010)	Pacific Eulachon

Ocean fisheries in the offshore and near shore marine areas (defined as the area from zero to three miles offshore) of the U.S. Exclusive Economic Zone (EEZ) and the coastal and inland marine waters of the west coast states (Washington, Oregon, and California) are not directed at eulachon, chum salmon, or steelhead, all of which are rarely caught in PFMC-managed fisheries (PFMC 2013). The ocean distributions for ESA-listed steelhead are not known in detail, but steelhead are caught only rarely in ocean salmon fisheries, and consideration of the likely stock composition suggests that the catch of steelhead is less than 10 per year from all the steelhead DPSs combined (NMFS 2001b). Eulachon and chum salmon catch levels in ocean fisheries are expected to be similar as steelhead. Ocean fisheries are directed at Chinook and coho salmon, therefore Snake River sockeye salmon are unlikely to be caught in ocean harvest, which has been verified through fishery sampling and post season reporting (PFMC 2016b). Spring-run Chinook salmon stocks' harvest mortality in ocean fisheries is also assumed to be zero based on the timing for when ocean fisheries are prosecuted, allowing spring-run Chinook salmon to enter freshwater areas before ocean salmon fisheries begin. These low levels of catch of all spring-run Chinook salmon have similarly been verified from these same sampling activities.

Three salmon ESUs experience measurable effects of harvest in the ocean. These include the LCR Chinook Salmon ESU, LCR Coho Salmon ESU, and Snake River Fall-run Chinook Salmon ESUs.

LCR Chinook Salmon ESU

In 2000 and 2001, NMFS required that the total brood year exploitation rate for the Coweeman stock (representing the LCR fall-run (tule) component of the ESU), in all fisheries combined, not exceed 65% (NMFS 2012d). The exploitation rate limit was derived using the Viability Risk Assessment Procedure (VRAP), which provided an estimate of an associated Rebuilding Exploitation Rate (RER). An RER for a specific population is defined as the maximum exploitation rate that would result in a low probability of the population falling below a specified lower abundance threshold and in a high probability that the population would exceed an upper abundance threshold over a specific time period. RERs were used originally as part of the assessment in the 1999 Pacific Salmon Treaty (PST) Opinion (NMFS 1999b) and the 2000 Opinion on PFMC Fisheries (NMFS 2000a). (For a more detailed discussion of VRAP and the related RER calculations, see (NMFS 1999c). The 65% RER was subsequently reviewed and reduced substantially, in 2002, with an RER of 49%, which was used as the consultation standard for the tule component of the LCR Chinook Salmon ESU from 2002 to 2006 (NMFS 2012d).

In 2007 NMFS concluded that a periodic review was warranted. The Washington Management Unit Recovery Plan (LCRFRB) also called for a review of the 49% RER standard and the associated effects. NMFS organized an ad hoc workgroup that included staff from the NMFS NWFSC and WDFW. The general conclusion from the array of analytical results was that harvest impacts needed to be reduced further. In the 2007 Guidance Letter to the PFMC, NMFS recommended that the PFMC lower the exploitation rate in 2007 for the LCR tule Chinook salmon populations from 49% to 42%. In 2008, the exploitation rate was reduced again to 41% (NMFS 2012d). NMFS further indicated our intention to review the information that had accumulated over these years and conducted further analysis that would provide the basis for an Opinion that would set harvest limits leading to reductions down to 37% by 2011.

At its November 2011 meeting, the PFMC considered, among other matters, new methodological approaches for use in the 2012 ocean salmon fishery management. The PFMC passed a motion to recommend that NMFS consider an abundance-based management (ABM) matrix for LCR tule Chinook salmon when formulating ESA Section 7 biological opinion consultation standards for salmon fisheries in 2012 and beyond. In 2012, NMFS issued its current Opinion, including an ABM matrix for the tule Chinook salmon populations. NMFS concluded in the Opinion that the proposed fishing seasons were not likely to jeopardize the continued existence of the LCR Chinook Salmon ESU (Table 85). PFMC Fisheries have been operating using this ABM matrix since then and continue to do so.

LCR Coho Salmon ESU

In 1997, the PFMC adopted a management plan (Amendment 13 to the Pacific Coast Ocean Plan) that constrained overall allowable fishery impacts on Oregon Coast natural-origin coho salmon. The management plan was built around a harvest matrix that allowed harvest impacts to vary depending on brood year escapement and marine survival. In 2000, after a review of Amendment 13, the PFMC adopted new changes to the FMP recommended by an ad hoc workgroup of fisheries experts; these changes included a lower range of harvest impacts when parental spawner abundance and marine survival were low.

LCR coho salmon were listed under Oregon's Endangered Species Act in July 1999 (NMFS 2014d). An ODFW specific fishery management plan (Oregon Matrix), which was modeled after the one for Oregon Coast natural-origin coho salmon, was approved by the Oregon Fish and Wildlife Commission in July 2001. The plan defined the allowable harvest rate for both ocean and inriver fisheries depending on brood year escapement and marine survival indicators

(NMFS 2014d). The resulting matrix was used by the states of Oregon and Washington for managing ocean and Columbia River fisheries for LCR coho salmon from 2002-2005.

In 2005, NMFS concluded in a conference Opinion that the exploitation rates anticipated in the 2005 PFMC Fisheries, based on the ocean component of the Oregon Matrix, were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU, which was then proposed for listing under the ESA as threatened (NMFS 2014d). The LCR Coho Salmon ESU was subsequently listed as threatened under the Federal ESA, effective August 29, 2005. Once the federal listing became effective for this ESU, the conference Opinion was confirmed as the Opinion (NMFS 2014d).

Since the federal listing of this ESU under the ESA in 2005, the states of Oregon and Washington have been working with NMFS to develop and evaluate a management plan that can be used as the basis for their long-term management. In 2006, NMFS concluded in an Opinion that a 15% total combined (ocean and in-river) exploitation rate was not likely to jeopardize the continued existence of the LCR Coho Salmon ESU. In 2008, NMFS completed a multi-year Opinion that used the ocean component of the Oregon Matrix to define the total harvest impact rate for ocean fisheries and Columbia River mainstem fisheries up to Bonneville Dam. The Proposed Action in the 2008 Opinion limited the exploitation rate to 15%. This strategy has been used, in part, due to the limited amount of data on the status of natural-origin LCR coho salmon populations. In 2012, the PFMC brought together an ad hoc workgroup to facilitate the process of updating the harvest management strategies for the LCR Coho Salmon ESU. Based on the workgroup’s recommendation, the PFMC proposed that NMFS manage fisheries under a new harvest matrix, which identifies exploitation rate limits based on two levels of parental escapement and five levels of marine survival (i.e., a 2 x 5 matrix). NMFS evaluated this strategy in a 2014 Opinion and concluded that PFMC Fisheries managed via this manner were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (Table 85).

Snake River Fall-run Salmon

Snake River fall-run Chinook salmon are broadly distributed and caught in fisheries from Alaska to California, but the center of their distribution and the majority of impacts occur in fisheries from the west coast of Vancouver Island to central Oregon. The total ocean fishery exploitation rate averaged 46% from 1986 to 1991. Following the listing of Snake River fall Chinook salmon under the ESA, the exploitation rate fell to 31% from 1992 to 2006 (NMFS 2008e). As a result of ESA consultation, ocean fisheries have been reduced since 1996 to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 base period (NMFS 2008e).

Fisheries affecting Snake River fall-run Chinook salmon have been subject to ESA constraints since 1992. Since 1996, ocean fisheries have been subject to a total harvest rate limit of 31.29% annually. This represents a 30% reduction in the 1988 to 1993 base period harvest rate. Snake River fall-run Chinook salmon are also caught in fall season fisheries in the Columbia River, with most of the impacts occurring in Non-Indian and treaty Indian fisheries from the river mouth to McNary Dam. Columbia River fisheries have a similar 30% base period reduction standard.

Total harvest mortality for the combined ocean and in-river fisheries can be expressed in terms of exploitation rates, which ocean fisheries are managed to, and which provide a common metric for comparing ocean and inriver fishery impacts (however, fisheries in the Columbia River are generally managed subject to harvest rate limits[26]). The total exploitation rate has declined significantly since the ESA listing of the Snake River Fall-run Chinook Salmon ESU in 1992. The total exploitation rate averaged 75% annually from 1986 to 1991, and 45% from 1992 to 2006 (NMFS 2008e).

Columbia River mainstem harvest of coho salmon and Chinook salmon are accounted for in the exploitation rate calculations presented above; however, other anadromous fish species were historically caught in mainstem fisheries. Commercial eulachon fisheries have been closed from the time of listing, however estimates for recent year tribal and stock assessment fisheries are reported in Section 2.2.1.1, but mainstem salmon and steelhead harvest is reviewed below.

2.3.5.2 Columbia River Mainstem Harvest

Anadromous fish have been harvested in the Columbia River Basin as long as there have been people here. For thousands of years, Native Americans have fished for salmon and steelhead, as well as for other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls, to spears, weirs, and traps (usually in smaller streams and headwater areas). Commercial fishing developed rapidly with the arrival of European settlers and the advent of canning technologies in the late 1800s. The development of non-Indian fisheries began circa 1830, and by 1861 commercial fishing was an important economic activity. Fishing pressure, especially in the late nineteenth and early twentieth centuries, has long been recognized as a key factor in the decline of Columbia River salmon runs (NRC 1996).

Treaty Indian fishing rights in the Columbia River Basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon* (Civil Case No. 68-513, D. Oregon having continuing jurisdiction over case filed in 1968). In the original *U.S. v. Oregon* Opinion (302 F.Supp. 899), the court affirmed that the treaties reserved to the Tribes 50% of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas. In at least a half-dozen published Opinions and several unpublished Opinions in *U.S. v. Oregon*, as well as dozens of rulings in the parallel case of *U.S. v. Washington* (interpreting the same treaty language for Tribes in the Puget Sound area), the courts have established a large body of case law setting forth the fundamental principles of treaty rights and the permissible limits of conservation regulation of treaty fisheries. The parties to *U.S. v. Oregon* (the Parties) are: the United States, acting through the Department of the Interior (USFWS) and Bureau of Indian Affairs (BIA)) and the Department of Commerce

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[26] Harvest rates are expressed as a proportion of the run returning to the river that is killed in river fisheries.

(NMFS); the CTWSR of Oregon, the CTUIR, the NPT, the Confederated Tribes and Bands of the Yakama Nation (collectively, the Columbia River Treaty Tribes); the SBT; and the states of Oregon, Washington, and Idaho.

Treaty Indian and non-Indian commercial and recreational fisheries in the Columbia River Basin were managed subject to provisions of the CRFMA from 1988 through 1998. The CRFMA was a stipulated agreement adopted by the Federal Court under the continuing jurisdiction of *U.S. v. Oregon* (Civ. No. 68-513 (D. Or.)). Following 1998, fisheries were managed subject to provisions of a series of short term agreements among the Parties, the durations of which ranged from several months that covered a single fishing season, to five years (i.e., 2003 through 2008). Since 1992, when affected salmonids were first ESA-listed, NMFS has consulted under Section 7 of the ESA on proposed *U.S. v. Oregon* fisheries in the Columbia River Basin because it is a federal agreement amongst the Parties. After the initial consultation, NMFS conducted a series of consultations to consider the effects of proposed fisheries as additional species were listed, as new information became available, and as fishery management provisions evolved to address the needs of ESA-listed species.

Most recently, the *U.S. v. Oregon* fisheries have been managed subject to the 2008-2017 *United States v. Oregon* Management Agreement ("2008 *U.S. v. Oregon* Agreement"). NMFS completed an Opinion on the 2008 *U.S. v. Oregon* Agreement on May 5, 2008 (NMFS 2008e). The Opinion concluded that fisheries management subject to the proposed agreement was not likely to jeopardize any of the affected ESA listed species.
The incidental take limits and expected incidental take (as a proportion of total run size) of listed salmonids for treaty Indian and non-Indian fisheries under the 2008 *U.S. v. Oregon* Agreement are captured in Table 86. As mentioned above, NMFS hereby incorporates by reference the Opinion (NMFS 2008e) analyzing the effects of this take into the environmental baseline.

Table 86. 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
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 (2012d) 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 (2012d) 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 part of a threatened ESA-listed group.

[9] Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2014d) 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

The 2008 *U.S. v. Oregon* Agreement describes specific provisions for managing Columbia River main stem fisheries, and certain tributary fisheries. Fisheries in the agreement occur from the Columbia River mouth upstream to the Wanapum Dam, in adjacent off channel areas, in specified tributaries between Bonneville and McNary Dam, and for spring-run Chinook salmon in the Snake River upstream to the border of Washington and Idaho. Fisheries in the agreement also occur in the Walla Walla River, the Yakima River, and in Icicle Creek (Wenatchee River). As described in the biological assessment (TAC 2008) these fisheries were expected to also have an indirect effect on the amount of marine derived nutrients returning to spawning and rearing areas because the fisheries would reduce the number of adult fish that would otherwise return to spawn and die. Therefore the analysis in the 2008 BA (TAC 2008) extended from the fishery footprint upstream to include all accessible salmon spawning and rearing areas in the Columbia River Basin. The rates in Table 86 are variable based on tiered schedules in the 2008 *U.S. v. Oregon* Agreement that are stratified by returning adult abundances.

Table 87 summarizes the allowed rates for each year that were determined based on the allowable tiered schedule ranges described in Table 86. Table 88 summarizes the actual post season performance rates after fisheries were implemented.

While the general principles for quantifying treaty Indian fishing rights are well established, their application to individual runs during the annual fishing seasons is complicated. Annual calculations of allowable harvest rates depend on (among other things) estimated run sizes for the particular year, the mix of stocks that is present, application of the ESA to mixed-stock fisheries, application of the tenets of the "conservation necessity principle" for treaty Indian fisheries, and the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty Indian fishing rights during a particular fishing season often cannot be established by a rigid formula, the treaty fishing right itself continues to exist and must be accounted for in the environmental baseline.

Table 87. Total annual allowable preseason harvest rates for fisheries managed under the 2008 *U.S. v. Oregon* Agreement (based on tiered abundances annually established through implementation of the plan (NMFS 2008e)) .

ESU or DPS		**Total impact annually allowed preseason based on abundance tier**							
Combined Rates[1]		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Snake River spring/ summer-run Chinook		11.0%	11.0%	13.0%	12.0%	11.0%	10.0%	12.0%	13.4%
UCR spring-run Chinook		11.0%	11.0%	13.0%	12.0%	11.0%	10.0%	12.0%	13.0%
UWR spring-run Chinook	In spring fisheries	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
LCR Chinook	Spring component	H.E.3	H.E.3	H.E.3	H.E.3	H.E.3	H.E.3	H.E.3	H.E.3
	Fall tule component[2]	41.0%	38.0%	38.0%	37.0%	38.0%	41.0%	41.0%	41.0%
	Fall bright component[4]	5,700	5,700	5,700	5,700	5,700	5,700	5,700	5,700
Snake River fall-run Chinook		33.3%	31.3%	33.3%	45.0%	45.0%	45.0%	45.0%	45.0%
LCR Coho[2]		8.0%	20.0%	15.0%	15.0%	15.0%	15.0%	22.5%	23.0%
CR Chum		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Snake River Sockeye		8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Separate Rates									
Tribal only	Steelhead B-Run (in fall fisheries)	15.0%	20.0%	20.0%	20.0%	15.0%	13.0%	20.0%	13.0%
Non-tribal only									
Snake River Steelhead	Group A Index (in winter/spring/summer fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Snake River Steelhead	Group B Index (in winter/spring/summer fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Snake River Steelhead	Group A Index (in fall fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Snake River Steelhead	Group B Index (in fall fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
UCR Steelhead	In winter/spring/summer fisheries	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
UCR Steelhead	In fall fisheries	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
MCR Steelhead	Summer component (in winter/spring/summer fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
MCR Steelhead	Summer Component (in fall fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
MCR Steelhead	Winter Component (winter fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
LCR Steelhead	Summer component (in winter/spring/summer fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
LCR Steelhead	Summer Component (in fall fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
LCR Steelhead	Winter Component (in winter fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
UWR Steelhead	Winter Component (in winter fisheries)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

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 rack escapement goals (H.E.) to the Cowlitz, Lewis and Sandy Rivers (goals are described in Section 2.2.1.2).
4/ Managed for an escapement goal of 5,700 fish in the North Lewis River.

Table 88. Annual post season performance of fisheries managed under the 2008 *U.S. v. Oregon* Agreement.

ESU or DPS		**Total impact annually achieved based on postseason reporting**							
Combined Rates[1]		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Snake River spring/ summer-run Chinook		9.1%	10.0%	9.1%	8.8%	10.6%	9.2%	12.5%	13.4%
UCR spring-run Chinook		9.1%	9.1%	10.8%	8.7%	10.5%	9.1%	12.4%	13.4%
UWR spring-run Chinook	In spring fisheries	5.9%	7.6%	16.4%	12.9%	10.0%	9.3%	8.9%	9.0%
LCR Chinook	Spring component[3]	yes	yes	yes	yes	yes	yes	yes	yes
	Fall tule component[2]	33.0%	37.0%	35.0%	40.8%	44.5%	32.9%	40.8%	34.90%
	Fall bright component[4]	5,485	6,283	9,294	8,205	8,143	15,197	20,809	2,149
Snake River fall-run Chinook		27.4%	37.9%	25.9%	33.0%	34.6%	31.3%	34.8%	31.3%
LCR Coho[2]		7.3%	18.7%	10.7%	13.5%	14.0%	13.7%	17.4%	24.4%
CR Chum		1.6%	1.6%	4.7%	0.1%	0.1%		0.8%	1.4%
Snake River Sockeye		4.6%	6.0%	6.8%	7.8%	9.7%	4.7%	5.0%	6.2%
Separate Rates									
Tribal only	Steelhead B-Run (in fall fisheries)	15.2%	16.8%	15.7%	21.1%	13.5%	14.0%	12.5%	12.1%
Non-tribal only									
Snake River Steelhead	Group A Index (in winter/spring/summer fisheries)	0.8%	0.7%	0.9%	0.9%	2.2%	0.8%	0.7%	0.5%
Snake River Steelhead	Group B Index (in winter/spring/summer fisheries)	0.1%	0.0%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%
Snake River Steelhead	Group A Index (in fall fisheries)	0.6%	1.0%	0.8%	1.6%	1.2%	1.6%	1.3%	1.1%
Snake River Steelhead	Group B Index (in fall fisheries)	1.1%	1.3%	1.8%	1.9%	1.8%	2.0%	1.6%	2.0%
UCR Steelhead	In winter/spring/summer fisheries	0.8%	0.7%	0.9%	1.5%	1.9%	0.9%	0.8%	0.5%
UCR Steelhead	In fall fisheries	1.0%	0.8%	0.8%	1.5%	1.2%	1.6%	1.3%	1.1%
MCR Steelhead	Summer component (in winter/spring/summer fisheries)	0.8%	0.7%	0.9%	0.9%	2.2%	0.8%	0.7%	0.5%
MCR Steelhead	Summer Component (in fall fisheries)	0.6%	1.0%	0.8%	1.6%	1.2%	1.6%	1.3%	1.1%
MCR Steelhead	Winter Component (winter fisheries)	0.3%	0.4%	0.7%	0.7%	0.8%	0.4%	0.7%	0.6%
LCR Steelhead	Summer component (in winter/spring/summer fisheries)	0.3%	0.4%	0.7%	0.7%	0.8%	0.4%	0.7%	0.6%
LCR Steelhead	Summer Component (in fall fisheries)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

LCR Steelhead	Winter Component (in winter fisheries)	0.3%	0.3%	0.7%	0.7%	0.8%	0.6%	0.6%	0.6%
UWR Steelhead	Winter Component (in winter fisheries)	--	--	--	0.3%	0.5%	0.6%	0.6%	0.6%

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.

2.3.5.3 Columbia River Tributary Harvest

Tributary fisheries target hatchery-origin steelhead, Chinook salmon and coho salmon, throughout the Action Area. These fisheries affect the status of ESA-listed fish by removing adults from the respective tributaries which may have otherwise contributed to the spawning population or to nutrient enhancement of the ecology. While they tend to target hatchery-origin fish it is important to review where NMFS has authorized tributary levels of fishing to evaluate where tributary levels of known incidental handling and mortality is occurring. Hatchery-origin fish are externally marked for easy identification (i.e., the adipose fin is clipped or removed), and in areas where natural-origin fish are present recreational fisheries are managed with the requirement that all unmarked adipose fin present adult salmon and steelhead be released. In areas where natural-origin fish are not ESA-listed, recreational fisheries may target them. They are managed to meet both hatchery broodstock needs, whereas unmarked fish may be included in hatchery broodstock needs, but are more often managed for natural production escapement goals. Commercial fisheries in these areas follow these general management guidelines but retain all fish regardless of external marking designation.

In its 2003 Opinion (NMFS 2003c), NMFS determined that the WDFW and ODFW adequately addressed the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon and steelhead in the relevant five Fisheries Management and Evaluation Plans (FMEPs). These FMEPs limited tributary harvest levels of managed fisheries to achieve the 5,700 escapement goal for bright fall-run Chinook salmon. The plans also kept harvest impacts below the rate developed during the PFMC process described above in the Ocean Harvest Section for fall-run Chinook salmon, below 4% for chum salmon, and 10% for steelhead, although the actual impacts are closer to 5%, on average, for steelhead in the Action Area (NMFS 2003c). While fisheries described in these FMEPs for spring-run Chinook salmon are selective for marked hatchery-origin fish, current tributary fisheries in the Action Area are managed to ensure hatchery escapement goals (those back to their respective release facilities) are met for spring-run Chinook salmon because of the limited amount of suitable habitat, as discussed above in Section 2.2.1.2. This management strategy using hatchery escapements continues to ensure the extinction risk is low in the short-term until upstream and down-stream passage issues can be resolved in the Cowlitz and Lewis basins.

Similarly in the Willamette River, another major tributary to the Columbia River, in 2001 NMFS evaluated an FMEP for UWR spring-run Chinook salmon (NMFS 2001a)and another FMEP for UWR winter-run steelhead (NMFS 2001a) submitted under Limit 4 of the final 4(d) rule. After evaluation of these FMEPs with respect to the criteria specified for Limit 4, NMFS determined that the plans adequately addressed all of the criteria. The FMEPs described that ODFW would implement selective fisheries for hatchery-origin spring-run Chinook salmon and steelhead in the Willamette River, meaning that all hatchery-origin spring-run Chinook salmon and steelhead would be ad clipped and that only fish that are ad clipped would be allowed to be retained in freshwater fisheries beginning in 2002 and thereafter. All unmarked, natural-origin fish were required to be released unharmed. The monitoring and evaluation measures identified in each FMEP assessed the encounter rate of natural-origin fish in the fisheries, fishery mortality, the abundance of hatchery-origin and natural-origin fish throughout the entire UWR Basin, and angler compliance. This information is used annually to assess whether impacts on ESA-listed fish are as expected. ODFW also conducts a comprehensive review of the FMEP at five year intervals to evaluate whether the objectives of the FMEP are being accomplished. Since implementation of the FMEPs the annual harvest rate on natural-origin UWR spring-run Chinook salmon has averaged 10.6% (ODFW 2015b) which is below the levels analyzed in the FMEP for natural-origin Upper Willamette winter steelhead.

In the UCR Basin, for areas upstream of Priest Rapids Dam, the local salmon recovery board (the UCSRB) has committed to pursue and support fishing opportunities (recreational and tribal) in the UCR that are consistent with meeting ESA obligations for ESA-listed populations (UCSRB 2007). The harvest of UCR steelhead varies from year-to-year depending on a tiered harvest rate schedule. Similar to other geographic areas described above, harvest depends on the total abundance of externally marked hatchery-origin steelhead from the upriver Wenatchee steelhead hatchery program, as without harvestable hatchery surpluses harvest would unlikely occur. Steelhead are harvested in tribal fisheries and in mainstem recreational fisheries, and there is incidental mortality associated with mark-selective recreational fisheries (i.e., catch and release mortality) while they target hatchery-origin steelhead. Harvest has negative impacts on the abundance, productivity, genetic and spatial diversity of natural-origin steelhead through the removal of natural-origin fish through incidental take and mortality. However, harvest of returning hatchery-origin fish can have beneficial impacts on the same parameters through removal of surplus hatchery-origin fish destined for spawning grounds.

WDFW regulates the harvest of hatchery-origin steelhead in the UCR Basin; there is no directed fishery on natural-origin steelhead in the basin (UCSRB 2007). NMFS (2003a) approved a tiered-approach to the harvest of hatchery-origin steelhead consistent with the UCR recovery plan through the ESA consultation and through the issuance of ESA Section 10(a)(1)(A) direct take enhancement permit (Permit No. 1395) for the Wenatchee steelhead hatchery program. The goal of the fishery is to reduce the number of hatchery-origin steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of natural-origin steelhead in the spawning populations. Hatchery-origin steelhead can be removed at dams and other trapping sites, or WDFW may allow recreational fisheries to selectively harvest hatchery-origin steelhead (i.e., ad clipped fish) subject to limits on the effects to natural-origin fish. Under the current ESA permit, steelhead fisheries targeting hatchery-origin steelhead may be implemented in the Wenatchee, Methow, and/or Okanogan subbasin when natural-origin steelhead run levels meet defined criteria. The current permit criteria (NMFS 2003a; UCSRB 2007) are:

- When the natural-origin (wild) steelhead run is predicted to exceed 1,300 fish at Priest Rapids Dam and the total steelhead run is predicted to exceed 9,550 steelhead, a harvest fishery may be considered as an option to remove excess adipose fin-clipped hatchery steelhead. For a fishery to commence, the predicted Wenatchee tributary escapement must meet the minimum Tier 1 criteria. The mortality impact on naturally produced steelhead must not exceed the specified limits for Tier 1 for the Wenatchee tributary (2 %).

- When the natural-origin steelhead run is predicted to exceed 2,500 fish at Priest Rapids Dam, the total steelhead run is predicted to exceed 10,035 steelhead, and the tributary escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 2 for the Wenatchee tributary (4%).

- When the natural-origin steelhead run is predicted to exceed 3,500 fish at Priest Rapids Dam, the total steelhead run is predicted to exceed 20,000 steelhead, and the tributary escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 3 in the Wenatchee tributary (6%).
- The WDFW may remove artificially propagated steelhead at dams or other trapping sites to reduce the number of artificially propagated steelhead in the spawning areas in excess of full habitat seeding levels to increase the proportion of naturally produced steelhead in the spawning population.

Under each fishery criterion, catch and release mortality of natural-origin steelhead is calculated at 5% (NMFS 2003a).

Incidental take of steelhead occurs in UCR spring-run Chinook salmon fisheries; spring-run Chinook salmon fisheries are strictly regulated and limited to no more than 1% incidental mortality (natural-origin and hatchery-origin combined) of UCR steelhead. Current estimates, based on observed steelhead encounters during the Icicle River recreational spring-run Chinook salmon fishery and the lower Wenatchee River fishery, indicate an annual estimated encounter rate of 53% (using a 10-year geometric mean of encounters). This encounter rate would provide a range of adult encounters from zero to ten steelhead (hatchery and natural-origin combined) during the fishery. With a 5% incidental catch-and-release hooking mortality rate, this fishery would result in the maximum incidental mortality of 0.8 fish or the take of one ESA-listed UCR steelhead annually (NMFS 2013b). Annual monitoring and reporting is required to ensure that these performance standards are met.

Spring-run Chinook salmon harvest in this geographic area targets unlisted spring-run Chinook salmon produced by the LNFH and surplus hatchery-origin UCR spring-run Chinook salmon produced by the safety-net components of the Chiwawa River and Nason Creek hatchery programs. In 2013, NMFS approved a new spring-run Chinook salmon fishery in the Wenatchee River below Tumwater Dam to the confluence of the Wenatchee and Columbia Rivers for the purpose of removing hatchery-origin fish that were excess to natural spawning needs while achieving criteria for protecting spring-run Chinook salmon diversity (PNI criteria) (NMFS 2013b; 2013i; 2013h). The incidental take of ESA-listed natural-origin spring Chinook salmon in the fishery is strictly limited based on the abundance of natural-origin spring Chinook salmon returning to the Wenatchee River to spawn. Maximum incidental mortality (including catch-and-release hooking mortality) is 2% (i.e., 2% of the annual natural-origin spring Chinook salmon run). In recent years, Wenatchee River spring-run Chinook salmon abundance has averaged between 500 and 600 fish meaning fisheries targeting hatchery-origin fish could continue annually until the incidental take of natural-origin spring Chinook salmon has reached 10 to 12 fish for the season in the Wenatchee River subbasin.

Summary

In summary, harvest in the Action Area results in incidental take of ESA-listed species in Table 9 and these take effects are accounted for in previous consultations on harvest actions, other than take from fisheries in tributaries of the LCR below Bonneville Dam for LCR coho salmon and LCR tule fall Chinook salmon. These fisheries in the Action Area have undergone a mix of Section 7 consultations, and in some cases Section 10(a)(1)(A) permitting, or 4(d) determinations under the 4(d) Limit, resulting in the escapements reviewed in Section 2.2.1, and were found to meet the ESA standards for avoiding jeopardy.

2.4 Effects of the Action

This Section describes the effects of the Proposed Action, independent of the environmental baseline, and cumulative effects. Under the ESA, "effects of the action" means the direct and indirect effects of an action on critical habitat and on the individuals within a population and how these affect the VSP parameters for the natural population(s) that make up the species, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur.

The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Section 2.4.1 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.4.2. Effects of the Proposed Action that are expected to occur later in time (i.e., just after timeframe of the Proposed Action) are included in the analysis in this Opinion to the extent they can be meaningfully evaluated. In Section 2.6, the Proposed Action, the status of ESA-protected species and designated critical habitat, the environmental baseline, and the cumulative effects of future state and private activities within the Action Area that are reasonably certain to occur are analyzed comprehensively 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.

2.4.1 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. These documents are available upon request from the NMFS Sustainable Fisheries Division in Portland, Oregon. "Pacific Salmon and Artificial Propagation under the Endangered Species Act" (Hard et al. 1992) was published shortly following the first ESA-listings of Pacific salmon on the West Coast and it includes information and guidance that is still relevant today. In 2000, NMFS published "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units" (McElhany et al. 2000) and then followed that with a "Salmonid Hatchery Inventory and Effects Evaluation Report" for hatchery programs up and down the West Coast (NMFS 2004c). In 2005, NMFS published a policy that provided greater clarification and further direction on how it analyzes hatchery effects and conducts extinction risk assessments (NMFS 2005c). NMFS then updated its inventory and effects evaluation report for hatchery programs on the West Coast (Jones Jr. 2006) and followed that with "Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks & Recommendations for

Operating Hatchery Programs Consistent with Conservation and Sustainable Fisheries Mandates" (NMFS 2008b). More recently, NMFS published its biological analysis and final determination for the harvest of Puget Sound Chinook salmon, which included discussion on the role and effects of hatchery programs (NMFS 2011g).

A key factor in analyzing a hatchery program for its effects, positive and negative, on the status of salmon and steelhead are the genetic resources that reside in the program. 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). NMFS monitors hatchery practices for whether they promote the conservation of genetic resources included in an ESU or steelhead DPS and updates the status of genetic resources residing in hatchery programs every five years. Jones (2016) provides the most recent update of the relatedness of Pacific Northwest hatchery programs to 18 salmon ESUs and steelhead DPSs listed under the ESA. Generally speaking, hatchery programs that are reproductively connected or "integrated" with a natural population, if one still exists, and that 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 ESU or steelhead DPS.

When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as "isolated" (also sometimes referred to as a "segregated" program). Generally speaking, isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. They promote domestication or selection in the hatchery over selection in the wild and select for and culture a stock of fish with different phenotypes, for example, different ocean migrations and spatial and temporal spawning distribution, compared to the native population (extant in the wild, in a hatchery, or both). 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, including abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS "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" (NMFS 2005c). 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 2005c). NMFS also analyzes and takes into account the effects of hatchery facilities, for example, weirs and water diversions – on each VSP attribute and on designated critical habitat.

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 various factors of hatchery operation to be applied to each applicable life-stage of the listed species at the population level (in Section 2.4.2), 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 2.6).

The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 89. Generally speaking, effects range from beneficial to negative for programs that use local fish[27] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[28]. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s) for broodstock. When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s) for broodstock, NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects for a specific hatchery program are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Table 89. Overview of the range in effects on natural population viability parameters from two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

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 2004).	**Negligible to negative effect** This 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

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[27] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[28] Exceptions include restoring extirpated populations and gene banks.

		program (i.e., the greater the isolation the closer to a negligible affect).
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. Broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** This 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 affect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance and productivity of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215).	**Negligible to negative effect** This is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible affect), 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** This 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 affect).

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 seven 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,

(4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,

(5) RM&E that exists because of the hatchery program,

(6) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and

(7) 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. The categories are:

(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 the status of an ESU will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery within the ESU affect each of the attributes" (NMFS 2005c). The category of effect assigned is based on an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the Environmental Baseline including the factors currently limiting population viability.

While NMFS has considered the potential for all categories of effects at all hatchery programs included in the proposed action, the subsequent site-specific analysis only includes description of the effects which are expected to occur at each location. Not every program will experience every type of effect, and where an effect is not expected, it is not mentioned in this analysis.

2.4.1.1 Factor 1. The hatchery program does or does not promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS

This factor considers broodstock practices and whether they promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS. It considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The effect of this factor ranges from positive 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. As described in Section 2.4.1, above, the origin of the hatchery broodstock used in the program can have a range of effects on the diversity and productivity parameters of the affected natural population. 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.

2.4.1.2 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 interation between hatchery-origin and natural-origin fish, as well as the effect of encounters with natural-origin at fish collection locations, can affect the viability of natural populations (all 4 VSP parameters; Section 2.4.1). The effect of this factor to these VSP parameters 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 at this time, based on the weight of available scientific information, 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. Hatchery fish can thus pose a risk to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that there are benefits as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011). Furthermore, 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, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains 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 2011g).

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-influenced 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 risk.

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 and Barrowclough 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 can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several, 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. 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). N_e can also be 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). 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). 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.

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., sibs, half-sibs, 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 are caused by gene flow[29] from other populations, hatchery[30] or natural. 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

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[29] Gene flow between groups of fish is often, and quite reasonably, interpreted as the result of actual matings between the two groups, but is more correctly considered simply the contribution of genes from multiple populations to a 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.

[30] NMFS considers outbreeding effects a risk with respect to hatcheries 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 classified as hatchery-influenced selection. Non-native hatchery fish may also contribute to hatchery-influenced selection.

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 and because of general concerns about diversity, NMFS advises hatchery action agencies to develop locally derived hatchery broodstocks. Additionally, unusual rates of straying into other populations within or beyond the population's MPG or 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-origin fish among natural spawners (pHOS) 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 finally spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Saisa et al. 2003; Blankenship et al. 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; McLean et al. 2004; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication) 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, typically from the same population. 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). On an individual level, exposure time in large part equates to fish culture, both the environment experienced by the fish in the hatchery and natural selection pressures, independent of the hatchery environment. On a population basis, exposure is determined by the proportion of natural-origin fish being used as hatchery broodstock and the proportion of hatchery-origin fish spawning in the wild (Lynch and O'Hely 2001; Ford 2002), and then by the number of years the exposure takes place. In assessing risk or determining impact, all three levels 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 for 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 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.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery-origin 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, though the differences have not always been statistically significant and in some years in some studies the opposite is 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-influenced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of interbreeding 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. The Interior Columbia Technical

Recovery Team (ICTRT 2007) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 28). As mentioned above, an important additional aspect of risk considered by the ICTRT that is apparent in this figure is origin of hatchery fish.

More recently, the Hatchery Scientific Review Group (HSRG) developed gene flow criteria/guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for isolated programs are based on pHOS and guidelines for integrated programs are also based 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). 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 more influence from natural selective forces. The HSRG guidelines vary according to type of program (isolated or integrated) and the conservation importance of the natural population. For a population of high conservation importance their guidelines are a pHOS of no greater than 5% for isolated programs

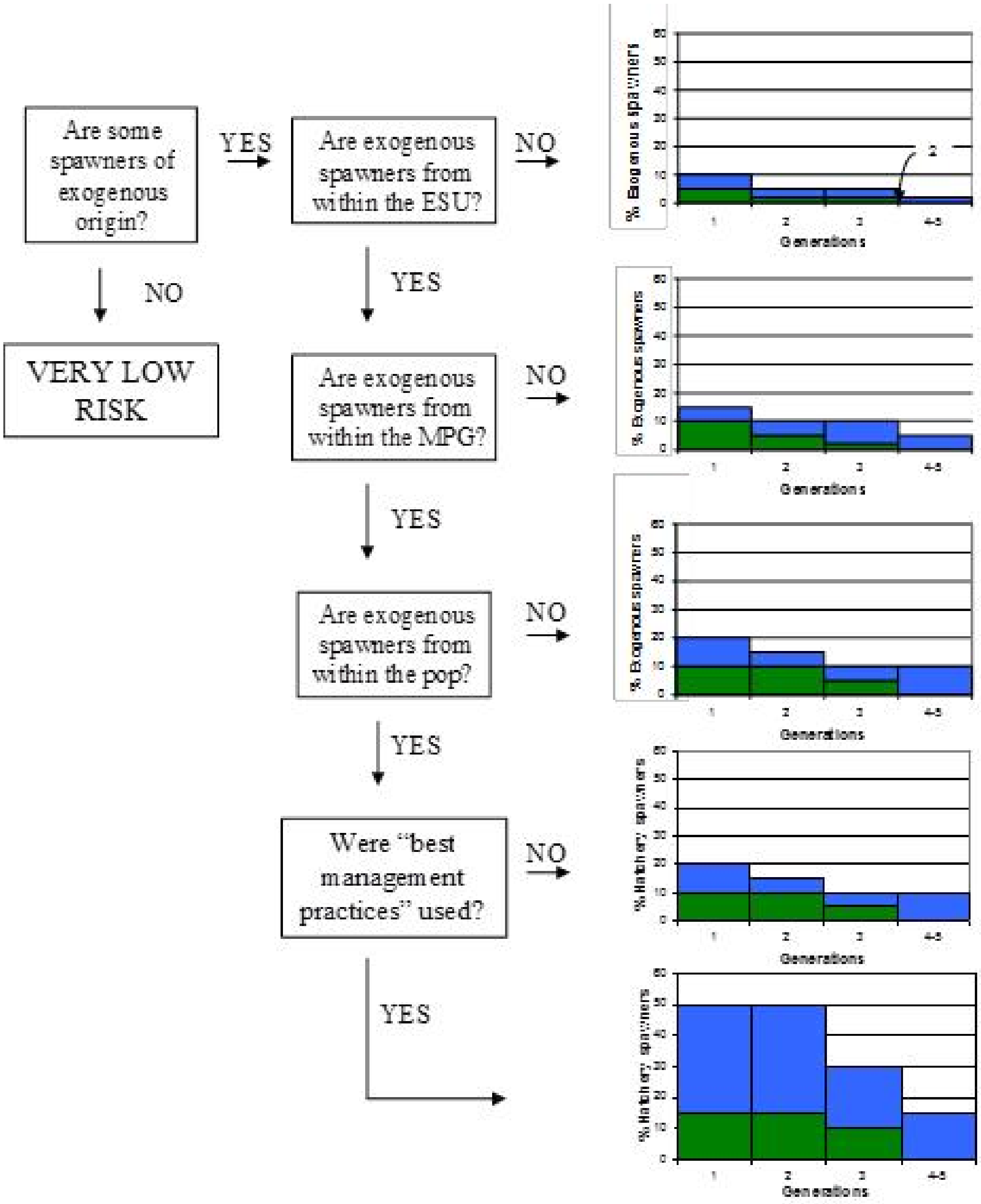

Figure 28. ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Green (darkest) areas indicate low risk combinations of duration and proportion of spawners, blue (intermediate areas indicate moderate risk areas and white areas and areas outside the graphed range indicate high risk). Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

or a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk, in the short-term. HSRG (2004) offered additional guidance regarding isolated programs, stating that genetic 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.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5%. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity". They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose demographic risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with "the proportion of the natural spawning population that is made up of hatchery fish" in the Conclusion, Principles and Recommendations Section (HSRG 2009), but with "the proportion of *effective* hatchery origin spawners" in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources Section (appendix C in HSRG 2009) they introduce a new term, *effective pHOS* ($pHOS_{eff)}$ defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference the HSRG defined *effective* pHOS as:

$$pHOS_{eff} = RRS * pHOS_{census}$$

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014). In the 2014 report, the HSRG explicitly addressed the differences between *census* pHOS and *effective* pHOS, by defining PNI as:

$$PNI = \frac{pNOB}{pNOB+pHOS_{eff}}$$

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the "effective" pNOB might be much lower than the census pNOB.

It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

A simple analysis of the expected proportions of mating types provides additional perspective on pHOS. Figure 29 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[31]. For example, the vertical line on the diagram marks the situation at a census pHOS level of 10%. At this level, expectations are that 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

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[31] These computations are purely theoretical, based on a simple mathematical binomial expansion ((a+b)2=a2 + 2ab + b2).

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 and with no overlap the proportion of NxN matings is (1-pHOS) and the proportion of HxH matings is 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.

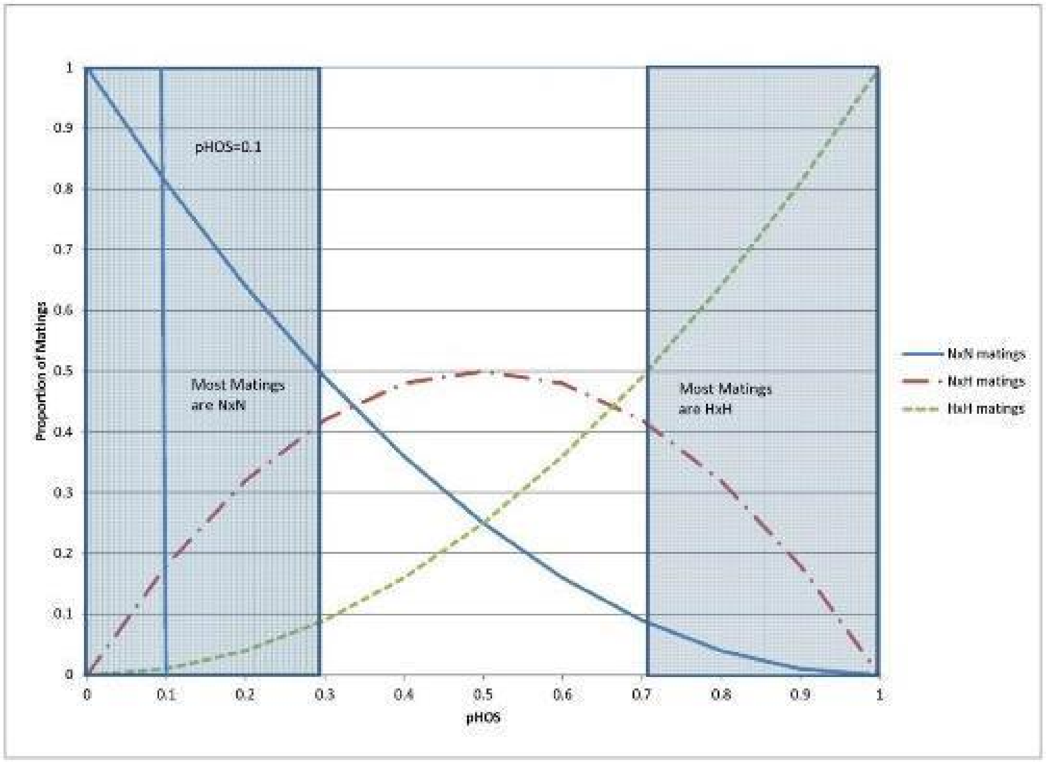

Figure 29. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

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 in that to the extent there is spatial overlap between hatchery and natural spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners is the acclimation of hatchery juveniles prior to release. Acclimation of hatchery juveniles prior to release increases the probability that hatchery adults will home back (return) to the release location reducing their potential to stray into natural spawning areas. Dittman and Quinn (2008) and Keefer and Caudill (2013) provide extensive literature reviews regarding homing in Pacific Salmon and Steelhead. 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 or olfactory stimuli to which the juvenile salmonids were exposed while living in the stream and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability for salmon and steelhead to home to specific streams when using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated as well as a way to provide for local fisheries (Quinn 1997; Dunnigan 2000; YKFP 2008).

Dittman and Quinn (2008) reference numerous experiments that indicated that a critical period for olfactory imprinting (smell) 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; Kostow 2012; Westley et al. 2013), although it does not always show a clear benefit (e.g.,Kenaston et al. 2001; Clarke et al. 2011). Acclimating fish for a period of time also allows them to recover from the stress from handling and transporting the fish to the release location.

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, at a hatchery facility, or by the use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of this measure 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.

The analysis also considers the effects from encounters with natural-origin fish that are incidental to the conduct of 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 volunteering into the hatchery itself, 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 to ESA-listed species. Handling of natural-origin fish at broodstock collection facilities would be expected to increase the potential for injury and stress due to delay, crowding in the trap, sorting (including netting, handling, anethsitizing), and from transport and release. 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 or to remove hatchery fish from rivers and streams and prevent them from spawning naturally. A weir is one type of device that is employed to effectively block upstream migration and force returning adult fish to enter a trap and holding area. Trapped fish are counted and sampled, and can be either retained or released to spawn naturally. The physical presence of a weir or trap can affect salmonids by:

Delaying upstream migration;
Causing the fish to reject the weir or fishway structure, thus inducing spawning downstream of the trap (displaced spawning);
Contributing to fallback of fish that have passed above the weir;
Injuring or killing fish when they attempt to jump the barrier (Hevlin and Rainey 1993; Spence et al. 1996), and
Affecting the spatial distribution of juvenile salmon and steelhead seeking preferred habitats.

Impacts associated with operating a weir or trap include the following:

Physically harming the fish during their capture and retention whether in the fish holding area or within a weir or trap;

Harming fish by holding them for long durations;
Physically harming fish during handling; and
Increasing their susceptibility to downstream displacement and predation, during the recovery period after release.

NMFS analyzes the design and operation of the weirs and traps to determine their potential negative impacts (Hevlin and Rainey 1993; NMFS 2011b). The installation and operation of weirs and traps are very dependent on water conditions at the trap site. High flows can delay the installation of a weir or make a trap inoperable. A weir or trap is usually operated in one of two modes: continuously – where up to 100% of the run is collected and sampled and those fish not needed for broodstock or retained for other reasons are released upstream to spawn naturally, or periodically – where the weir is operated for a number of days each week to collect a representative sample and otherwise left opened to provide fish unimpeded passage for the rest of the week. The mode of operation is established during the development of site-based collection protocols and can be adjusted based on in-season escapement estimates and environmental factors.

NMFS analyzes effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations. NMFS wants to know, for example, if 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. NMFS also analyzes changes to riparian habitat, channel morphology and habitat complexity, water flows, and in-stream substrates attributable to the construction/installation, operation, and maintenance of these structures.

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

NMFS also analyzes the potential for competition, predation, and premature emigration when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. This factor can have effects on the productivity VSP parameter (Section 2.4.1) of the natural population. The effect of this factor ranges from negligible to negative.

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct interactions when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish or through indirect means, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, when hatchery fish take up residency before naturally produced fry emerge from redds, and if hatchery fish residualize, meaning they fail to out-migrate as smolts as intended. Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on naturally produced 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).

Competition may result from direct interactions, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (Rensel et al. 1984). The potential for this and the corresponding threat to the health and survival of salmon and steelhead can only be considered at a heightened level since the capacity of freshwater and estuarine habitats to support salmon and steelhead has been greatly altered and reduced (ISAB 2015). Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced 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 salmon 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. Although newly released hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors, 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 life stages 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 naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported small-scale displacement of juvenile natural-origin rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. They also may prey on younger, smaller-sized juvenile salmonids. 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 salmon and Chinook salmon as well. Adverse impacts from residual Chinook and coho salmon hatchery salmon on naturally produced salmonids is definitely a consideration, 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-origin 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 sufficient size 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 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,[32] 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.

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 (direct consumption) 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 and by the progeny of naturally spawning hatchery fish and by 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. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and

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[32] "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.

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. 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 timing and release 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.

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. Non-infectious 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
- Release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990; Naish et al. 2008). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

Adherence to a number of state, federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; NWIFC and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a NPDES permit administered by the U.S. Environmental Protection Agency (EPA). 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.

2.4.1.4 Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, in the estuary, and in the ocean

Factor 4 can have potential effects on the productivity and abundance VSP parameters (Section 2.4.1) of any affected population. Based on a review of the scientific literature, NMFS's conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions and, while there is evidence that large-scale hatchery production can affect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for main stem rivers and estuaries. NMFS will support new research to discern and to measure the frequency, the intensity, and the resulting effect of density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information and will consider that re-initiation of Section 7 consultation is required in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.1.5 Factor 5. 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. These activities have the potential to affect the abundance, productivity, and spatial structure VSP parameters (Section 2.4.1) of any affected population. The level of effect for this factor ranges from positive to negative.

Generally speaking, negative effects on individual fish from RM&E are weighed against the indirect benefit or value of new information in crafting conservation strategies, particularly information that tests key assumptions and that reduces critical uncertainties. 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)

Direct observation is the least disruptive method for determining a species' presence/absence and estimating their abundance. 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 a 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 should not be walked on.

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.

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).

PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled, so it is critical that researchers ensure that the operations take place in the safest possible manner. Tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery holding tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice and Park 1984; Prentice et al. 1987; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3% and was at times as high as 33.3%.

CWTs are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

Mortality from tagging is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release—it can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal.

Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000c; 2008b) 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).

These effects 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 over effects of the Proposed Action 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 agencies, 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.

2.4.1.6 Factor 6. 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. It 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 and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. This factor can potentially affect a population's abundance, productivity, and spatial structure VSP parameters (Section 2.4.1). The effect of this factor ranges from negligible to negative.

2.4.1.7 Factor 7. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects in a Section 7 consultation. One is where there are fisheries that exist because of the HGMP (i.e., the fishery is an interrelated and interdependent action) and listed species are inadvertently and incidentally taken in those fisheries. These fisheries would have negative effects to the abundance and diversity VSP parameters of the affected populations (Section 2.4.1). 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 ESU or steelhead DPS from spawning naturally. The effects of these fisheries can range from positive (productivity and diversity VSP parameters; Section 2.4.1) to negative (abundance VSP parameter; Section 2.4.1).

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, and non-treaty sustainable fisheries objectives with regard to the 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.

2.4.2 Effects of the Proposed Action

Analysis of the Proposed Action identified that within the Action Area, multiple ESA-listed species are likely to be adversely affected and take will occur as a result of the seven factors described in Section 2.4.1.

NMFS has developed a three-step approach for aligning the distribution of Mitchell Act funds with the preferred alternative in the EIS and associated recovery plans adopted under the ESA. NMFS (2017) and Section 1.3 provide details including specific phase descriptions and implementation and performance review requirements. Effects are analyzed across the entire timeframe by factor in the following Sections.

The effect to each ESA-listed species is based on rationale presented in NMFS (2017). Where NMFS has identified Mitchell Act hatchery funding actions that have already been evaluated for their compliance with the ESA, these effects are incorporated into Section 2.3.4.

ESA-listed species are affected to varying degrees across the factors, and effects may vary by phase. Table 90 captures which factor potentially affects each corresponding ESA-listed species (affected ESUs/DPSs are denoted by 'X'). The subsequent Sections 2.4.2.1 through 2.4.2.8 detail for each ESA-listed species either the level of effect if a factor has been determined to have an effect or why there is no effect.

Table 90. Summary table of the effects of hatchery programs funded under the Mitchell Act during on the seven factors (as determined by NMFS (2017))

ESU/DPS	Factor 1: Broodstock Collection	Factor 2: Interaction on Spawning Grounds	Factor 3: Interaction in Juvenile Rearing Areas	Factor 4: Interaction in Migration Corridor, Estuary, Ocean	Factor 5: RME	Factor 6: Facility Effects	Factor 7: Fisheries
Pacific Eulachon Southern DPS		X	X	X			
LCR Chinook Salmon ESU	X	X	X	X	X	X	X
UCR spring –run Chinook Salmon ESU			X	X			
Snake River spring/summer-run Chinook Salmon ESU			X	X			
Snake River fall-run Chinook Salmon ESU			X	X			
UWR Chinook Salmon ESU	X	X	X	X			
LCR Coho Salmon ESU	X	X	X	X	X	X	X
CR Chum Salmon ESU	X	X	X	X	X	X	
SR Sockeye Salmon ESU			X	X			
LCR Steelhead DPS	X	X	X	X	X	X	
UCR Steelhead DPS		X	X	X			
Snake River Basin Steelhead DPS			X	X			
MCR Steelhead DPS		X	X	X			
UWR Steelhead DPS		X	X	X			
SRKW DPS			X	X			

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

Table 90 indicates NMFS expects no effects under Factor 1 for the Pacific Eulachon Southern DPS, UCR spring–run Chinook Salmon ESU, Snake River spring/summer-run Chinook Salmon

ESU, Snake River fall-run Chinook Salmon ESU, UWR Chinook Salmon ESU, SR Sockeye Salmon ESU, UCR Steelhead DPS, Snake River Basin Steelhead DPS, MCR Steelhead DPS, UWR Steelhead DPS, and SRKW DPS. These salmon ESUs and steelhead DPSs are not taken for broodstock for hatchery programs funded under the Proposed Action, and NMFS is not aware of any incidental take or subsequent effects caused by actions under this factor to these ESUs or DPSs. For the Pacific Eulachon and SRKW DPSs this factor has no effect to these species because they are not encountered during broodstock collection activities funded under the Proposed Action.

For the remaining expected effects of factor 1 on other listed salmon and steelhead species are described below by ESU/DPS.[33]

LCR Chinook Salmon ESU

For the Kalama River fall Chinook salmon program, 2016 was the last year that NOR adults were incorporated into the hatchery broodstock. This program will convert to an isolated program beginning with the 2017 brood. Previously, the Kalama River program has reduced NOR escapement by between 17- 24%. These impacts to NOR abundance ended with broodyear 2016.

The North Fork Toutle program has a goal of incorporating 228 NOR adults into the broodstock to achieve a pNOB target of 30%. Currently the NOR goal would represent approximately 45% of the recent NOR returns to the Green River. The number of NORs that can be collected for broodstock is limited to 30% of the NOR returns to the hatchery weir on the Green River (a North Fork Toutle River tributary), where the broodstock is collected. For the period from 2011 to 2015, an average of 189 NOR adults and jacks were retained from broodstock representing 39.4% of the NOR escapement to the Green River. Between 2017 and 2022 the release goal for this program under the Proposed Action will be reduced from 1,400,000 smolts to 1,100,000 smolts. The reduction in the program size will reduce the number of NOR adults needed to meet the same 30% pNOB target from 228 to approximately 179 adults. The removal of 179 adults for broodstock would represent approximately 35.4% of the NOR escapement to the Green River exceeding the no more 30% of the NOR returns for broodstock limit. NOR returns will have to increase before the pNOB goal and the 30% of the NOR return limit are achieved. The incorporation of NOR adults into the broodstock and the proposed reduction in overall releases are expected to increase PNI and the abundance and productivity of the Toutle River fall Chinook salmon population. Incorporating NORs into the broodstock will also provide a genetic resource that can be used to support natural recolonization of the NF and SF Toutle Rivers as habitat continues to recover.

An updated Washougal program began in 2014 that has a goal of incorporating 262 NOR adult fall Chinook salmon into the broodstock to achieve a pNOB of 30%. The number of NORs that could be collected for broodstock is limited to 30% of the Washougal NOR returns. Currently the 262 adults represent a removal rate of approximately 14% of the 2014-2015 average NOR returns. The release goal for the integrated program is currently 900,000 subyearlings plus

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[33] Here NMFS is not authorizing direct take of natural-origin ESA-listed fish for broodstock, as that is not part of the Proposed Action, but instead is simply ensuring it is incorporating interrelated effects known to occur.

1,100,000 subyearlings for the segregated program that were transferred out of the basin. Under the Proposed Action, between 2017 and 2022 the subyearling release goal for the integrated program will increase from 900,000 to 1,200,000, and the off-station isolated program will be discontinued. The larger integrated program will increase the number of NOR adults needed to achieve the pNOB target of 30% to approximately 350 adults, which is 23% of the 2014 -2015 average adult return. As the NOR abundance increases the proportion removed for broodstock would decrease, reducing the impact on the NOR fall Chinook salmon population in the Washougal River. The elimination of the segregated program and the continued incorporation of NOR adults into the broodstock for the integrated program is expected to increase PNI and the abundance and productivity of the Washougal River fall Chinook salmon population, and the program will act as a genetic repository for the population.

LCR Coho Salmon ESU

WDFW operates four integrated coho salmon programs: the Grays River, North Fork Toutle, Kalama Type-N, and Washougal. All four take broodstock under the restriction that no more than 30% of the adult NOR run can be collected for broodstock. The Grays River broodstock goal has been 184 adults, of which 55 would be NOR adults (pNOB target of 30%). From 2011 to 2015 adult NORs collected ranged from 20 to 84. The broodstock goal of 184 was for a program with an annual release of 150,000 smolts plus some additional eyed-eggs for a coho salmon enhancement project. Available escapement estimates (Table 45) indicate that the 55 NORs represent approximately 12% of the NOR returns to the Grays River. Under the Proposed Action, between 2017 and 2022 the program release goal will decrease to 75,000 smolts. At this level only 22 NOR adults would be needed to achieve the pNOB target of 30%. If the NOR population is as abundant as observed from 2010-2012, then pNOB could be increased to increase the overall PNI for the Grays River coho salmon population. The 22 NOR broodstock goal represents approximately 5% of the Grays River NOR returns. Doubling this number would not be expected to noticeably reduce the productivity of the NOR population and would be justified since this would be a considered a conservation program, that is, it would continue to conserve genetic resources. Furthermore, the reduction in abundance from the proportion of NOR adults used for broodstock would be replaced by Grays River hatchery coho salmon contributing to the naturally spawning population.

The North Fork Toutle Type-S coho salmon program has a pNOB target of 100%. The broodstock goal is 140 NOR adults and has averaged approximately 149 adults and jacks. The 140 broodstock goal has been exceeded in some years due to higher than expected pre-spawning mortalities resulting in the recent 5-year average of 149 adults and jacks retained for broodstock. The 140 NOR broodstock goal represents approximately 10% of the average total NOR returns to the Green River. Removing approximately 10% of the NOR abundance would not be expected to impact the productivity of the NOR population and impacts in abundances would be ameliorated by naturally-spawning hatchery coho salmon. Under the Proposed Action, between 2017 and 2022, the annual program release goal will decrease from 150,000 smolts to 90,000 smolts. This reduction would reduce the broodstock need to 82 NOR adults, which would be expected to further reduce the proportion of NOR adults removed to less than 5% of the NOR returns to the Green River, and would be expected to increase the abundance and productivity of the natural North Fork Toutle River coho salmon population. The incorporation of NOR adults into the broodstock and the proposed reduction in overall releases are expected to increase PNI and the abundance and productivity of the Toutle River coho salmon population. Incorporating NORs into the broodstock will also provide a genetic resource that can be used to support natural recolonization of the NF and SF Toutle Rivers as habitat continues to recover.

The Kalama Type-N coho salmon program has a pNOB target of 30%. The broodstock goal for this program is 550 adults of which 165 would be NOR adults. The program currently collects an average of 147 NOR adults for broodstock, this represents 68% of the NOR adults encountered at the Kalama Hatchery Weir. Abundance estimates of the NOR coho salmon population are similar to the number of NOR released below the hatchery weir. The removal of over 30% of the estimated NOR abundance and a corresponding high pHOS has adversely impacted the NOR coho salmon population in the Kalama River. To reduce these impacts on abundance and productivity, the release goal for this program was reduced from 600,000 to 300,000 smolts with the 2015 broodyear. At the 300,000 smolt release goal, only 83 NOR adults are needed for broodstock to achieve the 30% pNOB goal. This is expected to double the number of NOR coho salmon released below the hatchery weir to spawn naturally, increasing the overall abundance of the NOR population. The reduction in the number of hatchery smolts released, the reduction in the number of NOR needed for broodstock, and the continued incorporation of NORs into the broodstock is expected to increase the abundance and productivity of the NOR Kalama River coho salmon population. Furthermore, the integrated program will continue to preserve the genetic resources of the Kalama River coho salmon population.

The Washougal River coho salmon program has a pNOB target of 100%. Up to 2,150 NOR adults are needed to meet the program’s broodstock goal for all egg-take goals which include 200,500 eggs to produce the 150,000 integrated on-station release and 3,000,000 eggs for the isolated Klickitat River program. To achieve the pNOB target for the integrated on-station release, 122 NOR adults are needed for the broodstock. pNOB has been averaging approximately 41%. NOR adults collected for broodstock represent approximately 11% of the Washougal NOR returns. Under the Proposed Action, between 2017 and 2022, the annual release goal for the integrated program will decrease from 150,000 to 108,000 smolts. The broodstock needed for the reduced program (at 100% pNOB) is 74 adults. This level of broodstock collection represents approximately 13% of the recent 5-year average annual return to the Washougal River. The removal of 13% of the NOR returns would be expected to reduce the abundance of the natural coho salmon population but this reduction would be expected to be ameliorated by Washougal Hatchery coho salmon spawning naturally and an overall reduction in pHOS. Therefore the viability of the Washougal River natural-origin population should not be affected negatively. Furthermore, the incorporation of NOR coho salmon into the broodstock would continue to preserver the genetic resources of the Washougal River coho salmon population.

CR Chum Salmon ESU

Natural-origin and hatchery chum salmon are collected at the Big Creek Hatchery for broodstock to support the reintroduction of chum salmon into Oregon tributaries to the LCR. The program expects to collect up to 480 adults (hatchery and natural-origin) for broodstock, currently the goal is to produce 200,000 fed-fry for release on-station and provide eyed-eggs for remote-site incubation. The broodstock originated from natural-origin chum salmon collected in the Grays River and could potentially collect adults from there again if program broodstock needs are not met at Big Creek Hatchery. Broodstock was collected from the large Grays River population (recent 5-year average 7,556 NOR adults), until 2014 when returning hatchery and natural-origin adults were used from broodstock.

The program expects to handle up to 200 NOR adult chum salmon annually at the Big Creek Hatchery. Some of these will be used for broodstock and other will be released above the hatchery or outplanted into reintroduction areas. Effects on natural-origin chum salmon from collection and removal of adults for broodstock are expected to reduce the overall abundance of the natural-origin population but this is necessary in the short-term to support the reintroduction of chum salmon into historical habitat on the Oregon side of the Columbia River. The program is expected to continue as proposed into the future, though, these impacts would be expected to decrease overtime as the natural-origin populations become self-sustaining, potentially eliminating the need for the hatchery program altogether. This hatchery program, as proposed, would be expected to conserve CR chum salmon the genetic resources.

LCR Steelhead DPS

There are three integrated steelhead hatchery programs in the LCR Steelhead DPS: the Clackamas Winter, Kalama Summer, and Kalama Winter programs. Broodstock for the Clackamas program was derived from Clackamas River NOR winter steelhead in 2004 and it continued to incorporate NOR fish into the broodstock until 2012. Beginning in 2017, up to 49 natural-origin adults will be used for broodstock, which is not expected to exceed 2% of the Clackamas River NOR run. Adults from this program will be live-spawned and released back into the Clackamas River to potentially spawn again, which will further reduce risks due to the removal of NOR adults from the spawning population. The integrated program will replace a segregated program releasing non-location winter steelhead further reducing impacts on the Clackamas River winter steelhead population. The incorporation of NOR adults into the broodstock is expected to continue to preserve the genetic resources of Clackamas River winter steelhead population.

The Kalama River summer steelhead program uses up to 70 NOR adults as broodstock, with the goal of using no more than 30% of the Kalama NOR returns. The removal of NOR summer steelhead adults has averaged approximately 13% over recent years. Similarly, the Kalama River winter steelhead program uses up to 80 NORs, with the same 30% limit. The removal rate has been approximately 8% of the NOR winter steelhead returns. The pNOB goal for these programs is 100%. Because these hatchery programs live-spawn the NOR adult males used for broodstock, backfilling with HOR adults is not necessary, though a proportion of hatchery adults do spawn naturally (pHOS is not zero), so the overall abundance of the naturally-spawning population is not be affected. The incorporation of NOR adults into the broodstock for these two programs is expected to continue to preserve the genetic resources of Kalama River summer and winter steelhead populations.

2.4.2.2 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

Here Table 90 indicates NMFS expects no effects under this factor on the UCR spring–run Chinook Salmon ESU, Snake River spring/summer-run Chinook Salmon ESU, Snake River fall-run Chinook Salmon ESU, SR Sockeye Salmon ESU, UCR Steelhead DPS, Snake River Basin Steelhead DPS, UWR Steelhead DPS, and SRKW DPS. SRKW do not occupy the freshwater areas where interaction may occur under this factor, therefore NMFS has determined there will be no effects to this ESA-listed species via this factor. It would be rare for hatchery salmon and steelhead resulting from the Proposed Action to stray into these areas (hundreds of miles in some cases), let alone often enough and in large enough numbers to cause any adverse effect. Encounters with natural-origin salmon or steelhead from these ESA-listed ESUs or DPSs at adult collection facilities included in the Proposed Action also will not occur since none have been reported over the last twelve years (NMFS 2017) and NMFS expects that trend to continue into the future.

For the remaining expected effects of factor 2 on other listed species are described below by ESU/DPS.[34]

2.4.2.2.1 Non-salmonid species

Pacific Eulachon Southern DPS

Hatchery programs can potentially negatively affect eulachon through ecological interaction from superimposition by hatchery fish and the progeny of naturally spawning hatchery fish on eulachon during spawning. These effects would only potentially occur in the Kalama, Elochoman, Grays, and Coweeman Rivers.

There are currently no data or measurements of superimposition[35] on eulachon eggs by spawning hatchery fish or the progeny of naturally spawning hatchery fish. What reduces the likelihood of significant impact is that, returning hatchery-origin adults from the majority of programs in the Proposed Action will have either finished spawning before eulachon have begun their upstream migration, or they will occupy different spawning habitats. Returning adults from all Chinook salmon hatchery programs will finish spawning by the end of November (Table 14), before the beginning of the adult eulachon migration. Adult eulachon spawn timing temporally overlaps with returning adults from summer steelhead programs, but summer steelhead occupy different spawning habitats, preferring areas higher in the watershed (Table 57). While effects from these components of the Proposed Action are discountable, the effect of the winter steelhead programs from superimposition by hatchery fish or the adult progeny of naturally spawning hatchery fish on eulachon during spawning in the Kalama, Elochoman, Grays, and Coweeman Rivers is unclear.

The stock of winter steelhead used in the past and during Phase 1 of the Proposed Action, Chambers Creek winter steelhead, temporally and spatially overlaps with eulachon spawn timing and habitat. Hatchery programs that used this stock reported full maturation and spawning beginning the first week of December through the end of January, overlapping with eulachon spawn timing described by Gustafson et al. (2010). Eulachon eggs are commonly found attached

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[34] Here NMFS is not authorizing direct take of natural-origin ESA-listed fish for broodstock, as that is not part of the Proposed Action, but instead is simply ensuring it is incorporating interrelated effects known to occur.

[35] Superimposition in this case means disruption of gravels onto which eulachon have spawned by salmon and steelhead digging redds.

to sand or pea-sized gravel, though eggs have been found on a variety of substrates, including silt, gravel to cobble sized rock, and organic detritus (Moody 2008), similar to substrates steelhead are known to use (Kondolf and Wolman 1993). Historically, temporal and spatial overlap between natural winter steelhead run timing and eulachon was low, but the Chambers Creek winter steelhead stock was developed, through fish culture efforts, to return during a specific and early maturation time period (Crawford 1979), which overlaps temporally in spawn timing with eulachon. The Kalama River (Early) winter steelhead program is the only program proposing to recycle adult steelhead surplus above hatchery broodstock needs back into its receiving watershed. While this could result in continuous eulachon spawning ground interaction through superimposition by hatchery-origin adults, it will be negligible as they will not recycle winter steelhead that show signs of sexual maturity.

These effects on eulachon will likely remain into the future as the Proposed Action switches to a new LCR steelhead for isolated programs that exhibits an early run-timing similar to Chamber Creek winter steelhead.

2.4.2.2.2 Analysis of genetic effects of Mitchell Act hatchery programs on listed Columbia Basin salmon and steelhead

As explained in Section 2.4.1.2, NMFS's standard approach to analysis of genetic effects of hatchery programs is to consider three categories of effects: within-population diversity, outbreeding, and hatchery-influenced selection. Our experience has been that of the three categories, there is seldom a concern with within-population diversity. Moreover, in looking at current hatchery programs and considering what is necessary for aligning them with recovery needs, there are no obvious within-population diversity concerns. Given this, and the fact that no clear standards or recommendations exist for this category of risk, we will not consider this category of effect in this Opinion, assuming that any issues that arise will be program-specific, and will therefore be dealt with in future consultations.

However, as explained in the BA (NMFS 2017), there are obvious concerns with respect to outbreeding effects- specifically the erosion of genetic diversity among conservation groups (ESUs/DPSs or MPGs), as well as hatchery-influenced selection (based on pHOS or PNI). Basically, currently there are too many hatchery-origin fish on the spawning grounds in many Columbia River salmon populations[36,] particularly those in the lower Columbia, and in some cases the hatchery-origin fish are not from the same ESU/DPS or MPG as the natural-origin fish with which they interbreed. The Proposed Action implements reforms to reduce risks in these two categories over a relatively short period of years to the point where Mitchell Act hatchery programs are consistent with objectives described in ESA recovery plans.

Our main concern in analyzing genetic effects is usually not genetic diversity itself, but most often effects to the populations productivity and resiliency - its ability to flourish in its

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[36] Note that the purpose of a biological opinion is to determine whether an action jeopardizes a species, at the ESU or DPS level, whereas much of the discussion of genetic effects is analyzed at the population level. Negative impacts at the population level do not necessarily lead to jeopardy at the species level, but must be considered individually and included in the species-level analysis to enable the jeopardy determinations to be made.

environment and to be able to adapt to future environmental conditions, such as those caused by climate change. . Productivity and resiliency can be reduced by naturally produced fish interbreeding excessively with hatchery-origin fish on the spawning grounds and/or by interbreeding with hatchery-origin fish with a different genetic background from the natural-origin fish (e.g., from a different ESU or MPG). We term this phenomenon gene flow (or introgression). The actual effects of gene flow in terms of productivity are extremely difficult to measure, so this is rarely if ever done. Gene flow itself can be measured in some circumstances, but generally the surrogates pHOS (proportion of fish on the spawning ground that are of hatchery origin) and pNOB (proportion of the broodstock that are of natural origin). Most available guidelines and standards for gene flow are based on these surrogates. Throughout this Section inferences about gene flow and productivity will be based on and discussed in terms of these surrogate variables.

Some remarks on gene-flow standards are in order before we present more detailed analysis of the Mitchell Act hatchery programs in the Proposed Action. Two sets of recovery standards are prominent in recovery plans. Most prominent are standards developed by the HSRG based on a mathematical model by Ford (2002), which are discussed in Section 2.4.1.2. In brief, the HSRG categorizes programs as isolated (or segregated) or integrated, which they define in terms of goals, but are most easily understood operationally. For purposes of this document, an isolated (or segregated) program is one in which natural-origin fish are not included in the hatchery broodstock; an integrated program is one in which natural-origin fish are included in the broodstock. Currently the vast majority of programs funded under the Mitchell Act are isolated. The HSRG presents standards for the allowable level of hatchery-origin fish on the spawning grounds for both types of programs (HSRG 2009, Recommendation 8 in Section 2.2), based on the conservation importance of the affected natural population. For isolated programs the standard is a maximum pHOS level of 5% for primary (very important) populations, and 10% for contributing (moderately important) natural populations, although as explained in Section 2.4.1.2, the HSRG's current thinking is that 5% may be too high (HSRG 2014). In the absence of a decision by the HSRG to revise, we will use the existing standards for isolated programs influencing primary and contributing populations. For integrated programs the corresponding standards are a minimum proportionate natural influence (PNI) (Section 2.4.1.2) level of 67% and 50%, with pHOS maxima of 30% for both. The HSRG did not develop pHOS or PNI standards for stabilizing populations.

It is important to realize that under certain circumstances these standards may not apply. If a population is demographically challenged (i.e., at serious risk of extinction), such as CR chum salmon and possibly the Chinook salmon populations in the LCR Coast MPG, or if the population is actively recolonizing, such as Columbia chum salmon, or Chinook salmon exploring previously unavailable habitat, such as that upstream of dams, then these gene flow standards can be relaxed. The HSRG (2014), for example, describes a multi-phase approach in which the standards discussed above (e.g., 5% pHOS) do not apply in early phases. As described throughout this document, we rely on different pHOS and PNI goals for different populations for a variety of reasons specific to the population itself as well as to its place within the "species" – the ESU or DPS. Finally, the duty of an Opinionis to determine if an action causes jeopardy to a species, not a population. Therefore, it is important to keep in mind a population's relationship to the species when considering genetic effects at the population level.

While we use the HSRG standards in aligning Mitchell Act hatchery programs with recovery plans, we have placed two limitations on the usage of HSRG concepts. The first is that we use *census* rather than *effective* pHOS. NMFS's concerns about effective pHOS not being conservative enough are detailed in Section 2.4.1.2. The second limitation is the use of results from the HSRG's All-H Analyzer (AHA) model (Mobrand Jones & Stokes Associates 2005, Appendices C and D; HSRG 2009). The AHA model incorporates as an option use of fitness mechanics from the Ford model to influence population productivity and capacity (reviewed in RIST 2009). AHA has been used in a comprehensive analysis of Columbia Basin hatchery programs, and in detailed hatchery program planning by WDFW. Use of the AHA fitness function can lead to natural production increasing as pHOS is reduced. Assuming that natural productivity is depressed because of the influence of hatchery-origin fish, that effect can be expected to decrease once the hatchery influence is removed or reduced. No data are currently available on this topic, but empirical evidence from experimental harvest on a fish species in a laboratory indicates that recovery from genetic influences may take some time (Conover et al. 2009). Thus we assume no near-term genetically based increase in productivity of natural salmon and steelhead populations during the period of implementation of the Proposed Action.

Recovery planners in Oregon prefer a pHOS standard of a 10% maximum, based on the work of (Chilcote et al. 2011; 2013) demonstrating that productivity of salmon and steelhead populations decreases as pHOS levels rise above 10%. Although NMFS has voiced concerns about the methodology and some of the conclusions (Busack 2013), NMFS has concurred with its usage as a recovery standard (NMFS 2013e). Oregon recovery planners did not develop standards for integrated hatchery programs. Although somewhat more liberal than the HSRG standard of 5%, the Oregon standard has the advantage of being based on empirical data rather than a mathematical model, as the HSRG standard is. For this reason and for the sake of consistency, the Proposed Action uses the 10% standard.

The gene-flow standards discussed above do not cover all program types funded by the Mitchell Act. NMFS concluded in a previous Opinion (NMFS 2016g), that for isolated hatchery programs using extremely divergent broodstocks, no existing pHOS standard seemed appropriate. For programs using broodstocks that undergone substantial levels of intentional selective breeding to alter life history, and were known to have low levels of reproductive success relative to the natural-origin fish with which they interact, NMFS concluded, based on new modelling, that a maximum 2% gene flow standard was appropriate. At this time we consider this standard strictly applicable only to the Skamania summer and Chambers Creek winter steelhead stocks, and their local derivatives. Recent re-examination of the modelling we did for the Puget Sound steelhead consultations, comparison with results of modelling based on the Scott-Gill equation (WDFW 2008) that appear in recent LCR steelhead HGMPs (e.g., WDFW 2014f) shows that depending on spawning overlap and relative reproductive success (RRS), pHOS levels above 0.05 could be compatible with a 2% gene flow rate, and assuming even 50% spawning overlap, given the documented low RRS of Skamania and Chambers Creek steelhead (e.g. Leider et al. 1984), a census pHOS level of 5% is likely to be indicative of a gene flow level of considerably less than 2% in populations into which fish from these two stocks are released.

While we conclude that the existing gene flow standards discussed above are certainly more protective than the levels of hatchery influence that have been common in many areas of the Pacific Northwest for decades (e.g., pHOS in LCR tule fall Chinook salmon), NMFS finds that the current level of research supporting standards for genetic risk from hatchery programs is inadequate, given the importance of hatchery programs to the resource and the level of risk they may present. Especially disconcerting is the fact that after a decade of wide usage, HSRG concepts have not been subjected to peer-review in the primary scientific literature. Given the expanding capabilities of genomics research, and new modelling efforts such as that of Baskett and Waples (2013), we expect guidance on reduction of genetic risk to expand considerably during the implementation of the Proposed Action. As information becomes available, for example on the merits of a pHOS standard of 5% relative to one of 10%, NMFS will implement it through the consultation process.

A summary of genetic effects by ESU/DPS for Mitchell Act funded hatchery programs under the Proposed Action follows:

LCR Chinook Salmon ESU

For discussion of effects in this ESU, three categories of Mitchell Act funded programs will be considered: tule fall Chinook salmon programs releasing fish within the geographical boundaries of the ESU (nine), spring Chinook programs releasing fish within the geographical boundaries of the ESU (two), and programs releasing fish outside the ESU that may affect fish in the ESU (two). Most of the changes needed to align Mitchell Act hatchery programs with recovery planning in the LCR are occurring and will continue to occur in tule fall Chinook salmon programs, so most of the material in this Section concerns them.

Only one broodstock change was needed among Mitchell Act tule fall Chinook salmon programs in the LCR: Deep River Net Pens, a program in the Coast MPG area, which used a Cascade MPG broodstock (Washougal). This program is being discontinued as part of the Proposed Action for purposes of pHOS reduction. All other LCR tule fall Chinook programs already used within-MPG broodstocks, so no changes in broodstock source were needed. However, elevated pHOS levels, some upwards of 80% were noted in nearly all LCR tule fall Chinook populations (Table 19). As described in the BA (NMFS 2017), a step-wise process was developed to modify Mitchell Act funded programs to reduce pHOS:

1) Develop set of index populations on which to focus pHOS reductions,
2) Establish pHOS objectives,
3) Evaluate the relative role of different programs on pHOS in index populations,
4) Adjust programs or otherwise control returnees from them to achieve pHOS objectives.

Developing the set of index populations involved two important steps. The first was including only populations from the Coast and Cascade MPGs as potential index populations, and excluding the Gorge MPG from the risk calculation at this phase of implementation of the Proposed Action. As explained in the BA, not including all the MPGs in an ESU or DPS for purposes of risk reduction is a departure from the usual approach to recovery planning, but is consistent with NMFS' interpretation of the LCR recovery plan recovery scenario. Because of the challenges to recovering it, and questions about the historical function and genetic distinctness of the Gorge Chinook salmon MPG, recovery planners recommended that this particular's MPG's historical status and population structure be re-evaluated NMFS 2013e. NMFS agreed that the historical role merits further examination. In recognition of these uncertainties, recovery planners set the recovery standard (in terms of number of populations within an MPG needed to achieve viability) for Gorge fall Chinook at a lower standard and compensated by setting higher standards in the Cascade and Coast MPGs. Given the uncertainty about the Gorge MPG and large amount of analysis memorialized in recovery documents (ODFW 2010a; NMFS 2013e), the decision is to concentrate risk reduction and recovery measures on the highest priority natural populations is consistent with the recovery plan..

Within the Coast and Cascade MPGs, pHOS reduction measures were developed targeting a set of index populations that had recovery risk goals above medium (all the primary and a small number of contributing populations) (Table 13) but not initially targeting the remainder of the contributing populations and all the sustaining populations. The BA presents a number of persuasive justifications for this approach, but the question is how much additional risk is posed by deferring action on these non-index populations. As shown in the BA appendix (NMFS 2017), CWT recoveries demonstrate that strays from a given hatchery programs are likely to occur in multiple populations, so a change to a program implemented to reduce pHOS in an index population is likely to reduce pHOS in other populations as well. Additionally, many of these non-index populations are not required for recovery (classified as "sustaining), will be allowed to maintain high pHOS levels. Therefore, deferring action that would reduce pHOS in the non-index populations at least until the pHOS goals of the initial reductions are achieved seems low risk.

For reasons explained in the preceding material, in the analysis by ESU/DPS, NMFS adopted pHOS maxima of 10% as the default interim goal for index populations influenced by isolated programs and 30% for index populations influenced by integrated programs (with the expectation that the system is moving toward a long-term PNI of 67% or more), consistent with LCR recovery plan pHOS levels identified as necessary for achieving population recovery goals. However, these goals were applied only to the tule populations in the Cascade MPG; in the short-term and as a first step towards recovery, pHOS must be reduced to 50% or less for the populations in the Coast MPG. This was done in recognition of the distinctness and uncertain status of the populations in the Coast MPG.

As can be seen in Figure 30, the relationship between recent pHOS (expressed in the graph as HOS/NOS, which is pHOS/(1-pHOS)) and natural-origin spawners was very different in the Coast tule populations than in either the Cascade tule Chinook populations or the coho salmon populations in the corresponding MPGs. As a group, these populations exhibit both the lowest level of natural-origin spawners and the highest pHOS levels of all index Chinook and coho salmon populations. Biologists and recovery planners have expressed concern about the ability of these populations to sustain themselves without a regular influx of hatchery-origin spawners. There is considerable uncertainty about how these populations would perform under lower levels of pHOS (such as 5-10%), the best case scenario being that natural production would increase as pHOS is reduced, and the worst being that natural-origin production would drop even further, perhaps to a level where it is clear that the current natural production is entirely sustained by hatchery-origin spawners.

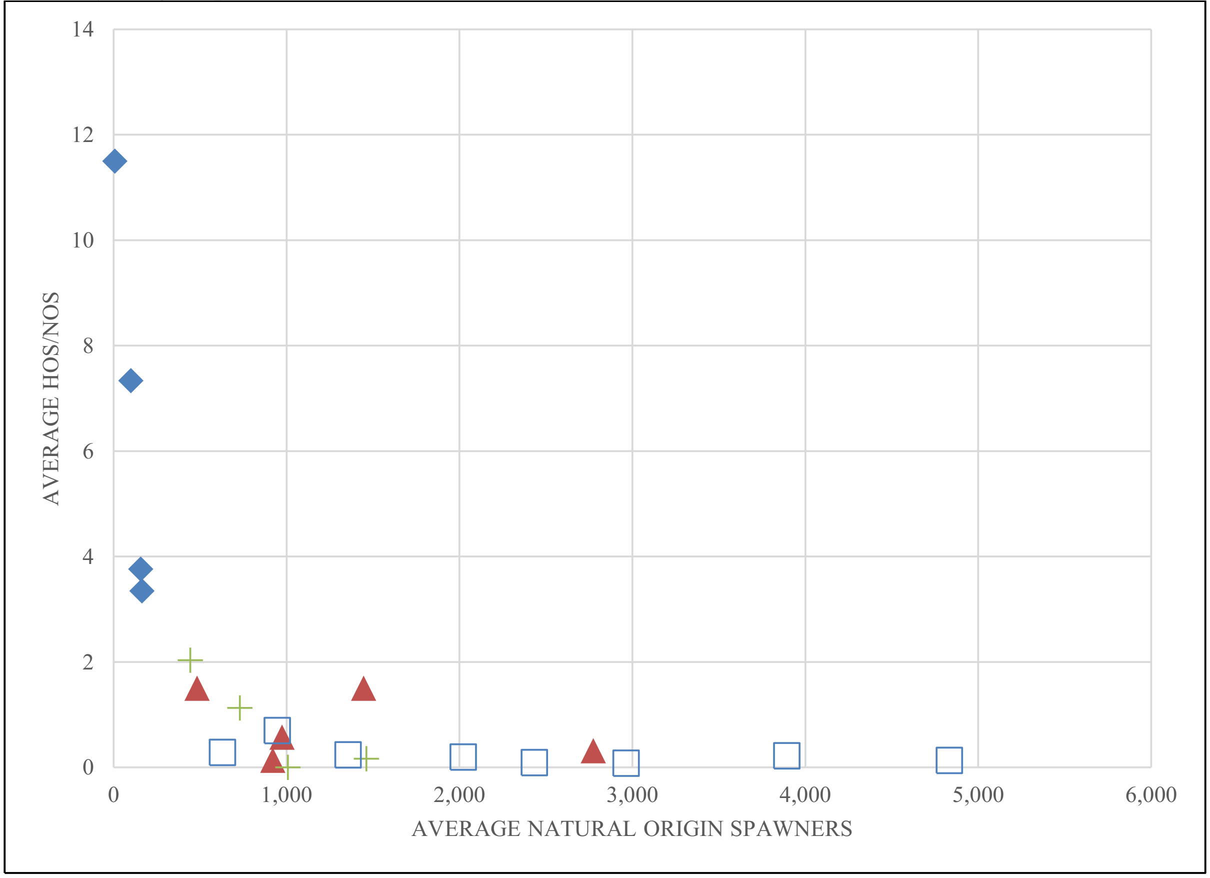

Figure 30. Mean HOS/NOS vs average natural-origin spawners (data from 2010-2014) for Chinook and coho salmon index populations. Coast Chinook and coho salmon MPGs = diamonds and plus symbols, respectively. Cascade Chinook and coho salmon MPGs= triangles and open squares, respectively. (NMFS 2017)

Because of the large reductions in program size required to reduce pHOS (e.g., about a 30% reduction in releases to reduce pHOS by 10%, and the uncertainty of the response to these reductions, adopting a more modest interim pHOS goal seems not only reasonable but prudent, especially if coupled with research designed to understand these populations better, but it is important to understand the risk of doing so.

The rationale of taking immediate action to reduce pHOS to 10% is that large deleterious change may be occurring and any further delay just allows more to occur. At best, delaying action or implementing a lesser action will delay recovery; at worst, delay may allow permanent damage to occur. On the other hand, large-scale hatchery effects have probably been occurring for many decades, and that the incremental change from one generation to the next may be minor after so many years of interaction. Certainly there are models of genetic change through selection, as well as controlled selective breeding experiments consistent with this concept. Moreover, region wide, natural production persists in many populations that have experienced high pHOS levels for many years, so there may be a limit to the extent to which fitness can be reduced through many years of high pHOS hatchery-influenced selection[37]. At present there is no way of knowing what the true situation is in these small Coast MPG fall Chinook salmon populations, due to limited data, but our opinion is that after many decades of high pHOS levels, reducing pHOS to no more than 50% should slow whatever fitness decline is still occurring and possibly lead to improved fitness over baseline conditions. As pointed out in the BA, a pHOS reduction to 50% could be a substantial reduction in ecological risk as well. At a pHOS level of 80%, the ratio of hatchery-origin to natural-origin spawners is 4 to 1; at a pHOS of 50% the ratio is 1 to 1.

Success of this "pulse-checking" exercise is critical to justification of the relaxed pHOS standard for the Coast MPG tule Chinook salmon populations. RM&E must be designed and implemented in the shortest possible time frame to inform the future management of these populations. The key question to be answered for these populations is what level of natural production they are capable of without a continuing subsidy of hatchery-origin spawners. A variety of responses to reduced pHOS are possible, some of which may not lead to clear conclusions without careful experimental design. Therefore it is essential that a multi-agency team be convened to develop hypotheses, determine response variables, and develop an adaptive management plan as soon as possible. Under the Proposed Action, this evaluation to require a minimum of 12 years (~3 Chinook salmon generations). Since it is uncertain whether these natural populations can sustain themselves without some level of hatchery subsidy, and given the lessening of genetic and ecological risk that will occur during the evaluation, and the knowledge that will be gained, deferring the imposition of alternate pHOS standards until phase 3 of the implementation of the policy direction is likely to be an effective and low-risk approach.

Proposed adjustments to the current suite of Mitchell Act funded programs to achieve the interim pHOS goals in index populations were based on a modeling effort called the Chinook assessment model (CAM) that incorporated a rigorous analysis of CWTs recovered over the last ten years. The methodology, which was jointly developed by NMFS, WDFW, and ODFW for implementation of the EIS Proposed Action, is described in detail in NMFS (2017). CAM takes maximum advantage of data available to evaluate the relative contribution of individual hatchery programs to pHOS in LCR tributary drainages. Because of sampling variation in the recovery of CWTs and variation inherent in estimating survival and harvest rates, the method undoubtedly is imprecise, but as better method is available for an analysis of this sort, it is best available science. pHOS objectives for LCR Chinook salmon index populations are presented in Table 91. Because NMFS can assess annually, whether to continue to fund these programs based on their performance, the pHOS requirements are likely to be met.

Table 91. Maximum Chinook salmon pHOS limits by ESA-listed natural population into which hatchery Chinook salmon originating from Mitchell Act funded hatchery programs are known to stray. Limits are calculated on a four-year running average.

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[37] The HSRG made this assumption in its AHA modelling of Columbia Basin hatchery programs (HSRG 2009), setting a "fitness floor" of 50%, assuming that genetic hatchery impacts could not reduce fitness beyond that.

Population	***Chinook salmon program type contributing to pHOS in population***	***pHOS limit***
Grays/Chinook Rivers	Isolated fall	50%
Elochoman/Skamokawa Rivers	Isolated fall	50%
Mill/Abernathy/Germany Creeks	Isolated fall	50%
Coweeman River	Isolated fall	10%
Lower Cowlitz River	Integrated fall	30%
Toutle River	Integrated fall	30%
Lewis River	Isolated fall	10%
Washougal River	Integrated fall	30%
Kalama River	Isolated spring	10%
Clackamas River	Isolated spring	10%

For the Proposed Action the set of measures to meet the interim pHOS goals included adjustments in program sizes and increased weir operations. No program size adjustments were made or are planned to the STEP programs at Astoria and Warrenton high schools, as they were considered too small to have a measurable effect on pHOS, but adjustments were made to every other Mitchell Act funded hatchery program in the Coast and Cascade Chinook salmon MPGs. All but two adjustments (Bonneville and Klaskanine) were reductions; overall under the Proposed Action Mitchell Act tule Chinook salmon releases will be reduced 24% in phase 2. Additionally, six new weirs will be put in place during phase 2 (South Fork Toutle, Skamokawa, Mill, Abernathy, Germany, and Cedar Creek) to assist in pHOS management actions toward reductions from current levels.

Because NMFS funds these programs, the pHOS requirements are certain to be met. The pHOS requirements will be phased-in for several reasons. First, to reduce risks to SRKW, the adjustments will be phased in over five years. A gradual reduction in tule Chinook salmon available as prey for SRKW will have a lesser effect on the whales. This phase-in will also allow collection of baseline information for research designed to increase understanding of ecological interactions between hatchery-origin and natural-origin fish in the estuary and plume.

Second, the Proposed Action assumes certain levels of weir efficiency that may not be initially met, and in some cases possibly will turn out to be unrealistically high, because weir placement typically involves adjustments before they reach full effectiveness. Fortunately, weirs can be tested immediately and necessary modifications to operations and structures made during the years before fish from the reduced programs begin returning. If weirs at some locations prove ineffective, then additional program reductions will be necessary. Issues associated with weirs are discussed in detail later on in this Section.

Third, because of imprecision inherent in the CAM modelling, the program adjustments may prove to be insufficient to reduce pHOS to achieve the interim goals. As previously mentioned, this insufficiency may not be known for nine years, and even then may be unclear due to statistical issues associated with monitoring pHOS (discussed in more detail below).

Fourth, in a given population, an appreciable portion of the natural-origin fish may have had hatchery-origin parents. Because there will be fewer of these as a result of pHOS reduction, the number of natural-origin fish in the population may decline, and this will have a pHOS increasing effect relative to the planned reduction. On the other hand, decreasing the density of spawners may obviate this effect. However important this effect is, it will not be apparent for another generation. Given the five-year implementation schedule, this effect may not be detectable in an index population until year 13, although if it is a widespread phenomenon it should be detected elsewhere starting in year nine.

Although the Proposed Action includes a number of substantive program reductions, it includes a large increase in the Bonneville program. The effect of this increase on pHOS in the Gorge MPG must be carefully monitored. The rationale for this increase was that pHOS in Gorge populations is declining due to recent changes in tule Chinook salmon hatchery releases including reductions at Spring Creek National Fish Hatchery and the discontinuation of a tule program in the Little White Salmon River, and is likely now considerably less than the 2010-2014 level. CAM modelling showed that based on what is currently known about dispersion of returning adults from the Bonneville tule program, even with this increase, pHOS in Gorge MPG populations will increase over current levels. However, this is a dynamic situation that must be monitored carefully.

The Proposed Action pHOS requirement for integrated programs affecting index populations is a maximum of 30%. This level is protective enough for recovery only if PNI is high, which requires a pNOB value to be twice that of pHOS for a primary population (HSRG 2009). Standards for pNOB are not explicitly included in the Proposed Action. Currently pNOB is not close to that level in any of the Mitchell Act tule programs. For the risk level to be acceptable in these integrated programs, PNI must show a steady increase to at least 67% by the end of the transition period.

During consultation, a funding grantee WDFW, highlighted an additional complexity in achieving the pHOS goals: measuring pHOS. pHOS estimates, like nearly all important parameters we attempt to measure in fishery science, will vary from year to year due to variation in natural processes and sampling/measurement error. For this reason, NMFS-stipulated values in permits and incidental take statements are typically stated as running means, usually over a time period based on the generation time of the species. WDFW pointed out during the consultation that pHOS averaged over a short time period can easily overestimate pHOS (WDFW 2016b), and NMFS agrees. WDFW's suggested solution is the use of critical values rather than running means. Developing a solution to this problem, be it critical values, running means, a combination of the two or another approach needs to be a high priority during implementation of the Proposed Action.

The conclusion that these changes will be difficult to measure and will take some time to realize is a cautious reflection on the consequences of the phasing period requirement, our limited precision in determining and quantifying the source of pHOS in a population, ambiguity about what to expect in the short term when pHOS is reduced, and monitoring complexity. The pHOS reductions, even to interim goals and even if they fall short of target for a few years during this transition period, will steadily reduce the level of risk of hatchery-induced selection from present levels to levels that will not limit the survival or recovery of LCR tule fall Chinook populations.

Two spring Chinook salmon programs are funded by the Mitchell Act in the LCR area. The first is the isolated Kalama spring Chinook salmon program. Spring Chinook pHOS is under 10% in the Kalama (WDFW 2014d). However, this is estimated from surveys above the weir at Kalama Falls Hatchery at RKM 16; pHOS is not monitored below the weir. While pHOS for the population is unclear, and needs to be monitored in the future, it is unlikely that it exceeds 50%, the recovery standard for a contributing population.

A more serious concern is straying of these fish to other populations. A recent WDFW review of CWT recoveries (Marston and Iverson 2012) indicate that while the fish stray at a rate of about 5%, which is not excessive, most of the strays are recovered on the spawning grounds in the Lewis River. Based on the WDFW review we estimate that for the 2004-2008 escapements, Kalama hatchery program strays comprised an average of 7% of the Lewis River spring Chinook escapement. Strays from all other populations combined should comprise less than 5% of spawners (see Section 2.2.1.2). While more recent data are needed, steps should be taken now to substantially reduce the fraction of Kalama hatchery spring Chinook salmon in the Lewis River escapement. The current risk is low because the Kalama and Lewis are neighboring populations and the Lewis program has been used within the last decade to backfill shortages at Kalama (a procedure which has been terminated), so the strays at Lewis have some Lewis ancestry. In addition, part of the problem may be the partial Lewis ancestry of the Kalama fish. If this is the case, cessation of backfilling from Lewis may correct the problem to some extent. At any rate, updating data and taking steps to reduce the Kalama contribution to the Lewis population are necessary.

The second LCR spring Chinook salmon hatchery program funded by the Mitchell Act is the Cathlamet Channel net-pen program. The program uses Cowlitz stock, which are from the Cascade spring Chinook salmon MPG, and releases them in Cathlamet Channel in the Coast region of the Lower Columbia, 14.5 RKM below the mouth of the Cowlitz River, which is the nearest watershed harboring a spring Chinook salmon population. The obvious genetic risk posed by the program is the possibility that fish will stray into spring Chinook populations other than the Cowlitz. The program is too young to have a CWT record for returns. Ideally, unharvested fish will return to the area of the net pens, where there are no natural spring Chinook populations with which they could interbreed. To this end, they undergo early rearing at nearby Grays River Hatchery, and acclimate in the net pens for six months before release (WDFW 2014a). The hope is that if they do move farther upstream to spawn, they will go to the Cowlitz, where they will have no impact, and not go to the Lewis or Sandy Rivers, both of which contain spring Chinook salmon populations. The Cathlamet program may need to be adjusted once CWT straying data are available, but at present there is no evidence that it presents a genetic risk to the LCR spring Chinook MPG.

UWR Chinook Salmon ESU

The Proposed Action includes no near-term changes for the Clackamas spring Chinook salmon program. This isolated program uses broodstock developed from Willamette returns beginning

40 years ago, but for many years has used only returns to the Clackamas as broodstock (ODFW 2016b). Overall, basin pHOS has been reduced considerably in the last 15 years. The most recent data (2015) indicate that although pHOS is about 30% in the lower basin, it is far less in the upper basin, where 90% of the preferred spawning grounds are, indicating that overall pHOS is under 10%.

LCR Coho Salmon ESU

As described for coho salmon programs in Table 1, the Proposed Action elements addressing LCR coho salmon were developed on a parallel path to those addressing LCR Chinook salmon, so much of the discussion above on LCR Chinook salmon also applies to coho salmon. There were three important differences between the species, however: the number of changes needed to match broodstocks within ESU or MPG, the overall pHOS level in the ESU, and the amount of information available for development of pHOS reduction measures.

Although only one Mitchell Act funded program, Deep River, had a broodstock change, from a Cascade MPG S-type stock to type-N Coast MPG stock via a new Elochoman program, changes were made at the interrelated and interdependent SAFE programs on the Oregon side of the Columbia, and as a result, going forward, only Coast MPG stocks will be released in the Coast MPG (WDFW and ODFW 2016).

For pHOS reduction measures, the same four steps used for LCR Chinook were used for LCR coho salmon, as much as possible:

1) Develop set of index populations on which to focus pHOS reductions
2) Establish pHOS requirements
3) Evaluate the relative role of different programs on pHOS in index populations
4) Adjust programs or otherwise control returnees from them to achieve pHOS requirements.

It is noteworthy that pHOS levels are lower, and natural production levels higher in the LCR Coho Salmon ESU than in the LCR Chinook Salmon ESU. There was no clear break between the pHOS situation in the Coast and Cascade MPGs Figure 30, as in LCR Chinook salmon. As a consequence, the pHOS standards of 10% for integrated programs and 30% for isolated programs were used in both the Coast and Cascade MPGs. Establishing the relative contributions of different hatchery programs proved more difficult than in LCR Chinook salmon because there were far fewer CWT recoveries available for analysis in coho salmon. A combination of approaches was used. Subbasin-specific program reductions were done in Washington tributaries where programs were sited (Grays, Deep R., North Fork Toutle, Kalama, and Washougal), extended weir operations were proposed in streams where early-returning (type-S) were a pHOS source (Elochoman, Skamokawa, and South Fork Toutle), and production will be shifted in the interrelated and interdependent SAFE programs based on available site-specific knowledge of straying behavior (WDFW and ODFW 2016). In addition the Bonneville program was reduced, which will likely reduce any straying from that program. Overall, after compilation of the site-specific measures to limit hatchery fish straying and pHOS, the result was a proposed 14% decrease in Mitchell Act funded coho salmon hatchery production below

Bonneville and a proposed 12% increase in Mitchell Act funded coho salmon production above Bonneville Dam. Details of the increase must be approved through the *U.S. v. Oregon* process.

pHOS objectives for LCR coho salmon index populations under the Proposed Action are presented in Table 92.

Table 92. Maximum coho salmon pHOS limits by ESA-listed natural population where hatchery coho salmon originating from Mitchell Act funded hatchery programs are known to stray. Limits are calculated on a three-year running average.

Population	***Coho salmon program type contributing to pHOS in population***	***pHOS limit***
Grays/Chinook Rivers	Integrated	30%
Elochoman/Skamokawa Rivers	Integrated	30%
Clatskanie River	Isolated	10%
Scappoose River	Isolated	10%
Lower Cowlitz River	Integrated late	30%
Coweeman River	Isolated	10%
South Fork Toutle	Isolated	10%
North Fork Toutle	Integrated late	30%
East Fork Lewis	Isolated	10%
Washougal River	Integrated late	30%
Clackamas River	Isolated late	10%

The risks in deferring immediate action are basically the same as were outlined for LCR Chinook salmon, however it is important to point out that the risks are lower because the pHOS levels are generally lower and the population status is better for LCR coho salmon. Because NMFS can assess annually, whether to continue to fund these programs based on their performance, the pHOS requirements are likely to be met.

Further adjustments may have to be made to programs and weir operations during the transition. A robust monitoring plan is critical, including a greater emphasis on building the CWT database for LCR coho salmon.

CR Chum Salmon ESU

The Big Creek chum salmon hatchery program is designed and operated to serve a conservation purpose, using broodstock from the Grays River population and fish that are now returning to the Big Creek. This is a recolonization program, meaning there are currently no CR Chum occupying this habitat, and at this stage, demographic concerns outweigh any risk posed by hatchery-induced selection, so no pHOS/PNI standards are being applied at this time. However, to continue to be consistent with recovery the program should in time develop a local stock, and move to PNI-based management.

LCR Steelhead DPS

Through the Mitchell Act, NMFS funds several steelhead programs in the LCR (Table 1), an important change in hatchery practices that will benefit steelhead recovery is elimination of the Chambers Creek early winter steelhead (EWS) stock from the LCR region. The Mitchell Act will no longer fund these hatchery programs. This stock, which originated in Puget Sound and has been selectively bred to have a distinct non-natural life history (Crawford 1979) has been released for many decades at several locations in the LCR. From an overall diversity perspective, eliminating Chambers Creek releases undoubtedly reduces risk. Steelhead from Puget Sound differ from those in the Columbia Basin at allele frequencies at marker loci, and there is evidence that the release of Chambers Creek fish has influenced patterns of genetic diversity in the LCR (Phelps et al. 1994). In addition, there is evidence that Puget Sound and Columbia steelhead differ in chromosome number (Thorgaard 1983; Ostberg and Thorgaard 1999).

Chambers Creek winter steelhead and their summer steelhead analog, the Skamania stock have long been used in a particular style of management in which the intent is to have hatchery fish available for harvest that genetically interfere only minimally with wild fish due to having their spawn timing advanced during years of hatchery culture. This style of management, based on making hatchery fish genetically different from the wild fish in the streams in which they are planted, in is in sharp contrast to the emerging prevailing model for salmon hatcheries of attempting to minimize genetic differences between wild and hatchery fish. Although theoretical work continues on the relative value of the two approaches (Baskett and Waples 2013), concerns have been repeatedly voiced about the risk of the “maximize differences” approach (reviewed in NMFS 2015a; NMFS 2016g; 2016k).

The Proposed Action includes a plan to switch from the Chambers Creek stock to a new EWS stock (hereafter called KEWS) to be developed from early returning adults from the Kalama integrated steelhead program. The intent is to substitute a LCR stock for the Chambers stock that still has earlier return and spawn timing than native fish and that smolts primarily at one year of age rather than at two or more. The last releases of Chambers stock winter steelhead will be in 2017. The expectation is that transition to the new stock will be completed within 12 years. Transition to the KEWS stock will be immediate in the Klineline Ponds (Salmon Cr.) program, and in the Kalama R. EWS program. In three other programs- Coweeman R., Washougal R., and Rock Cr., the transition will be in two steps, first to the Eagle Cr. (Clackamas) stock, and then to the KEWS stock.

There are three aspects of this plan that merit detailed discussion: 1) risks involved in using the transitional stock, 3) risks to other natural populations from using the KEWS stock, and 4) monitoring genetic metrics in these programs once they use KEWS stock. This list also includes discussion of impacts from the Skamania summer steelhead hatchery programs.

- Use of the transitional stock. An immediate switch to Eagle Creek returnees will slow any ongoing erosion of between-DPS diversity that the Chambers Creek stock was causing, as well as stopping any ongoing accumulation of outbreeding depression effects, however, the Eagle Cr. fish are of Big Creek stock, which originated in the LCR, but in the Southwest Washington DPS. This course of action will discontinue the Puget Sound-origin Chambers Creek stock and still keep programs going while a local equivalent is being developed. Given the long history of Chambers Creek releases in the area, we view the limited-time use of the Eagle Cr. fish as a low-risk substantial improvement over baseline conditions.
- Risks to populations from using the KEWS stock. During development, the KEWS stock is expected to diverge considerably from the Kalama population (as well as the populations in other streams where it will be released). A 2% gene flow limitation will be required for primary populations into which the stock is released. Use of the KEWS stock in multiple populations imposes an among-population diversity impact just as use of the Chambers Creek stock did: to the extent gene flow does occur and is not balanced by genetic drift, populations, diversity among populations receiving gene flow from the KEWS stock will be decreased. The same situation holds for the continuing Skamania summer steelhead programs funded by the Mitchell Act. Given the overall downsizing of steelhead hatchery efforts in the LCR, including the creation of new genetic reserve streams that receive no hatchery releases, it is NMFS' opinion that the release of fish from a single hatchery stock into multiple populations in the LCR does not pose a significant risk to the survival or recovery of the LCR steelhead DPS.
- WDFW bases estimates of gene flow on either a demographic method using estimates of pHOS, spawning overlap, and relative reproductive success; a direct genetic method; or both (detailed in NMFS 2016h; 2016g). The demographic method requires estimates of pHOS, spawning overlap, and relative reproductive success of hatchery-origin and natural-origin fish. The direct genetic method, based on divergence at marker gene loci between the hatchery stocks and natural populations, has thus far only been applied to Chambers Creek and Skamania stock impacts to Puget Sound steelhead populations. The current genetic method may be usable in the LCR DPS for evaluation of summer steelhead impacts, but may not work on the KEWS stock in the short term due to the low level of divergence between the KEWS and recipient populations. Another approach based on parental genotyping may be necessary. Alternatively, the demographic approach will require estimates of the factors listed above, which are difficult to monitor. If the demographic approach is to be explored, the spawn timing and RRS of the KEWS must be carefully monitored as the stock is developed. Whatever approach or combination of approaches is taken must be adequate to ensure pHOS/gene flow standards are being met. Development of a genetic monitoring plan for the Mitchell Act funded isolated steelhead programs is a high short-term priority. WDFW already has a genetic monitoring plan under development for LCR steelhead (WDFW 2015a).

Currently the Mitchell Act funds two steelhead hatchery programs in the Clackamas River[38], a winter program and a summer program. The Clackamas wild winter steelhead program

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[38] The Clackamas River steelhead population is currently part of the LCR steelhead DPS, but a review of genetic data done as part of a five-year status update (NWFSC 2015) indicate, pending further data collection and analysis, that perhaps it should be part of the Upper Willamette River DPS (NMFS 2016a).

originated using native broodstock and was well integrated through broodyear 2012 with a pNOB of 20% and a maximum pHOS of 7% (ODFW 2016c), for a PNI value of above 67%. Under the Proposed Action the program would begin incorporating NOR adults into the broodstock beginning with broodyear 2017. Thus, this program would meet gene-flow standards for recovery for a primary population.

Currently the level of gene flow from summer steelhead into the Clackamas winter steelhead population is not known. However, for a variety of reasons, we expect that it is low: the Skamania stock for the most part spawns earlier than the native winter steelhead, the stock is known to have poor reproductive success, and in the Clackamas River, where pHOS due to summer steelhead would be expected to be highest, overall pHOS (summer+winter combined) is only 7%. Gene flow from summer steelhead could easily be under 2%, but this needs to be verified, given that this is a life-history that does not naturally occur in the Clackamas River. So at this point, the Clackamas summer steelhead program does not appear to pose a substantial risk to survival or recovery of either the LCR or UWR steelhead DPSs, but this position must be reconsidered in the light of new data within five years.

Gene flow/pHOS objectives for steelhead populations into which steelhead from Mitchell Act funded steelhead programs may stray are presented in Table 1Table 93. Because NMFS can assess annually, whether to continue to fund these programs based on their performance, the gene flow/pHOS requirements are likely to be met.

Table 93. Maximum steelhead gene flow and pHOS limits by ESA-listed natural population where hatchery steelhead originating from Mitchell Act funded hatchery programs are known to stray. Limits are calculated on a three-year running average.

Population	***Program type contributing to genetic effects in population***	***Gene flow limit***	***Census pHOS limit***
Coweeman	Isolated	≤2.0%	≤5.0%
SF Toutle	Isolated	≤2.0%	≤5.0%
Kalama	Isolated/integrated	≤2.0%*	≤5.0%**
Salmon Cr	Isolated	≤2.0%	≤5.0%
Clackamas	Integrated winter; isolated summer	N/A	Winter: ≤10.0%; Summer: ≤5.0%
Washougal	Isolated	≤2.0%	≤5.0%
Upper Gorge	Isolated	≤2.0%	≤5.0%
Klickitat (S/W)	Isolated	N/A	≤5.0%
All UCR Pops (Wenatchee, Methow, Entiat, Okanogan)	Isolated	N/A	≤5.0%

MCR Steelhead DPS

The Proposed Action includes no near-term changes to the *U.S. v. Oregon* Klickitat isolated summer steelhead hatchery program, which releases Skamania stock fish. The Skamania stock was developed at the Skamania hatchery on the Washougal River, within the LCR Steelhead DPS, from a mixture of summer steelhead from the Klickitat and Washougal Rivers (Crawford 1979). So although in the case of this program the Skamania stock is not a perfect match in terms of diversity to the population in which it is released, which is part of the Middle Columbia River Steelhead DPS, it shares ancestry. Long-term planning by the Yakama Nation and WDFW, the program operators, involves transitioning to a local stock, integrated program once funds are available for the necessary infrastructure (WDFW 2011). No pHOS data are available, but a detailed analysis (Narum et al. 2006) of genetic structure of steelhead in the Klickitat Basin, including assessment of impacts from Skamania releases, was recently done. The study revealed considerable structure within the basin, and substantive differentiation between the Klickitat and Skamania steelhead. Use of the Structure program (Pritchard et al. 2000) resulted in only 4% of the fish sampled being classified as Skamania stock. This indicates a low level of natural production coming from Skamnia hatchery fish spawning in the wild, and thus a low genetic impact. Preliminary results from radio-telemetry studies (Zendt et al. 2016) suggest that there is temporal separation between the spawning of Skamania steelhead and NOR Klickitat steelhead. The majority of (75%) of the hatchery steelhead spawned from mid-November to Mid-March and 85% of the NOR steelhead spawned from mid-March to mid-May. The radio-telemetry also suggested some spatial separation in spawning locations with 90% of the known-fate hatchery steelhead spawned below RM 20 and 64% of the NOR steelhead spawned from RM 20 upstream (Zendt et al. 2016). Although estimating pHOS needs to be a priority for this program, as in all Mitchell Act funded isolated steelhead programs, data available to date suggests that gene flow from the Skamania stock is low, and unlikely to significantly affect the survival or recovery of the Klickitat steelhead population or the MCR Steelhead DPS, provided pHOS/gene flow from the program remains within the limits in Table 93.

UCR Steelhead

Only one steelhead hatchery program funded by the Mitchell Act has a possibility of genetically impacting UCR: the program at Ringold Springs. Although no data are available showing that fish from this program spawn in any of the four UCR watersheds that harbor ESA-listed steelhead populations (Entiat, Methow, Wenatchee, Okanogan), radio telemetry data show that returning steelhead from the program do move upstream beyond Ringold Springs (WDFW 2016a), so genetic interactions with steelhead populations in this DPS are a possibility. However, we consider the possibility small due to the large distance between Ringold Springs and any of those other watersheds, and the fact that the fish are distinctly marked (both the right ventral and adipose fins are clipped) so that those travel upstream that are not harvested can be readily identified and removed at upstream dam and hatchery traps. Thus, we consider gene flow between fish released at Ringold Springs and natural UCR steelhead populations as a low risk to their diversity and productivity.

2.4.2.2.3 Analysis of Encounters at Adult Collection Facilities

NMFS (2017) lists all of the respective hatchery programs and the estimated maximum number of natural-origin adults that could be handled during broodstock collection activities funded as part of the Proposed Action. NMFS (2017) also describes in detail the recent annual collections of ESA-listed salmon and steelhead species and their potential effects on ESA-listed species. The effects under this aspect of factor 2 vary from hatchery to hatchery. Many hatchery facilities have river spanning weirs or barriers that direct all hatchery and natural-origin fish into the hatchery. Some facilities rely on hatchery fish volunteering into the hatchery to obtain broodstock. Natural-origin fish may also volunteer into the hatchery where they are sorted, and either retained for broodstock or released. The number of natural-origin adults handled at the hatchery facilities funded under the Proposed Action varies depending on (a) the location of the hatchery (low vs. higher in any specific basin), (b) if a weir or barrier is included, (c) the species reared, and (d) distance from the mainstem Columbia River. This latter factor can affect how many fish from upper Columbia River populations could be encountered.

Table 94 presents the expected maximum number of ESA-listed salmon and steelhead that could be encountered at the hatchery facilities during broodstock collection. The expected number of encounters varies greatly from facility to facility, again, as described above.

NMFS (2017) shows that the expected maximum number encountered substantially exceeds what has actually been observed at the hatchery facilities. For example, at Bonneville Hatchery, estimates are that up to 1,400 NOR coho salmon could be encountered during broodstock collection, considerably greater than the estimated 289 NOR coho salmon that were encountered in 2015. The Bonneville data illustrate the variability in the NOR returns, which have ranged from 289 in 2015 to 1,384 in 2011. It should also be noted that a proportion of these NOR coho salmon, those identified by an intact adipose fin, may actually be hatchery coho salmon that were not accurately clipped. Thus, the actual number NOR salmon and steelhead encountered may be less than reported.

As described in Section 2.4.1.2, the handling of natural-origin fish at these broodstock collection facilities would be expected to increase the potential for injury and stress due to delay, crowding in the trap, sorting (including netting, handling, anethsitizing), and from transport and release. The incidental mortality associated with handling may occur immediately due to injury or may be delayed due to increased stress. Best management practices are used at these facilities to reduce the potential for injury or stress of NOR salmon and steelhead. These include but are not limited to monitoring adult holding ponds to prevent overcrowding; processing returning adults frequently to remove NOR adults and limit the delay in upstream migration; maintaining adequate flows in the holding ponds to reduce stress; and maintaining adequate processing facilities that minimize stress during anesthesia, sorting, and transport. All of these actions will help ensure that the take of NOR adult salmon and steelhead is not a concern.

Table 94. Expected maximum number of ESA-listed salmon and steelhead that could be encountered at hatchery facilities located within specific watersheds (data from NMFS (2017)).

Watershed	**Hatchery Facility**	**ESU/DPS from which fish are expected to be collected.**	**Expected maximum number that could be encountered**	**Comment**
Mainstem Columbia River	Bonneville Hatchery	LCR Fall Chinook Salmon	1,600	
		LCR Coho Salmon	1,400	
		Snake River Fall Chinook	650	Unmarked URB fall Chinook salmon could be from other non-listed populations or hatchery programs.
		CR Chum Salmon	50	
		LCR, MCR, UCR, and SR steelhead	110	Could be from any these DPSs due to the proximity of the hatchery to the mainstem Columbia River
		SR Sockeye Salmon	<10	Sockeye could be from SR or from unlisted sockeye salmon populations
	Ringold Springs	UCR Steelhead	50	Handled during recycling activities.
Big Creek	Big Creek Hatchery	LCR Fall Chinook Salmon	200	
		LCR Coho Salmon	700	Passed above the hatchery.
		CR Chum Salmon	200	Some will be used as broodstock.
Youngs Bay	Klaskanine Hatchery and SF Clatsop Co. Fisheries Hatchery	LCR Fall Chinook Salmon	20	No unmarked fall Chinook salmon have been encountered.
		LCR Coho Salmon	120	Released above the hatchery.
		CR Chum Salmon	10	
Clackamas River	Clackamas Hatchery	LCR Steelhead	50	Expected to increase when new intake becomes operational. May be used for broodstock.
		UWR Spring Chinook Salmon	350	Expected to increase when new intake becomes operational.

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Comment
North Fork Toutle River	North Fork Toutle Hatchery	LCR Fall Chinook Salmon	2,000	Proportion may be used for broodstock
		LCR Coho Salmon	10,000	Proportion may be used for broodstock
		LCR Steelhead	0	No native summer steelhead population
		CR Chum Salmon	10	
Grays River	Grays River Hatchery	LCR Fall Chinook Salmon	25	
		LCR Coho Salmon	150	Proportion may be used for broodstock
		CR Chum Salmon	50	Proportion may be used for broodstock
Elochoman River	Beaver Creek	LCR Fall Chinook Salmon	20	
		LCR Coho Salmon	20	
		CR Chum Salmon	20	
Kalama River	Kalama Falls Hatchery and Fallert Creek Hatchery	LCR Fall Chinook Salmon	6,000	
		LCR Spring Chinook Salmon	500	
		LCR Coho Salmon	3,000	Proportion may be used for broodstock
		LCR Steelhead (summer)	1,000	Proportion may be used for broodstock
		LCR Steelhead (winter)	2,400	Proportion may be used for broodstock
		CR Chum Salmon	25	
Washougal River	Washougal Hatchery	LCR Fall Chinook Salmon	3,000	Proportion may be used for broodstock
		LCR Coho Salmon	1,000	
		CR Chum Salmon	25	
	Skamania Hatchery	LCR Steelhead (summer)	200	
		LCR Steelhead (winter)	200	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Comment
Klickitat River	Klickitat Hatchery	MCR Steelhead	10	

These encounters are maximum levels of expected handling. Mortality is expected to be incidental and may vary from passing fish upstream or to the release location, as some natural-origin fish are truck upstream to continue migration. Incidental handling is expected to result in mortality rates of less than 3% at most for any individual hatchery. The effects are low negative individually. See Table 121 and Table 122 in Section 2.8 for expected mortality. NMFS expects the rates of mortality due to handling to remain the same or perhaps decrease as handling methods improve. However, conditions can vary from year to year. Programs could see up to a five percent increase in mortality over average rates in a single year due to factors beyond the control of the operator. Any one-time increase that is larger than five percent more than average rates would indicate that the mortality effects of handling are greater than previously thought.

2.4.2.2.4 Weirs

Adult collection facilities can also include weirs that are not directly adjacent to hatchery facilities. WDFW proposes to operate 12 weirs to collect broodstock, monitor NOR adult escapement, and to manage hatchery adult escapement (i.e.; remove hatchery strays). Included in these 12 weirs are seven existing weirs and five new weirs targeted for installation and operation, some beginning in 2017 (NMFS 2017).

These weirs are a mix of types depending on the location and how long they been operational. Some existing weirs have a permanent concrete sill that the weir is attached to (e.g., Elochoman) but the new weirs that are proposed, and most of those currently operated, are resistance board weirs that are installed and operated for temporary or seasonal use – they are installed before the fish return from the ocean and they are removed when the run ends. These river-spanning weirs generally consist of floating resistance board Sections, a live trap box or boxes, and fixed panel sections (WDFW 2014b). The resistance board sections are attached to the bottom of the river to a seal plate, usually a long metal angle iron that is anchored to substrate.

The anchoring of the weirs to the substrate can shift bottom sediments at the point of attachment and the “footprint’ where the weir rests on the river bottom, since it would preclude within that footprint natural movement of sediment from river flow. However, this effect is confined to the specific location of the weir, and upon removal, sediment will again shift with the water movement. The weirs are in fact located within a stream to maximize the collection of adult fish while minimizing the disturbance to the substrate. The majority of these weirs are located in lower river sections where the substrate is primarily gravel and cobble which allows for the weirs to be installed without intrusive machinery. Furthermore, after the weir is removed, the first major freshet would obscure any evidence of the weir installation in terms of disturbed substrate.

Impacts to the substrate associated with weir placement, presence, and removal are considered minimal in their physical and temporal extent. Because any disturbances are limited to the immediate area of the weir and are brief, these effects are insignificant to the physical and biological features of critical habitat, and to individual fish that are present in these areas.

With regard to the effects of weir operation, the timing of weir operation depends on the species being targeted for removal and monitoring. For fall Chinook salmon the weirs are generally operated from August to October, whereas for coho salmon operation would extend into November. The goal of the weirs is to maximize the number of hatchery adults collected, which means that up to -100% of the co-occurring natural-origin fish may encounter the weir. Interception of the entire run is rarely achieved, however, due to high water events that reduce the effectiveness of the weir or lead to the trap being removed earlier than planned. In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Proposed Action, to submit detailed updated FMEPs evaluating fishery effects on each LCR Chinook salmon natural population for ESA authorization.

As described in Section 2.4.1.2 the operation of weirs and assoicated traps can impact ESA-listed salmon and steelhead through a number of factors, but can be reduced to three main factors: weir rejection, migration delay, and delayed mortality after release due to collection and handling at the weir (this is in addition to the incidental mortality that is identified in Table 95 and Section 2.4.1.2.

To analyze the effects on ESA-listed species, NMFS must consider the high level of variability in the natural environment in the rivers and locations for each weir, as they range from tributaries near the mouth of the Columbia River upstream to tributaries near Bonneville Dam. Furthermore, even excluding the effects of these types of local environmental conditions coupled with weather events, there is natural variability due to the factors outside each location that affect the survival and productivity of the natural-origin populations. These outside factors affect smolt-to-adult survival as illustrated by the variations in survival manifested in changes in the abundance of natural-origin adults returning as seen across the years in Section 2.2.1 for each ESU or DPS. Variability is also seen in things like spawning distribution (Schroeder et al. 2013; Whitman et al. 2014), time of first spawning and peak spawning (Whitman et al. 2014) for any run of salmon or steelhead. Determining impacts on listed species from the operation of the weirs versus changes due to natural variation has been estimated by comparing things such as redd distribution, peak spawning date, and pre-spawning mortality before and after the operation of the weirs.

The Proposed Action has been funding the operation of weirs for a number of years in the LCR including the Grays, Elochoman, Coweeman, Sandy, and Washougal rivers (NMFS 2011h). Impacts on listed species from the operation of the weirs, as indicated above, would be expected when changes in redd distribution, time of peak spawning, and an increase in pre-spawning mortality are substantially outside the ranges observed prior to the installation of the weirs. The pre-weir ranges for these measurements would be expected to represent range if natural environmental effects on the populations and not those associated with the weir operations. If the observed changes in redd distribution below the weir increases by more than 10% outside the pre-weir range this would indicate that the operation of the weir is having an adverse effect on the natural-origin population. Additionally, an increase in delayed mortality by more than 5%, and a change in the peak migration timing, would also indicate that the weir is having an adverse impact beyond our expectations. Evaluations of weir effects has shown that the installation and operation of the weirs has not noticablely lead to changes in spawning distribution (indicating weir rejection); time of peak spwaning (indicating delayed migration); and increased pre-spawning mortality (indicating increased mortality due to handling for those populations affected (NMFS 2014e).

NMFS expects this experience and results to be replicated at each additional site, given they all exist in a similar geographic area, while trapping operations occur during the same season, and in watersheds with similar hydrologic profiles.

To minimize the effects of weir operation, best management practices include, but are not limited to:

- Checking the trap daily, at a minimum. When fish passage is heavy the trap may be checked multiple times daily.
- Monitoring recruitment of fish into the trap box to inform modifications in protocol necessary to minimize passage delays of NOR fish and maximize collection of hatchery fish.
- Paying close attention to the recruitment of fish into the adult trap and the accumulation of fish below the trap. If fish are not adequately moving into the trap, modifications will first be made to adjust flow and/or trap box configuration and try to increase trapping efficiency. If this does not encourage fish to move into the live box, a beach seine may be used to either capture fish or crowd them into the live box or an area where they can be safely processed.
- Modifying schedules or protocols if there is over-crowding in the trap or if fish numbers are building-up downstream of the trap and migration may be delayed. Modification of sampling schedule or trapping protocols will consider both the benefits of improved passage and the adverse impact on pHOS. This can be accomplished by opening the upstream gate on the trap or removing (or submerging) a section of the weir.
- Monitoring of recruitment into the trap and the abundance of adult fish below the weirs that move into the trap may indicate that an alternative location for weir placement would be appropriate to minimize delay and weir rejection.

Table 95 lists the estimated number of natural-origin adult and jack salmon and steelhead that would be authorized to be handled annually at each of the weirs. Under these handling allowances, each weir can be operated to meets its goals of collecting broodstock, monitoring escapement, and removing hatchery strays even if the returns are greater than expected or the weir is more efficient in a particular year. This will prevent the weir from being removed before all of the hatchery fish have returned.

The estimated direct handling mortality of 3% is based on past handling experience, but actual mortality rates are expected to be less, due to the best management actions for handling fish described above, and the experience of the technicians operating the weirs. The loss of up to 3% of the adults handled would have only a minor effect on the abundance of the natural-origin populations. New information on the status of natural populations gained by operation of the weirs and the reduction in hatchery strays will be beneficial and perhaps, at least partially, offset handling mortality.

Table 95. Operational and proposed weirs to be operated by WDFW for the collection of broodstock, RM&E, and for removal of hatchery strays, the maximum number of natural-origin adults and jacks of each species expected to be encountered at the weirs, and the estimated mortalities (assumes a 3% direct handling mortality). MA denotes weirs currently funded by Mitchell Act.

Watershed	Status	Species encountered	Number encountered	Estimated mortalities
Grays (MA)	In place, not currently operated, but would be restarted	Fall Chinook	750	<23
		Coho Salmon	800	<24
		Chum Salmon	8,500	<225
Skamokawa	New	Fall Chinook	200	<6
		Coho Salmon	1,425	<43
		Chum Salmon	500	<15
Elochoman (MA)	In place (to be expanded)	Fall Chinook	750	<23
		Coho Salmon	800	<24
		Chum Salmon	1,000	<30
Mill Abernathy Germany	New	Fall Chinook	210	<6
		Coho Salmon	1,125	<34
		Chum Salmon	250	<8
South Fork Toutle	New	Fall Chinook	350	<11
		Coho Salmon	5,500	<165
		Chum Salmon	250	<8
		Summer Steelhead	50	<2
Coweeman (MA)	In place	Fall Chinook	1,600	<48
		Coho Salmon	800	<24
		Chum Salmon	100	<3
		Winter Steelhead	300	<9
Cedar Creek	In place (to be expanded)	Fall Chinook	400	<12
		Coho Salmon	1,000	<30
		Chum Salmon	250	<8
		Summer Steelhead	50	<2
Washougal (MA)	In place	Fall Chinook	1,200	<36
		Coho Salmon	80	<3
		Chum Salmon	250	<8

		Summer Steelhead	100	<3
Kalama (MA)	In place	Fall Chinook	3,200	<96
		Coho Salmon	150	<5
		Chum Salmon	250	<8
		Summer Steelhead	200	<6
NF Toutle (MA)	In place	Fall Chinook	700	<21
		Coho Salmon	2300	<70
		Chum Salmon	250	<8
		Summer Steelhead	50	<2

2.4.2.3 Factors 3 and 4. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary and ocean

NMFS has determined no effects to SRKW here, as these effects occur in areas where SRKW do not occur, other than the ocean, and effects to the SRKW that may occur in the ocean are analyzed separately in Section 2.4.2.8. Here we focus on effects as identified in Table 90 between both of these factors to ESA-listed anadromous fish species, eulachon and salmonids, as described in Table 9, occurring in the Columbia River.

2.4.2.3.1 Ecological Effects on the Pacific Eulachon Southern DPS

Competition and Predation

The run timing for adult eulachon and hatchery spring Chinook salmon and winter and summer steelhead may overlap in the migratory corridor from December to June (Table 101) (NMFS 2014b), but they do not share the same natal steams. Streams that support eulachon are below Bonneville Dam and most spring Chinook salmon and summer steelhead return to areas above Bonneville Dam. Thus, there is likely to be limited overlap in habitat use between spring Chinook salmon, summer steelhead and eulachon. Overlap between winter steelhead and eulachon during spawning is much more likely because both occupy LCR tributaries and run and spawn at the same time of year. However, adult eulachon are about one sixth the size of adult steelhead (20 cm versus 120 cm), and thus are unlikely to use the same types of microhabitats.

Juvenile eulachon may overlap with juvenile salmon and steelhead in the LCR and estuary as they migrate to the ocean in the spring. Competition with salmon and steelhead is unlikely, because eulachon emigrate soon after hatching at about 4-8 mm (NMFS 2014b), a tenth the size of outmigrating salmon and steelhead. The small size of eulachon does make them susceptible to predation by outmigrating salmon and steelhead, but the information on diet composition (Section 2.2.1.1), suggests that eulachon are not found in the stomachs of salmon and steelhead in the Columbia River below Bonneville Dam.

Disease

The draft recovery plan outline for eulachon (NMFS 2016f) assess disease effects on eulachon in the Columbia River and ranks it as the 11th threat out of 16. The Biological Review Team found very little information relative to impacts of diseases on eulachon. Viral hemorrhagic septicemia virus (VHSV) was identified from eulachon, but the impact of this virus on eulachon is difficult to assess. This virus has been isolated from a wide range of marine fish hosts and given the right conditions may result in disease, but what the conditions are that cause an infection to result in disease is unknown (NMFS 2016f). The risk of VHSV being transmitted from hatchery salmon and steelhead to eulachon is negligible, because VHSV has not been detected in salmon and steelhead sampled in the Columbia River migratory corridor or the estuary, despite the use of sensitive detection techniques (i.e., PCR; Arkoosh et al. (2004); Van Gaest et al. (2011)).

2.4.2.3.2 Ecological Effects on Salmon and Steelhead

Our analysis of factors 3 and 4 uses a model based on the PCDRisk ecological interactions model developed by Pearsons and Busack (2012). This model is used to estimate the amount of predation by and direct (contest) competition with released hatchery fish on natural-origin salmon and steelhead to the mouth of the Columbia River. It does not estimate interactions among natural fish or among hatchery fish, although both interaction scenarios are likely to occur. While this model provides some quantitative estimates of ecological interactions, the estimates are derived from parameters based on best available qualitative judgment. Therefore, the most appropriate way to think of these estimates is as a relative measure of the species most likely to be adversely affected by the release of hatchery fish from Mitchell Act Programs.

We will also discuss other aspects of salmon and steelhead biology that influence ecological interactions based on current scientific literature that were not considered in the model or require more elaboration. These are: 1) residence time, primarily in the estuary; 2) the amount of spatial and temporal overlap of hatchery and natural salmon and steelhead; 3) diet composition; 4) indirect competition/density dependence; 4) disease; and 5) predator attraction. All of these aspects must be considered when assessing the effects of hatchery fish on natural populations of salmon and steelhead, and assist in understanding the uncertainty in our modeled estimates of direct competition and predation.

Predation and Competition Model

Recently, a multiagency technical team completed a large-scale effort (Mackey et al. 2014) to model the ecological impacts (predation, disease, competition) of all Upper Columbia salmon and steelhead hatchery programs on various non-target taxa of concern (NTTOC) using the PCD Risk model (Busack et al. 2005; Pearsons and Busack 2012). PCD Risk is an individual-based model that simulates predation and competition impacts on naturally produced salmonids caused by hatchery smolts in fresh water as they move downstream. Because of a lack of key input data such as natural-origin fish population size, we are not able to use the model in its entirety to assess ecological impacts quantitatively here. However, in consultation with Todd Pearsons of the Grant PUD, Craig Busack of NMFS developed predation and competition indices that are intended to give some sense of the probability of either a predation or competition (direct or contest as opposed to indirect or scramble) event based on the relative sizes of randomly drawn pairs of interacting fish.

Using the means and standard deviations of hatchery and natural-origin fish from various reports (NMFS 2016b), distributions of 10,000 hatchery-origin and 10,000 natural-origin fish were generated. Hatchery-origin fish distributions were truncated by habitat segregation. Then, 10,000 random draws of pairs of hatchery and natural-origin fish were performed. For the predation index, a pairing could result in predation if a natural-origin fish was 50% or less the length of a hatchery-origin fish (Pearsons and Busack 2012). Recent work conducted by Daly et al. (2009) demonstrated that Chinook and coho salmon consumed prey about 25% of predator body length or less. Thus, we used this value in the model as well. The index was the proportion of draws in which predation was possible. For the competition index, the proportional difference in size between hatchery-origin and natural-origin fish was assigned a probability of dominance, and the average dominance probability was calculated over all 10,000 pairs.

In addition, a competition decrement (amount of weight loss from a competitive encounter) was calculated for each of the simulated 10,000 natural-origin fish (Busack et al. 2005; Pearsons and Busack 2012). To do this, fish length was converted to weight using the bioenergetics equations in the PCD Risk model, with an assumed temperature of 10°C for the Columbia Basin. The calculation assumes that a fish will die if it loses 50% of its weight, and that a dominated fish will not eat for the rest of the day. The probability of a competitive encounter resulting in weight loss is estimated at 5%. Computation of the indices and competition decrement was done using an R script written by Busack (2014). Also, because of the similarity in the size of hatchery fish at release, indices were not calculated for each program, but by species and size of fish at release (NMFS 2016b).

To calculate the number of possible interactions hatchery fish from a particular program with natural-origin fish we used the following equation:

*Interactions = survival of hatchery fish * migration time*(1- habitat segregation)*release number*

We used the NTTOC database inputs values for habitat segregation, the proportion of hatchery-origin fish that occupy different habitats than natural-origin fish due to size, based on species. Data were unavailable for fall chum salmon as the development of the model did not originally include this species. Therefore, we used the smallest value for this parameter as a conservative estimate (NMFS 2016b).

After determining the possible number of interactions, we then had to calculate the number of natural-origin fish that could be preyed upon or competed with to the point of death. To calculate the number preyed on by fish released from each program, we used the following equation:

*Number eaten = possible interactions*predation index*piscivory rate*

The piscivory rate was determined using values in the NTTOC database for each hatchery species (HETT 2014). Again, because no values were available for chum salmon, we used the values for fall Chinook salmon because of the similarity in size at release to chum salmon. The number of natural-origin fish competed with to death by each program was calculated using the following equation:

*Number lost to competition = possible interactions*competition index*competition decrement*0.05 (probability of weight loss).*

Survival of hatchery-origin fish was based on the number of dams they had to travel through to reach the mouth of the Columbia River. NMFS (2016e) calculated about an 80% survival of hatchery-origin fish due to natural causes and about 90% survival of hatchery-origin fish after passage through each dam. For example, hatchery-origin fish released above Bonneville Dam would have an overall survival of 72% after passage through one dam. Fish released above Lower Granite (8 dams) and Priest Rapids (5 dams) would have an estimated survival of 34 and 47%, respectively. Table 1 in Morris et al. (2015) found that survival in 2014 and 2015 from Lower Granite to Bonneville ranged from 55 to 76% in 2014 and 37 to 44% in 2015 for yearling Chinook salmon, sockeye salmon and steelhead. For UCR stocks, survival ranged from 57 to 97% in 2014 and 45 to 82% in 2015 (Morris et al. 2015; Table 1). Thus, the survival estimates of hatchery-origin juveniles we used in this analysis are in accordance with other sources.

Knowledge of the migration time of juvenile hatchery fish through the Columbia Basin is possible based on PIT tag detections. However, very few hatchery programs below dams PIT tag fish because detection sites are largely located in conjunction with dams. Thus, program specific migration times were not obtainable, but we were able to identify a program for each species that could be used as a surrogate to calculate migration rates (Table 96). The one exception is chum salmon, and for this species we used fall Chinook salmon migration times because they are the most similar in size at release. Travel time and residence time are difficult to separate; more discussion on this topic follows below in the section on travel/residence time.

Table 96. Travel time of released hatchery smolts to Bonneville Dam. Based on data from 2013-2015 (PTAGIS 2016)*.

Species	**Program**	**Median Time to Bonneville Dam from Release (days)**	**Distance to Bonneville Dam from Release (RM)**	**Migration Rate (RM/day)**
Spring Chinook salmon	Klickitat	28	223	8
Fall Chinook salmon	Snake River	22	235	10.6
Coho salmon	Twisp-mid Columbia Coho Restoration program	25	422	16.9
Steelhead	Wenatchee	23	336	14.6

* Date accessed: July 26, 2016

Model Results

Table 97. The maximum potential number or percentage of natural-origin salmon and steelhead taken due to predation and direct (contest) competition with hatchery-origin fish released as part of this Proposed Action under current conditions, and predation occurring when prey are < 0.5 predator length (NMFS 2016d).

Species	Life Stage	Number		Number natural-origin in estuary-MA FEIS	Total Percentage
		Predation	Competition		
Chinook salmon	Subyearling	378,997	260,074	13,698,933	5.2
	Yearling	9,222	62,787		
Coho salmon	Subyearling	29,470	21,907	944,363	9.1
	Yearling	0	34,343		
Steelhead	Parr	2	2,296	1,370,738	0.6
	Smolt	0	5,624		
Fall chum salmon	Subyearling	606,156	91,637	4,922,680	14.2
Sockeye salmon	Age-1	31,141	353,246	353,246	14.1
	Age-2	11,415	353,246		

Table 98. The maximum potential number or percentage of natural-origin salmon and steelhead taken due to predation and direct competition with hatchery-origin fish released as part of this Proposed Action under current conditions, and predation occurring when prey are < 0.25 predator length (NMFS 2016c).

Species	Life Stage	Number		Number natural-origin in estuary-MA FEIS	Total Percentage
		Predation	Competition		
Chinook salmon	Subyearling	36,741	260,023	13,698,933	2.6
	Yearling	0	63,151		
Coho salmon	Subyearling	3,239	21,808	944,363	6.3
	Yearling	0	34,321		
Steelhead	Parr	0	2,289	1,370,738	0.6
	Smolt	0	5,340		
Fall chum salmon	Subyearling	225,435	91,569	4,922,680	6.4
Sockeye salmon	Age-1	0	30,764	353,246	11.9
	Age-2	0	11,430		

Table 99. The maximum potential number or percentage of natural-origin salmon and steelhead due to predation and direct competition with hatchery-origin fish released as part of this Proposed Action with production changes to the tule Chinook and coho salmon programs, and predation occurring when prey are < 0.5 predator length (NMFS 2016m).

Species	Life Stage	Number		Number natural-origin in estuary-MA FEIS	Total Percentage
		Predation	Competition		
Chinook salmon	Subyearling	465,252	250,863	13,698,933	5.8

	Yearling	10,735	66,904		
Coho salmon	Subyearling	33,723	18,650	944,363	9.5
	Yearling	0	37,501		
Steelhead	Parr	2	2,514	1,370,738	0.6
	Smolt	0	6,432		
Fall chum salmon	Subyearling	675,326	88,244	4,922,680	15.5
Sockeye salmon	Age-1	8,819	34,966	353,246	16.3
	Age-2	0	13,966		

Table 100. The maximum potential number or percentage of natural-origin salmon and steelhead due to predation and direct competition with hatchery-origin fish released as part of this Proposed Action with production changes to the tule Chinook and coho salmon programs, and predation occurring when prey are < 0.25 predator length (NMFS 2016l).

Species	Life Stage	Number		Number natural-origin in estuary-MA FEIS	Total Percentage
		Predation	Competition		
Chinook salmon	Subyearling	42,868	251,431	13,698,933	2.6
	Yearling	0	67,270		
Coho salmon	Subyearling	4,167	19,202	944,363	6.8
	Yearling	0	40,639		
Steelhead	Parr	0	2,540	1,370,738	0.6
	Smolt	0	5,964		
Fall chum salmon	Subyearling	291,600	90,520	4,922,680	7.8
Sockeye salmon	Age-1	0	33,646	353,246	13.3
	Age-2	0	13,411		

Because all listed populations of salmon and steelhead travel through the mainstem Columbia River on their way to the ocean, adverse ecological effects are likely to be spread out over a variety of populations. Within the action area, there are listed fish from eight salmon ESU's and five steelhead DPSs comprised of about 181 populations that are likely to be present in the mainstem Columbia River during the emigration of hatchery-origin salmon and steelhead (Section 2.2.1).

However, our results show that of the five listed salmonid species in the Columbia Basin, ecological effects will be most severe on sockeye and fall chum salmon (Table 97 - Table 100). For both species, because of a relatively small body size during migration, they become vulnerable to the larger life stages of released hatchery-origin fish throughout their time in the tributary and the migration corridor. This is in contrast to coho salmon subyearlings and steelhead parr, which are protected from ecological effects in the migratory corridor because they do not migrate until they reach a larger size (Busby et al. 1996). In addition, relatively few sockeye salmon are produced in the Basin, which increases the proportion of the species affected, even though a relatively small number of individuals are lost. Furthermore, it is likely that most sockeye juveniles are produced from unlisted UCR sockeye populations, because the

Snake River Sockeye Salmon ESU is at very low abundance; odds are low that these few fish will be the ones consumed. Therefore, we believe the effect here to Snake River sockeye is low to negligible. In the future, we expect the percentage of fish potentially lost to competition and predation to decrease by less than one percent for all species relative to current conditions.

Our model also does not account for the beneficial effects of juvenile hatchery-origin fish releases, mainly in the form of prey for natural-origin salmon and steelhead. Although we have no way of quantifying this benefit, natural fish are equally as likely as hatchery fish to consume hatchery juveniles, especially subyearling Chinook and chum salmon. Although adults returning to freshwater are generally assumed not to feed during their migration to natal spawning areas, juvenile hatchery fish could provide a source of food for those salmon and steelhead adults residing in the same marine waters.

Travel/Residence Time

Because the Columbia River Estuary begins so far upstream from the river mouth (146 miles), it is difficult to separate travel time of fish through the estuary from residence time. Steelhead, spring Chinook salmon, and coho salmon typically move rapidly through estuaries (Weitkamp et al. 2014). For example, time between freshwater release and recovery in the ocean for steelhead varied from 23.4 days for fish released from the Willamette and Umatilla Rivers and 41.1 days for fish released from the Snake River, but sample sizes were small (6 and 36 fish, respectively) (Daly et al. 2014). McComas et al. (2006) found that mean travel rate from Bonneville Dam to RM 6 was 34 rm/day for both yearling and subyearling hatchery Chinook salmon. The mean travel time of yearling Chinook salmon from Lower Granite Dam to Bonneville Dam (302 RM) was 13 days (range 7 – 35), which equates to a travel rate of 23 rm/day. Morris et al. (2015) found migration time was even faster down to rm 47, from 35-53 rm/day for yearling and subyearling Chinook salmon, steelhead and sockeye salmon. In contrast, Roegner et al. (2012) also found that migration rates below Bonneville of yearling Chinook salmon ranged from < 0.6 to 18 RM/day, demonstrating that a constant migration speed downstream is highly unlikely.

In addition, travel/residence time may be dependent on the stream of origin because Interior Columbia River populations appear to move more quickly through the estuary than coastal populations. For example, steelhead from the Alsea River moved through the estuary from 7-12 RM/day, interior Columbia stream-type Chinook salmon and steelhead moved from 31-56 RM/day Weitkamp et al. (2014). These studies demonstrate that migration of hatchery juveniles is faster on average than what we calculated for use in our model (8-17 RM/day; Table 96), possibly leading to overestimation on our part for ecological interactions.

Once fish reach the estuary, residence time differed by species and life history; chum and sockeye salmon were typically caught during a 2-4 week period, yearling Chinook salmon, steelhead and coho salmon were caught for a 6-8 week period and subyearling Chinook salmon were present for at least 2 months, and possibly longer due to the end of sampling in July, when subyearling Chinook salmon were still being caught (Weitkamp et al. 2012). Most of these fish were of hatchery–origin (91-100%). Another study by Bottom et al. (2008) found that Chinook salmon estuary residence time (time of first contact with salt water) ranged from 10-219 days and averaged 73 days. However, almost half of the Chinook salmon sampled were less than 60 mm, much smaller than Chinook salmon released from hatchery programs. Estimates from marked hatchery groups indicated that Chinook salmon had residency periods of about one week

(Dawley et al. 1986; Bottom et al. 2008), but may have underestimated residency due to sampling of larger stream-type Chinook salmon and not smaller ocean-type Chinook salmon. More sampling of hatchery subyearling Chinook salmon is needed to determine their residence time in the estuary to be able to better assess ecological effects of this life history.

2.4.2.3.3 Spatial/temporal overlap

Spatial and temporal overlap varies by fish species and age. Yearling coho, Chinook salmon, and steelhead of both hatchery- and natural-origin use deep channels and different migration pathways through the lower 86 Rkm of the estuary (e.g., navigation channel versus off-channel). In addition, steelhead swimming closest to the surface and Chinook salmon swimming deepest of all Pacific salmon species (Harnish et al. 2012; Weitkamp et al. 2012), which influences travel times and survival during the spring outmigration from April to June.

The maximum abundances of yearling Chinook salmon, coho salmon, and steelhead in the estuary occurred in mid-May (Weitkamp et al. 2012). These patterns are consistent with those before large-scale hatchery production and other anthropogenic changes (Weitkamp et al. 2012). One exception is the earlier March abundance peak of yearling Chinook salmon ((Rich 1920); Burke (2004) in (Weitkamp et al. 2012)) that was not detected in this study. However, Weitkamp et al. (2012) did not sample prior to April and did not see evidence in the April sampling period of an earlier peak. In addition, the daily smolt counts at Bonneville Dam that begin in March also did not capture an earlier March peak. It is possible that this peak no longer occurs and represents a lost life history strategy, or that current sampling regimes are not able to pick up this signal (Weitkamp et al. 2012). For example, sampling in different estuary zones by Roegner et al. (2012), found that yearling Chinook salmon abundance was concentrated in March and early April in the tidal freshwater zone, late March to early May in the middle estuary, and April and May in the lowest estuary zone.

Subyearling Chinook tend to occupy shallower habitats than yearlings (Weitkamp et al. 2014), with this life stage accounting for 97.4% of the Chinook salmon in the estuary (Roegner et al. 2012). Chinook salmon less than 90 mm are the primary users of Columbia River wetlands (Bottom et al. 2008). In addition, subyearlings can be found throughout the year, although abundance is low from October through January. Their peak abundance differed depending on estuary zone; from April to June in the tidal freshwater zone, two peaks in May and July in the middle estuary zone, and July in the lower estuary zone. Weitkamp et al. (2012) also found peak subyearling abundance in June/early July. During the winter and early spring, fry comprised 25% of the samples, with the highest percentage of fry in the tidal freshwater zone. Most of the Chinook salmon fry (85%) were from either the Cascade MPG or were Spring Creek fall Chinook salmon. These data suggest that subyearling Chinook salmon overlap with yearling Chinook salmon, coho salmon and steelhead is minimal and they are likely protected from ecological effects through both habitat partitioning and temporal differences.

In addition to subyearling Chinook salmon, Roegner et al. (2012) found that the predominant species and life history types using the shallow tidal freshwater and estuary sites were chum salmon fry from March to May. Weitkamp et al. (2012), found that sampling in mid-April yielded low catches of juvenile salmon, but that chum salmon abundance peaked in mid-May, which overlaps with the timing identified in Roegner et al. (2012)'s work. In addition, the peak in sockeye salmon abundance occurred in late June/early July. Thus, both of these species are not likely to interact to a large degree with yearling hatchery fish due to temporal and spatial differences in habitat use; chum salmon mostly use the shallow areas and sockeye salmon abundance peaks after yearling Chinook salmon have likely moved offshore. However, both species are exposed to hatchery-origin subyearling Chinook salmon, which use the shallow habitats and are present for most of the year.

This overlap with hatchery subyearling Chinook salmon can be further refined based on work by the Lower Columbia River Estuary Partnership (LCREP) (Sagar et al. 2015). The LCREP found higher proportions of marked salmonids higher in the tidal freshwater area than closer to the Columbia River mouth. Also, marked Chinook salmon were present primarily from May through July. In contrast, unmarked Chinook salmon were found throughout the spring and summer until August. Unmarked and marked juvenile spring Chinook salmon had similar spatial distributions in the marine environment, but peak abundance occurred earlier for hatchery fish (May), than for natural fish (June). One caveat is that small-scale spatial overlap is unknown due to sampling of fish using trawls that sample a large volume of water (Daly et al. 2012), which is not informative for vertical or dispersed/aggregated patterns. Also, decreases in the proportions of hatchery-origin fish from the estuary to the ocean suggest that hatchery-origin fish may have reduced survival early in their marine residence (Claiborne et al. 2014). Interestingly, there was no evidence for selective mortality of smaller salmonids, which the authors believe was because of favorable ocean conditions for salmonids (e.g., cooler temperatures, plenty of food).

Competition between adults is most likely to occur for spawning sites because adults entering freshwater are generally assumed not to feed, and migrate quickly to their natal streams. Redd superimposition may also occur if fish overlap in habitat, but it is difficult to assess this effect without knowing microhabitat details. However, run-timing and habitat segregation limit interspecific competition potential (Table 101 and

Table 102; (NMFS 2013e; Appendix F)).

Here is additional rationale behind our designations for competition likelihood in

Table 102 among species:

- Sockeye salmon spawn in lake systems, which may separate them from spawning habitat of other Pacific salmon and steelhead species (Groot and Margolis 1991) because no other listed Pacific salmonid is known in lakes
- Chum salmon spawn in shallower, slower-flowing streams and side channels more often than other salmon species and spawn soon after freshwater entry (Johnson et al. 1997)
- Spring Chinook salmon return to natal streams before any of the other salmon species and spawn far upriver (Myers et al. 1998)
- Fall Chinook salmon return to natal streams at the same time as coho and chum salmon, and spawn in the mainstem or lower tributaries of rivers with a few days to weeks of freshwater entry (Myers et al. 1998)
- Coho salmon entry into natal streams is highly dependent on freshets; delays in fall rains could delay river entry and spawn timing (Weitkamp et al. 1995)
- Summer steelhead usually spawn further upstream than winter steelhead and spend more time in freshwater (Busby et al. 1996)
- Sympatric species (such as spring Chinook salmon and steelhead) have species-specific differences in habitat preference (NMFS 2013e; Appendix F)

Interactions that result in a high likelihood of competition are those that occur between fish of the same species and run-type (e.g., hatchery-origin and natural-origin spring Chinook salmon), because they share the same habitat requirements, have the same run and spawn times, and are similar in size (NMFS 2013e; Appendix F). Hatchery fish of the same species could potentially increase the likelihood for intraspecific competitive interactions. However, management of pHOS limits this potential (see Section 2.4.2.2) by controlling the number of hatchery fish spawning naturally.

Table 101. Estimated timing of listed salmon and steelhead juveniles and adults, both hatchery and natural, in various habitat types **(**Busby et al. 1996; NMFS 2013e).

		Month																								
Species	**Life stage**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**
Spring Chinook	juvenile	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	▓	▒	░	░	░	░	░	░	░	░
	adult	▓	▓	▓	▓	▓	█	█	█	█	█															
Fall Chinook	juvenile														█	█	█	█	▒	▒	▒	▒	░	░	░	░
	adult	░	░	░	░	░	░	░	▓	▓	█	█	█													
Coho	juvenile						█	█	█	█	█	█	█	█	█	▓	▓	▒	░	░	░	░	░	░	░	░
	adult	░	░	░	░	░	░	░	░	░	█	█	█	█	█	█	█									
Summer steelhead*	juvenile						█	█	█	█	█	█	█	█	█	█	█	▒	░	░	░	░	░	░	░	░
	adult	░	░	▓	▓	▓	▓	▓	▓	▓	▓	█	█	█	█	█	█	█	█							
Winter steelhead*	Juvenile						█	█	█	█	█	█	█	█	█	█	█	▒	░	░	░	░	░	░	░	░
	adult	▒	▒	█	█	█	█	█																		
sockeye	juvenile				█	█	█	█	█	█	█	█	█	█	█	█	▓	▓	▒	▒	░	░	░	░	░	░
	adult	░	░	░	▓	▓	▓	▓	█	█	█	█	█	█												
chum	juvenile														█	█	▓	▓	░	░	░	░	░	░	░	░
	adult	░	░	░	░	░	░	░	░	░	▓	▓	█	█												

* Natural-origin steelhead can rear for up to 3 years in freshwater

Natal stream	█
Migration corridor	▓
Estuary	▒
Ocean	░

Table 102. Likelihood and rationale for competitive interactions between adult salmon and steelhead species based on information in Table 101.

Natural Salmon Species	**Proposed Action Hatchery Salmon Species**				
	Spring Chinook	**Fall Chinook**	**Coho**	**Chum**	**Steelhead**
Spring Chinook	High: same habitat, timing and body size	Low: different habitat and timing	Low: different habitat, timing, body size	Low: different habitat and timing	Medium: different habitat and body size, same timing
Fall Chinook	Low: different habitat and timing	High: same habitat, timing and body size	Medium: different habitat and body size, same timing	Medium: different habitat and body size, same timing	Low: different timing and body size
Coho	Low: different habitat, timing, body size	Medium: different habitat and body size, same timing	High: same habitat, timing, and body size	Medium: different habitat and body size, same timing	Low: different timing and body size
Sockeye	Low: different habitat	Low: different habitat	Low: different habitat	Low: different habitat and timing	Low: different timing and body size
Chum	Low: different habitat and timing	Medium: different habitat and body size, same timing	Medium: different habitat and body size, same timing	High: same habitat, timing and body size	Low: different timing and body size
Steelhead	Medium: different habitat and body size, same timing	Low: different timing and body size	Low: different timing and body size	Low: different timing and body size	High: same habitat, timing and body size

Diet Composition

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. Thus, diet overlap among salmon and steelhead in all estuarine zones is high.

Schabetsberger et al. (2003) found that juvenile salmonids in the Columbia River plume tend to feed selectively on highly pigmented and relatively large prey (i.e., crab larvae, amphipods, adult krill), even though these species are less dominant than other zooplankton. The threshold size for piscivory was 80 mm fork length (Keeley and Grant 2001; Schabetsberger et al. 2003), with a large fish component in the diets of Chinook and coho salmon exceeding that length. The richer diet consumed in the ocean may confer survival benefits on juveniles that move quickly through the estuary (Daly et al. 2014).

Chinook and coho salmon off the coasts of Oregon and Washington ate primarily the same prey in May and June (Brodeur et al. 2011). Diet was comprised of adult krill, and juvenile sand lance (*Ammodytes hexapturus*), rockfish (*Sebastes* spp.), and greenling (*Hexagrammos* spp.). However, Chinook salmon also ate sculpin (cottids) and amphipods, while coho salmon also ate crab larvae (*Cancer* spp.). As salmon continued to grow during their residence in coastal marine waters, diet shifts occurred based on size of these fish. Coho salmon shifted from a diet of mainly rockfish, crab larvae and adult krill to predominately juvenile forage fish when they reached a size of 240 mm fork length. For Chinook salmon, fish comprised 55% of their diet from 80-100 mm fork length and 95% of their diet at > 375 mm fork length (Daly et al. 2009; Daly et al. 2014). There was no difference in diet between natural and hatchery fish (based on one year of data; Daly et al. 2014). Thus, in years where food may be limiting, intraspecific competition will likely be more severe.

Density Dependence

Density dependence can be divided into two categories: compensation and depensation. Compensation occurs when a population's growth rate is highest at low densities and decreases as population density increases, usually caused by limited resources such as space or food. Depensation occurs when a population's growth rate decreases at low densities, which could occur when either the death rate increases or the birth rate decreases (e.g., trouble finding mates to produce offspring; ISAB 2015).

Spawning/Rearing Areas

ISAB (2015) found that density dependence exists within many populations of Chinook salmon and steelhead in the Interior Columbia Basin, based on adult recruits to parent spawner curves. When specifically examining hatchery effects on salmon and steelhead, the ISAB (2015) found using preliminary modeling that for Snake River spring/summer Chinook salmon, hatchery supplementation did not lead to an increase in natural-origin returns, although total spawning abundance increased. Although a majority of populations modeled did not show an increase in smolt production when the number of hatchery spawners increased, a few did.

Two specific examples were described in the ISAB (2015) report investigating density dependence of steelhead in the Columbia River Basin. The first is at Clackamas Hatchery where a summer steelhead hatchery program reduced the productivity of the natural winter steelhead population (Kostow and Zhou 2006). However, after the summer steelhead population was terminated, the wild winter steelhead population had increased in abundance from < 100 fish to 1,500 fish. For this example, effects were attributed to ecological causes versus genetic causes because little interbreeding occurs between summer and winter steelhead due to temporal separation. Production of natural coho and spring Chinook salmon has also increased, likely due to less pressure on the limited resources available (could be either food or habitat for either juvenile or adult life stages). The second example is from the Umatilla River in Oregon where steelhead productivity declined with increases in total spawners, smolt abundance did not increase with increases in total spawners, the length-at-age declined and the percentage of older smolts increased with additional spawners likely due to slower growth. All three pieces of evidence suggest that food and rearing habitat are limiting production of natural-origin steelhead in the Umatilla River.

Modeling of coho salmon populations on the coast showed that a population that includes hatchery fish will produce fewer recruits than a population comprised of only natural-origin fish (~ 55% less when ocean conditions are good and 13% less when ocean conditions are poor). Under simulations where hatchery production had not been terminated, it was predicted that current productivity would be 27% lower (ISAB 2015).

Estuary/Ocean

The ISAB (2015) concluded there is little direct evidence of density dependent interactions between hatchery and natural-origin juvenile salmonids in the Columbia River estuary and ocean because of the lack of carefully designed experimental studies. The lack of scientific knowledge about density dependence of Columbia River salmonids during their time in the estuary and ocean is an important information gap, as understanding density dependence might help explain abundance patterns of natural salmonid resources in the Columbia River Basin. Density dependence is not included as a limiting factor in the Columbia River estuary ESA recovery plan module for salmon and steelhead because of uncertainty about the mechanisms and effects of density dependence in the estuary (NMFS 2011c).

Other researchers have expressed similar sentiments about the lack of information needed to appropriately assess density dependence. Daly et al. (2012) stated that competition for food resources could not be determined due to the lack of an estimate of prey availability and whether or not it is limiting (Daly et al. 2012). However, other researchers found that the amount of food in juvenile salmon stomachs was < 1% of body weight (Dawley et al. 1986; Weitkamp et al. 2014), which is generally lower than that found in studies of other estuary systems. This could be an indicator of competition with hatchery fish or an exceedance of system carrying capacity. However, hatchery-origin fish had lower values for stomach fullness than natural-origin fish. In addition, for both juvenile steelhead and juvenile spring Chinook salmon, unmarked fish had smaller lengths, but better body condition, fuller stomachs and higher Insulin Growth Factor (IGF-1) levels than hatchery counterparts (Daly et al. 2012; Daly et al. 2014).

Predator Attraction

Throughout a salmon's lifecycle, they are at risk to predation from a variety of birds, fish, and marine mammals. Predation on natural-origin salmon may be affected directly or indirectly by hatchery-origin salmon that change the density of prey (hatchery and natural-origin fish) available to predators (ISAB 2015).

Feeding rates of individual predators along with predator abundance and the length of time that prey remain vulnerable all lead to the total consumption of prey by predators (ISAB 2015). When individual predators become satiated, they reduce their feeding rate even if prey density is increasing. This response is known as a depensatory function response and can be offset by a compensatory increase in the number of predators due to either 1) aggregation in the short term, or 2) increased reproduction in the long term (ISAB 2015).

Avian Predation on Outmigrants

When comparing natural and hatchery-origin salmon predation rates, multiple studies in the Columbia River have shown that hatchery-origin salmonids are more susceptible to avian predation compared to natural-origin salmonids (Collis et al. 2001; Ryan et al. 2003; Kennedy et al. 2007; ISAB 2015). Additionally, a study by Hostetter et al. (2012) identified that hatchery-origin steelhead and steelhead that were in an "externally degraded condition" were consumed more frequently by double-crested cormorants (which pursue prey underwater) compared to natural-origin steelhead. This study suggested that avian predators may prefer to consume smolts that are less likely to survive to adulthood (Hostetter et al. 2011; Hostetter et al. 2012; ISAB 2015). However, this does not exclude the notion that avian predation occurs on a substantial amount of "non-degraded" smolts (Hostetter et al. 2012; ISAB 2015).

Effects of the Proposed Action on predation

Large releases of hatchery-origin fish may have a positive effect on natural-origin fish by preventing predator consumption on natural-origin fish due to the large number of hatchery-origin fish in the same area. Hatchery-origin fish are more likely to be preyed upon if there is a higher ratio of hatchery-origin fish to natural-origin fish in the same vicinity, creating a "buffer" for the natural-origin fish from the predators (ISAB 2015). However, large releases of hatchery-origin fish may have a negative effect on natural-origin fish by affecting the number of predators in the area; a large presence of fish has been shown to correlate with an increase of predators (e.g., pikeminnow) at the same time as hatchery releases increased (Kirn et al. 1986; Beamesderfer and Rieman 1991; ISAB 2015). If predator populations followed this trend continually, the "buffering" function that hatchery-origin fish could provide natural-origin fish would essentially be cancelled out by the sheer number of predators in the area. Ideally, predator levels should not rise above where they would be if hatchery releases did not occur in that area (ISAB 2015). Flagg et al. (2010) according to (ISAB 2015), concluded that releases of hatchery-origin fish affect the behavior of predator populations in the Columbia River. However, no studies have demonstrated what these effects mean to natural-origin populations. Thus, we assume that the effects of predator attraction are reflected in the current status of the species, and will continue at similar levels.

2.4.2.3.4 Nutrient Enhancement/ Gravel Conditioning

The return of hatchery fish likely contributes nutrients to the action area. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase productivity in watershed areas, enhancing food resources for naturally produced salmon and steelhead (Cederholm et al. 1999; Scheuerell et al. 2005). Table 103 shows that adult hatchery-origin salmon and steelhead spawning naturally contributes an estimated 5,414 kg of phosphorous to the action area annually, which likely compensates for some marine-derived nutrients lost from declining numbers of natural-origin fish. Under the Proposed Action, the reductions to programs over time (i.e., reduced hatchery production and releases) is likely to result in a loss of 272 kg of phosphorous annually compared to current contributions of hatchery fish. The programs can also be expected to improve the condition of spawning gravel beyond the current conditions as hatchery fish continue to return to natal streams occupied by natural-orgin fish into the future (Montgomery et al. 1996). Thus these effects are expected to be cumulative over time.

Table 103. Total phosphorous imported by adult returns from the proposed hatchery programs based on the equation (Imports=hatchery adults*mass*phosphorous concentration) in Scheuerell et al. (2005).

Conditions	**Estimated number of hatchery-origin returns across all programs[1]**	**Adult mass (kg)**	**Concentration of phosphorous (kg/adult)**	**Phosphorous imported (kg/year)**
Current	259,044	5.5	0.0038	5414
Future	246,015	5.5	0.0038	5142

[1]This number is based on the number of hatchery fish released from each program multiplied by the smolt to adult return estimate (NMFS 2016l). This does not account for fish lost to harvest.

2.4.2.3.5 Disease Effects

The hatchery programs would be operated in compliance with state co-manager fish health protocols pertaining to movement and monitoring of cultured fish (Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989; IHOT 1995; ODFW 2003; NWIFC and WDFW 2006). When egg-to-release survival rates are high for fish propagated in the hatchery programs that are part of the proposed action, this indicates that protocols for monitoring and addressing the health of fish in hatcheries have been effective at limiting mortality. In addition, hatchery fish from these programs migrate out of the Basin relatively quickly (Table 96), limiting exposure time and/or pathogen shedding in freshwater. Although fish are monitored monthly during rearing, there are situations where fish that may be infected with pathogens are released into the watershed. Sometimes this may occur as a preventative measure for manifesting the disease; by decreasing stressors such as crowding in the hatchery environment, the disease may not manifest. However, this practice also may contribute to increased pathogen levels in the natural environment if the disease does occur. We believe this to be a rare occurrence as this has only occurred three times from October 2014 to September 2016 from all MA funded WDFW-operated facilities (WDFW 2015d; 2015c; 2016c; 2016a). We recommend that hatchery operators and/or fish health specialists alert NMFS when the situation may warrant early release and discuss options for handling of infected/diseased fish.

Although a variety of pathogens have been detected in Oregon and Washington hatcheries over the last few years, no novel or exotic pathogens have been found (Table 104). However, it is important to note that detection of a pathogen does not mean that disease was observed. Table 105 indicates the number of epizootics (20-30 per year) occurring from some pathogen infections is much less than the number of pathogen detections 3,000-4,000 per year. In addition, all of the epizootics, with the exception of BKD and IHNV, are curable using treatments approved for use in fish culture such as formalin, hydrogen peroxide, and various antibiotics.

The low frequency of epizootics from native pathogens, in combination with frequent monitoring and treatment options under current fish health policies suggest that the amplification of pathogens during rearing of fish in hatcheries on natural-origin salmon and steelhead is likely indiscernible from natural pathogen levels in the natural environment. In future reports, it would be useful to provide tables similar to what is provided below for all MA facilities grouped by State Authority, along with the duration (in days) of each epizootic and magnitude (% of production lost), to better gauge the risk of disease on natural-origin salmon and steelhead

Table 104. Pathogens detected at all Oregon facilities from 2013 to 2015.

Pathogen Group	**Pathogen (Disease caused)**	**% All Pathogen Detections**		
		2013	**2014**	**2015**
External Parasite	*Icthyobodo sp.*	< 1	< 1	< 1
	Trichodina	2.6	1.8	3.9
	Gyrodactylus sp.	3.8	2.9	6.1
	Ichthyophthirius multifiliis	< 1	1.2	3.7
	Gill amoeba	< 1	< 1	0
	Copepods	1.5	< 1	< 1
Bacterium	*Renibacterium salmoninarum* (BKD)	10.0	26.0	23.0
	Aeromonas salmonicida (Furunculosis)	1.5	1.4	8.0
	Flavobacterium psychrophilum (Coldwater)	30.2	20.4	31.1
	Flavobacterium columnare (columnaris)	< 1	<1	1.6

	Flavobacterium sp. (Bacterial Gill Disease)	0	<1	< 1
	Yersinia ruckeri (Enteric Red Mouth)	< 1	< 1	< 1
	Aeromonas/Pseudomonas sp. (Septicemia)	36.4	39.0	16.9
Virus	*Infectious Hematopoietic Necrosis Virus*; IHNV	5.6	4.5	1.2
Unknown	Erythrocytic Inclusion Body Syndrome; EIBS	< 1	< 1	< 1
Fungus	various	6.1	3.8	6.9
Internal Parasite	*Henneguya sp.*	< 1	< 1	< 1
	Ceratonova shasta	< 1	< 1	1.9
	Myxobolus cerebralis	< 1	< 1	0
	Myxobolus sp.	< 1	< 1	< 1

Sources: (ODFW 2014a; 2015a; 2016d)

Table 105. Pathogen infections resulting in disease (epizootics) at all MA funded facilities in Washington October 2014 to September 2016 and Oregon from October 2013 to September 2015.

Pathogen (Disease)	**Number of Epizootics**	
	WDFW Facilities	**ODFW Facilities**
Fungus	6	18
Trichodina	3	0
Icthyobodo	3	0
Ichthyophthirius multifiliis	14	1
Flavobacterium psychrophilum (Coldwater)	11	13
External Parasites-grouped	0	5
Flavobacterium columnare (Columnaris)	12	3
Renibacterium salmoninarum (BKD)	0	2
Aeromonas salmonicida (Furunculosis)	7	1
Flavobacterium sp. (Bacterial Gill Disease)	6	0
Infectious Hematopoietic Necrosis Virus; IHNV	3	0

Sources: (ODFW 2014b; 2014c; 2014d; 2014e; 2014f; 2015e; 2015g; 2015f; 2015d; 2015c; WDFW 2015d; 2015c; 2016c; 2016a)

In the future, migration from out-of-area-stocks (e.g., Rogue River) to native stock for propagation will also reduce disease risk. This is because native salmon and steelhead may already have some level of tolerance or resistance to endemic pathogens that non-native fish do not possess (Atkinson and Bartholomew 2010). Thus, non-native fish may be more likely to amplify pathogen levels than native fish because fewer pathogens are required to cause the disease (Hallett et al. 2012).

2.4.2.3.6 Summary of Ecological Effects for Salmon and Steelhead

All of this information on travel/residence time, spatial and temporal overlap, and diet composition, suggests that hatchery fall Chinook salmon likely pose the largest ecological risk to natural-origin fish (primarily smaller Chinook salmon and chum salmon) out of all the hatchery fish that are released due to their long juvenile residence time, and large degree of spatial and temporal overlap with natural-origin fish in the migratory corridor and estuary. This effect is most likely to be in the form of competition for space in good ocean years and perhaps also for food during years of poor ocean conditions because of the large overlap in diet between hatchery and natural fish. Predator attraction from the large releases of hatchery-origin fish may act as a "buffer" against predation on natural-origin fish.

NMFS has presented its summary for ecological effects for salmon and steelhead in (NMFS 2017). In this section, NMFS quantified the overall effects by species, and has noted where possible the individual likely effects to ESUs or DPSs independently. Using this information NMFS hereby qualitatively summarizes the likely effects to each ESA-listed salmon and steelhead ESU and DPS affected in the Action Area via the vectors we have identified above (i.e., Competition and Predation, Predator Attraction, Nutrient Enhancement/ Gravel Conditioning, and Disease) in Table 106. Explanations of each effect are given in the previous sections.

Table 106. Summary of effects on ESA-listed species from hatchery programs funded through the proposed action. Effects: high negative, moderate negative, low negative, negligible, no effect, positive, and not applicable.

ESA-listed salmon or steelhead species	Predation and Competition	Predator Attraction	Nutrient Enhancement/ Gravel Conditioning	Disease[2]
LCR Chinook Salmon ESU	low negative	negligible	positive	negligible
UCR spring –run Chinook Salmon ESU	negligible	negligible	positive	negligible
Snake River spring/summer-run Chinook Salmon ESU	negligible	negligible	positive	negligible
Snake River fall-run Chinook Salmon ESU	low negative	negligible	positive	negligible
UWR Chinook Salmon ESU	negligible	negligible	positive	negligible
LCR Coho Salmon ESU	negligible	negligible	positive	negligible
CR Chum Salmon ESU	moderate negative	negligible	positive	negligible

ESA-listed salmon or steelhead species	Predation and Competition	Predator Attraction	Nutrient Enhancement/ Gravel Conditioning	Disease[2]
SR Sockeye Salmon ESU	negligible	negligible	positive	negligible
LCR Steelhead DPS	negligible	low negative[1]	positive	negligible
UCR Steelhead DPS	negligible	low negative[1]	positive	negligible
Snake River Basin Steelhead DPS	negligible	low negative[1]	positive	negligible
MCR Steelhead DPS	negligible	low negative[1]	positive	negligible
UWR Steelhead DPS	negligible	low negative[1]	positive	negligible

[1] Negative effect due to the best available science showing steelhead swim closer to the surface than other species, therefore are more likely to be preyed upon.

[2] More research is needed to correlate a negative or positive effect to these ESA-listed salmon or steelhead species.

These risk levels can be managed to some extent by certain practices. As with all generalizations, there are exceptions, but operators must conform to the following:

- Release date and location. The potential for ecological interactions increases as more overlap occurs between hatchery and natural-origin fish. To limit overlap, releases of salmon or steelhead yearling smolts should if possible take place after the majority of natural-origin fish have exited the system or have grown to a size where they are less likely to be eaten. In general, hatchery yearling smolts released downstream of McNary Dam should not be are released before the last week of March. Release location can also influence interaction potential, so releases should be made only at sites specified in the BA (NMFS 2017).
- Size of fish released. The size of the smolts released relates directly to the extent to which any interactions result in harm or mortality to natural-origin fish: the larger a smolt is at release, the more likely it could out-compete or prey on others. Average smolt size and variability should not exceed that specified in the BA (NMFS 2017).
- Number of fish released. Obviously, the more fish released, the greater the potential for ecological interactions. Typically hatchery programs tend to take eggs in excess of need (usually) to cope with possible shortfalls due to a variety of operation causes. This usually leads to more fish being released than plan. NMFS has considered this problem for some time and has concluded that for programs it funds that at any program no single release should exceed 105% of the target release number, and over five years, the average should not exceed 102% of target specified in the BA (NMFS 2017).
- Number of residualized fish released. Ecological interactions can also increase when hatcgery fish residual due to early sexual maturation (precocity). Residualism itself

cannot be determined at the hatchery, but the rate of precocity serves as a logical surrogate. In any year the rate of precocity should be kept under 5%, and the 5-year average should not exceed 3%. It should be noted that while these standards are appropriate for the suite of current and planned Mitchell Act funded programs, they may have to be modified for any future funding of upstream spring and spring/summer Chinook salmon programs.

Although information to date suggests that negative effects are occurring from the release of hatchery fish on listed natural-origin fish, critical research is still needed to further investigate this topic to better understand the magnitude of the negative effect and to improve the estimates of model parameters. In addition, to implementing the proposed RM&E, NMFS plans on developing specific studies in coordination with the NMFS NWFSC and other Federal, state and tribal partners to better understand the effects of ecological interactions on listed natural-origin salmon and steelhead, and SRKW in freshwater and marine environments. To do this requires a plan to phase-in the reductions/increases that will occur to certain programs over a five-year period. It is likely that no changes to release numbers will occur during the first two years after completion of the opinion to allow for the collection of baseline data. Some examples of studies that could be performed to assess how these reductions/increases may influence ecological interactions are:

1. Determine impacts of hatchery releases to density, relative abundance and residency of unmarked vs. marked subyearling Chinook salmon using the Kalama and Cowlitz Rivers because the Kalama River hatchery programs will experience a substantial reduction, while the Cowlitz Salmon hatchery will not, serving as a reference system for this and all studies outlines below.
2. Determine impacts of hatchery releases to feeding patterns of unmarked and marked salmon by examining conspecific feeding competition in terms of stomach fullness and composition of prey items. Prey resources will be monitored to ensure that stomach content changes are not based on changes in prey availability. Stomach contents of salmon from above and below the target confluence will be compared to look for hatchery impacts to feeding patterns.
3. Determine impacts of hatchery releases to growth rates of unmarked salmon by examining daily growth increments of otoliths and levels of insulin-like growth factor 1 (IGF-1) from unmarked subyearling Chinook salmon from 3 sites at each tributary: Washington shore upstream, confluence, and Washington shore downstream. Efforts will be concentrated on the Washington shore because we think we will see the greatest impacts in fish on the same side of the river as the target tributaries.
4. Determine impacts of hatchery reductions on avian predation (to start in 2018) using PIT tags to examine whether predation rates on hatchery released subyearling Chinook salmon by Caspian terns and double crested cormorants change after hatchery reductions are implemented

2.4.2.4 Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

Table 90 indicates that NMFS expects no effects under this factor on the UCR spring–run Chinook Salmon ESU, Snake River spring/summer-run Chinook Salmon ESU, Snake River fall-run Chinook Salmon ESU, UWR Chinook Salmon ESU, SR Sockeye Salmon ESU, UCR Steelhead DPS, UWR Steelhead DPS, and SRKW DPS. Natural-origin salmon or steelhead considered part of these ESUs or DPSs are not taken as a result of hatchery funding decisions that lead to RM&E activities, and NMFS is not aware of any incidental take or subsequent effects to these ESUs or DPSs given the locations and descriptions of RM&E activities provided by NMFS (2017).

For Pacific eulachon and SRKW RM&E activities funded through the Proposed Action do not pose a risk to the viability to these ESA-listed species because these activities only affect salmon and steelhead. Eulachon juveniles will not be present in the vicinity near study sites when state agencies may perform electrofishing activities. Eulachon adults typically enter the Columbia River from December to May with peak entry and spawning during February and March. Length of incubation ranges from about 28 days in 4°-5° C waters to 21-25 days in 8° C waters depending upon stream temperature (described in Section 2.2.1.1). Sampling activities associated with RM&E activities will occur outside these months, so eulachon will not be present and these activities therefore pose no risk.

SRKW do not occupy the freshwater areas where interaction may occur under this factor, therefore NMFS has determined there will be no effects to this ESA-listed species via this factor.

Effects to ESA-listed species by the Proposed Action under this factor are described below. The amount of take is grouped by the affected species and not by the RM&E project. The same information is presented in the ITS grouped by RM&E project.

LCR Chinook Salmon ESU

During RM&E activities funded through the Proposed Action in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek, and Washougal Rivers electrofishing activities will encounter juvenile LCR fall and spring Chinook salmon during activities associated with monitoring steelhead introgression from hatchery steelhead programs. NMFS (2017) describes expected capture, handle, tag and sample, and mortality estimates resulting from proposed RM&E activities and this information is presented in Table 107 for reference.

Table 107. Natural-origin juvenile LCR Chinook salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under steelhead introgression monitoring funded through the Proposed Action (NMFS 2017).

MPG	Population (State)	Encountered	Mortality	Adult equivalent	Average % of recent spawning population
Cascade Spring	Toutle (WA)	0	--	0	0
	Kalama (WA)	2,000	80	1	0.8%

Coastal Fall	Grays/Chinook (WA)	10,000	400	0	0.7%
	Elochoman/ Skamokawa (WA)	10,000	400	1	0.0%
Cascade Fall	Toutle (WA)	20,000	800	1	0.5%
	Coweeman (WA)	10,000	400	1	0.2%
	Kalama (WA)	8,000	320	1	0.0%
	Lewis (WA)	10,000	400	1	0.0%
	Salmon (WA)	10,000	400	1	Unknown
	Washougal (WA)	10,000	400	1	0.0%

We calculated adult equivalents for the juvenile mortalities expected in Table 107 using two sources for comparison. Groot and Margolis (1991) suggest natural mortality rates of 90% are common during Chinook salmon outmigration, with annual ocean mortality ranging from 34.1%-36% annually. Given that most Chinook salmon return as four year olds (Table 14) ocean mortality would annually amortize for the number of years spent in the ocean, which generally runs one more year for fall Chinook salmon than spring Chinook salmon. We used this information to calculate the adult equivalents of juvenile mortalities and compared them with rates of SAR survival for specific Columbia River hatchery salmon and steelhead stocks in specific watersheds in Table 107. Because survival rates produced similar results and SAR data was available for specific stocks, hatchery stock-specific SARs were used. Where no stock-specific SAR was available we relied on the closest geographic population to act as a surrogate given that information from Groot and Margolis (1991) suggests a general application to all Chinook salmon is warranted. These estimated adult equivalents allowed us to calculate the percentage of the spawning population the mortalities may have accounted for, using the most recent 5-year average of total spawners in each watershed (Table 107). The result is that these juvenile removals represent less than 1% of any individual LCR Chinook salmon natural population's total adult spawner average. Therefore NMFS concludes these expected take levels are negligible and do not pose a risk to the viability of LCR Chinook salmon populations, individually or collectively.

Operation of the North Fork Toutle River Fish Collection Facility will result in take through trapping, handling, tagging, and release mortality. Up to 50 natural-origin Chinook salmon adults would be trapped, handled, and or tagged before releasing them back into the North Fork Toutle River and as result less than 2%, or the equivalent of 1 adult fish would die as result of these activities. This represents 0.5% of the recent 5-year average based on information in Section 2.2.1.2 (Table 20). This level of take is inconsequential and is mitigated by enabling passage to otherwise inaccessible habitat which increases natural population spatial distribution. Therefore NMFS concludes these expected take levels to be negligible.

In the Kalama River, during RM&E activities performed as part of the Kalama Research Program both adult and juvenile LCR spring Chinook salmon will be encountered and take will result. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 108.

Table 108. Natural-origin juvenile LCR spring Chinook salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under Kalama Research program monitoring funded through the Proposed Action (NMFS 2017)..

MPG	Population (State)	Encountered	Mortality	Adult equivalent	Average % of spawning population
Cascade Spring	Kalama (WA)	502 (adults)	13	13	11.3%
		1,330 (juveniles)	67	0	0

For the Kalama River spring Chinook salmon population, the maximum expected adult mortalities represent 11.3% of the recent 5-year average adult total spawning population, which is just 115 fish (Table 16). The actual number of NOR spring Chinook salmon mortalities has averaged less than one adult for spring Chinook salmon trapped and sampled at the Kalama Falls Hatchery. The population is listed as a contributing population for recovery, and the maximum expected rate of removal of natural-origin adult spawners via this factor is a risk to population viability, given the population averages just over 100 natural-origin spawners annually.

Juvenile LCR fall Chinook salmon will be encountered in Mason Creek, Rock Creek of the East Fork Lewis River, Mill Creek of the East Fork Lewis River, and Mill Creek of Salmon Creek during RM&E activities to evaluate the benefits and risks of juvenile wild fish rescue programs. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 109.

Table 109. Take table for Chinook salmon encountered during juvenile fish rescue research evaluation to be conducted in tributaries of the East Fork Lewis River and Salmon Creek, LCR, Washington, from spring 2017 – spring 2018 (NMFS 2017).

MPG	Population (State)	Juveniles Encountered	Mortality	Adult equivalent	Average % of spawning population
Cascade Fall	Lewis (WA)	10,000	20	0	0
	Salmon (WA)	10,000	20	0	0

Using a similar approach to estimating effects, the proposed RM&E will not measurably affect any LCR Chinook salmon population's total abundance. Furthermore, these activities will reduce the likelihood of injury and/or mortality during the in-stream and out-migrant surveys by taking the following best management practices:

(1) Fish will be sampled only when water temperatures are ≤18°C

(2) Fish being held for sampling will be placed in aerated buckets and supplied with fresh water to maintain appropriate temperature and oxygen levels.

(3) Prior to biological sampling and/or tagging, fish will be anaesthetized in a buffered ($NaHCO_3$) tricaine methanesulfonate (MS-222) solution (~60 mg/L).

(4) Fish will be sampled as quickly as possible and allowed to fully recover before release.
(5) Staff will be trained to properly capture, handle, tag, and mark fish.

NMFS concludes these expected take levels do not pose a risk to the viability of LCR Chinook salmon natural populations in their respective watersheds, either individually or collectively.

Additional RM&E activities funded through the Proposed Action which are not expected to result in the take of LCR Chinook salmon are:

- Population abundance and spawning composition of LCR Chinook populations. Surveys would occur but any natural adult salmon observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. The activities occur during natural steelhead spawning occurrence (depicted in Table 57). Returning adults from each Chinook salmon natural population will finish spawning activity prior (based on timing depicted in Table 14 to steelhead spawning occurrence therefore surveys performed will not affect LCR Chinook salmon.
- Harvest monitoring activities in the mainstem Columbia River sport and commercial fisheries, as well as tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no take associated with these sampling activities, in and of themselves. Therefore NMFS concludes these activities to have no effect on LCR Chinook salmon.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations (October-December) in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging of portions of the juvenile coho releases to track the outmigration and survival of the fish. These activities occur outside the range of LCR Chinook salmon and there is no anticipated take associated with these sampling activities. Therefore, NMFS concludes that these activities will have no effect on LCR Chinook salmon.
- Klickitat River monitoring and evaluation activities. These include spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR Chinook salmon and there is no anticipated take associated with these sampling activities. Therefore NMFS concludes these activities to have no effect on LCR Chinook salmon.

CR Chum Salmon ESU

RM&E electrofishing activities in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek and Washougal Rivers will encounter juvenile CR chum salmon while monitoring steelhead introgression from hatchery steelhead programs. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 110.

Table 110. Natural-origin juvenile CR chum salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under the Proposed Action.

MPG	Population (State)	Encountered	Mortality	Adult equivalent	Average % of recent spawning population
Coast	Grays/Chinook (WA)	100	400	0	0.0%
	Elochoman/ Skamokawa (WA)	10,000	400	0	0.0%
Cascade	Toutle (WA)	20,000	800	0	0.2%
	Coweeman (WA)	10,000	400	0	0.2%
	Kalama (WA)	8,000	320	0	0.2%
	Lewis (WA)	10,000	400	0	0.1%
	Salmon (WA)	10,000	400	0	0.1%
	Washougal (WA)	10,000	400	0	0.0%

We calculated adult equivalents for the juvenile mortalities expected in Table 110 using two sources for comparison. Groot and Margolis (1991) report that natural chum salmon mortality rates (fry to adult) range from 97% to 99.7%. Adult equivalents calculated using these mortality rates were compared with rates using SAR survival obtained for hatchery-origin CR chum salmon raised in either the Grays River or Duncan Creek. Where survival rates produced similar results and data was available for a specific stock (e.g., Grays River chum salmon have a specific SAR averaging 0.16%) we applied the stock-specific SAR. As only two stock-specific SARs were available (Table 110) we relied on the closest geographic population to act as a surrogate given information from Groot and Margolis (1991) suggests a general application to all chum salmon is warranted given fluctuations between various Pacific Ocean chum stocks SAR is small. These estimated adult equivalents allowed us to calculate the percentage of the spawning population the mortalities may have accounted for, using the most recent 5-year average of total spawners in each watershed (Table 110). Several populations do not currently have total spawner estimates, and Table 110 thereby only reports the expected adult equivalents killed as a result of handling mortalities of juveniles during RM&E activities. This approach estimates these juvenile removals represent less than 1% of any given population's total spawners or less than one adult equivalent given the average known SAR of chum salmon. Therefore, NMFS concludes these expected take levels do not pose a risk to the viability of CR chum salmon populations in their respective watersheds, either individually or collectively.

RM&E activities in Mason Creek, Rock Creek of the East Fork Lewis River, Mill Creek of the East Fork Lewis River, and Mill Creek of Salmon Creek will encounter juvenile CR chum salmon during activities associated with evaluation of the benefits and risks of juvenile wild fish rescue programs. Expected capture, handle, tag and sample, and mortality estimates NMFS (2017) are presented in Table 116.

Table 111. Take table for chum salmon encountered during juvenile fish rescue research evaluation to be conducted in tributaries of the East Fork Lewis River and Salmon Creek, LCR, Washington, from spring 2017 – spring 2018 (NMFS 2017).

MPG	Population (State)	Juveniles Encountered	Mortality	Adult equivalent	Average % of spawning population
Cascade Fall	Lewis (WA)	10	1	0	0
	Salmon (WA)	10	1	0	0

This proposed RM&E will not appreciably affect either of the two CR chum salmon natural population's total recent adult spawner averages. Furthermore, these activities will reduce the likelihood of injury and/or mortality during the in-stream and out-migrant surveys by taking the five best management practices that are described above for LCR Chinook salmon. Therefore NMFS concludes that these expected take levels associated with the evaluation of the benefits and risks of juvenile wild fish rescue programs funded through the Proposed Action do not pose a risk to the viability of CR chum salmon natural populations, either individually or collectively.

Additional RM&E activities funded through the Proposed Action which do not result in the take of CR chum salmon include:

- Population abundance and spawning composition of CR chum salmon. Surveys would occur but any natural adult salmon observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. The activities occur during steelhead spawning (Table 57). Returning adults from each chum salmon population will finish natural spawning before (based on timing depicted in Section 2.2.1.8) steelhead spawning, therefore surveys will not affect CR chum salmon.
- Harvest monitoring in the mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no take associated with these sampling activities. Therefore NMFS concludes these activities to have no effect on CR chum salmon natural populations.
- Operation of the North Fork Toutle River Fish Collection Facility. This includes adult salmonid monitoring, sampling, handling and tagging in the North Fork Toutle River. No chum salmon have been recorded at the facility during operation and no take is anticipated from these sampling activities. Therefore NMFS concludes these activities to have no effect on the CR chum salmon natural populations.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish (NMFS 2017). These activities occur outside the range of CR chum salmon so no take is anticipated from them. Therefore NMFS concludes these activities to have no effect on the CR chum salmon populations individually or collectively.
- RM&E activities in the Kalama River. No chum salmon have been recorded during past operations and there is no anticipated take associated with these sampling

activities. Therefore NMFS concludes these activities will have no effect on CR chum salmon natural populations, either individually or collectively.

- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of CR chum salmon, so there is no anticipated take associated with these sampling activities. Therefore NMFS concludes that these activities will have no effect on CR chum salmon natural populations, either individually or collectively.

LCR Coho Salmon ESU

Electrofishing activities in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek, and Washougal Rivers will encounter juvenile LCR coho salmon during RM&E activities associated with monitoring hatchery steelhead introgression. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 112.

Table 112. Natural-origin juvenile LCR coho salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under the Proposed Action.

MPG	Population (State)	Encountered	Mortality	Adult equivalent	Average % of recent spawning population
Coastal Fall	Grays/Chinook (WA)	10,000	400	0	1.9%
	Elochoman/ Skamokawa (WA)	10,000	400	1	0.7%
Cascade Fall	Toutle (WA)	20,000	800	1	0.9%
	Coweeman (WA)	10,000	400	1	0.1%
	Kalama (WA)	8,000	320	1	2.0%
	Lewis (WA)	10,000	400	1	0.6%
	Salmon (WA)	10,000	400	1	0.4%
	Washougal (WA)	10,000	400	1	0.4%

We calculated adult equivalents for the juvenile mortalities expected in Table 112 using two sources for comparison. Groot and Margolis (1991) has general estimates of coho salmon SARs derived from multiple sources. They suggest coho salmon SARs generally range from 0.98% to 7.72% (meaning mortality rates range from 98.02% to 92.28%). This information corroborates with SARs obtained for specific Columbia River hatchery coho salmon in specific watersheds (Table 112). Where no stock-specific SAR was available we relied on the closest geographic population to act as a surrogate, given that Groot and Margolis (1991) suggest a general application to all coho salmon is warranted. Using this approach the estimated adult equivalents in Table 112 allowed us to calculate the average percentage of each natural spawning population that would be mortalities. For every population except the Kalama River, we estimate that these juvenile removals represent less than 1% of any LCR coho salmon population's total recent spawner abundance. Therefore NMFS concludes these expected take levels do not pose a risk to the viability of these LCR coho salmon natural populations, either individually or collectively. For the Kalama River coho salmon natural population, the expected juvenile removals (320 fish) when converted to adult equivalents (1 adult fish) represent approximately 2% of the total natural-origin spawner average (these number were calculated using Table 45). The population is listed as a contributing population for recovery, and this rate of mortality for natural-origin adult spawners via this factor would lead to a low negative risk rating, given that the population averages less than 100 fish annually.

Operation of the North Fork Toutle River Fish Collection Facility will result in take of LCR coho through trapping, handling, and tagging and release mortality. Up to 1,000 adult coho would be trapped, handled, and or tagged before releasing them, and 20 adult fish would die as result of these activities. This represents 1.8% of the recent 5-year average based on information in Section 2.2.1.2 (Table 45). This level of take is expected to be mitigated by the increased spatial distribution provided by fish passage to otherwise inaccessible habitat above the collection facility. Therefore NMFS concludes these expected take levels are negligible and do not pose a risk to the viability of the North Fork Toutle River coho salmon natural population.

Juvenile LCR coho salmon will be taken during activities in the Kalama River performed as part of the Kalama Research Program. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 113.

Table 113. Natural-origin juvenile LCR coho salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under Kalama Research program (NMFS 2017).

MPG	Population (State)	Encountered	Mortality	Adult equivalent	Average % of spawning population
Cascade Spring	Kalama (WA)	1,300 (juveniles)	65	1	2.0%
		200 (egg/fry)	10	0	0

For the Kalama River coho salmon natural population, these expected adult mortalities represent 2.0% of the recent 5-year average adult natural spawning population (Table 45). The population is listed as a contributing population for recovery, and this rate of removal of natural-origin adult spawners by the proposed action would lead to a low negative risk rating, given that the natural population averages just over 50 natural-origin fish annually.

Juvenile LCR coho salmon are expected to be encountered in Mason Creek, Rock Creek of the East Fork Lewis River, Mill Creek of the East Fork Lewis River, and Mill Creek of Salmon Creek during activities associated with evaluation of the benefits and risks of juvenile wild fish rescue programs. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 114.

Table 114. Coho salmon take table for juvenile fish rescue research evaluation to be conducted in tributaries of the East Fork Lewis River and Salmon Creek, LCR, Washington, from spring 2017 – spring 2018 (NMFS 2017) (egg/fry encounters/mortality added to juveniles).

MPG	Population (State)	Juveniles Encountered	Mortality	Adult equivalent	Average % of spawning population
Cascade	Lewis (WA)	17,000	540	9	0.5%
	Salmon (WA)	15,000	540	9	0.4%

Using a similar approach to estimating adult equivalents as we did for the electrofishing effects described earlier in this section, it appears this activity will reduce the productivity of the East Fork Lewis River coho salmon population by 0.5% and the Salmon Creek coho salmon population by 0.4% (Table 45). These affects are negligible with respect to the productivity of either of these populations. Furthermore these activities will reduce the likelihood of injury and/or mortality during the in-stream and out-migrant surveys by taking the five best management practices described above in the LCR Chinook Salmon ESU review of this RM&E activity. Therefore NMFS concludes these expected take levels associated with this activity will not pose a risk to the viability of LCR coho salmon natural populations, either individually or collectively.

Additional RM&E activities funded through the Proposed Action which will not result in the take of LCR coho salmon:

- Population abundance and spawning composition of LCR coho salmon. Surveys would occur but any adult salmon observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. These activities would occur during steelhead spawning (Table 57). Coho will finish spawning activity before (Table 43) steelhead spawning, therefore surveys performed will not affect or take LCR coho salmon.
- Harvest monitoring in the mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no take associated with these sampling activities. Therefore NMFS concludes that these activities will have no effect on LCR coho salmon.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish. These activities occur outside the range of LCR coho salmon so no take is anticipated from them. Therefore NMFS concludes these activities to have no effect on LCR coho salmon.
- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration

monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR coho salmon, so there is no take associated with these sampling activities. Therefore NMFS concludes that these activities would have no effect on the LCR coho salmon.

LCR Steelhead DPS

Mitchell Act funded monitoring of LCR steelhead natural population abundance and spawning composition occurs during steelhead spawning (Table 57). This is typically done through trapping, netting, or hook-and-line sampling of adults. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 115.

Table 115. Natural-origin adult LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities associated with population abundance (NMFS 2017).

DPS	MPG	Population (State)	Encountered (adults)	Mortality	Average % of recent spawning population
LCR Steelhead	Cascade Summer	Kalama (WA)	Included in Kalama Research Project (see below)		
		EF Lewis (WA)	Up to 200	Up to 4	0.4%
		Washougal (WA)	Up to 600	Up to 12	1.7%
		SF Toutle (WA)	Up to 300	Up to 6	2.2%
		Coweeman (WA)	Up to 200	Up to 4	0.7%
		Kalama (WA)	Included in Kalama Research Project (see below)		
		EF Lewis (WA)	Up to 200	Up to 4	0.9%
		Salmon Creek (WA)	Up to 100	Up to 2	Unknown
		Washougal (WA)	Up to 600	Up to 12	2.7%

For the majority of the steelhead natural populations affected by this RM&E activity the expected adult mortalities represent less than 2% of the recent 5-year average adult total spawning abundance (Table 61 and Table 62 were used to calculate averages). The South Fork Toutle and Washougal River winter steelhead populations are the only two populations where the effect results in lowering the recent 5-year average by more than 2%, but expected mortalities are less than 3%. NMFS rates the risk from these take levels as low negative collectively to the LCR steelhead DPS, because the majority of these are primary populations (necessary for recovery).

Electrofishing activities in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek, and Washougal Rivers will encounter juvenile LCR steelhead during RM&E activities associated with monitoring hatchery steelhead introgression. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 116.

Table 116. Natural-origin juvenile LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities associated with steelhead hatchery program introgression monitoring funded through the Proposed Action (NMFS 2017).

MPG	Population (State)	Encountered[1]	Mortality	Adult equivalent	Average % of spawning population
Cascade Summer	Kalama (WA)	7,400	104	7	1.3%
	EF Lewis (WA)	7,400	104	7	0.7%
	Washougal (WA)	7,400	104	7	1.0%
Cascade Winter	SF Toutle (WA)	14,800	208	6	1.3%
	NF Toutle (WA)	14,800	208	6	1.1%
	Coweeman (WA)	14,800	208	6	1.2%
	Kalama (WA)	7,400	104	3	0.3%
	EF Lewis (WA)	7,400	104	2	0.5%
	Salmon Creek (WA)	14,800	208	4	Unk
	Washougal (WA)	7,400	104	2	0.4%

[1] encounters are for eggs/fry and juveniles/smolts combined.

We calculated adult equivalents for the juvenile mortalities expected in Table 116 using Quinn (2005) as a basic source of information (SARs derived from over 215 sources). Quinn (2005) suggests steelhead SARs average 0.13% (= mortality rate average of 99.87%). This is lower than SARs obtained for Columbia River hatchery steelhead (Table 116; e.g. Kalama winter steelhead SAR average of 2.87%), therefore we used the higher SARs to calculate adult equivalents. Where no stock-specific SAR was available, we used the SAR from the closest geographic population. WDFW expects steelhead fry to be encountered and killed during RM&E activities in each watershed. We estimated how many fry would reach smolt stage using a fry-to-smolt survival rate from Quinn (2005) and then applied the SAR to calculate adult equivalents. We then converted this to the percentage of the natural spawning population using the most recent 5 year average of total spawners in each population (data from Section 2.2.1.10). We estimate these juvenile removals represent less than 1.7% of any given LCR steelhead population's total spawners, with the impact being less than 1.0% for over half the populations. Therefore NMFS concludes these expected take levels pose a negligible risk to LCR steelhead.

Operation of the North Fork Toutle River Fish Collection Facility will result in take of LCR steelhead through trapping, handling, and tagging and release mortality. Up to 650 natural-origin winter steelhead adults and up to 25 natural-origin summer steelhead adults would be trapped, handled, and or tagged before releasing them back into the North Fork Toutle River. As a result, less than 2%, or 13 adult winter and 1 adult summer steelhead would die as result of these activities. This mortality represents 4.7% of the recent 5-year average North Fork Toutle winter steelhead spawning abundance (there is no natural summer steelhead population) (Section 2.2.1.2) (Table 61 and Table 62). The effect on winter steelhead population productivity is expected to be offset or mitigated by enabling passage to otherwise inaccessible habitat and increasing natural population spatial structure. NMFS therefore concludes these expected take levels are negligible and do not pose a risk to the viability of the North Fork Toutle River steelhead natural population.

Both adult and juvenile LCR steelhead would be taken in the Kalama River during activities performed as part of the Kalama Research Program. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 117.

Table 117. Natural-origin juvenile LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under Kalama Research program monitoring funded through the Proposed Action (NMFS 2017).

MPG	Population (State)	Encountered[1]	Mortality	Adult equivalent	Average % of recent spawning population
Cascade Summer	Kalama (WA)	1,552 (adults)	Up to 21	21	5.9%
	Kalama (WA)	8,000 (juveniles)	Up to 550	16	
Cascade Winter	Kalama (WA)	1,012 (adults)	Up to 16	16	3.4%
	Kalama (WA)	8,000 (juveniles)	Up to 550	16	

[1] encounters are for eggs/fry and juveniles/smolts combined.

These expected adult mortalities represent 5.9% of the recent 5-year average adult total abundance of winter steelhead in the Kalama River (Table 61). The effect of this RM&E activity on the Kalama winter steelhead population is roughly half that of the summer population. Both populations are categorized as primary (necessary for recovery). Therefore NMFS concludes that the effects of this factor pose a negative risk to the viability of the Kalama summer steelhead population, and a low negative risk to the Kalama winter steelhead population.

Juvenile LCR steelhead are expected to be encountered in Mason Creek, Rock Creek of the East Fork Lewis River, Mill Creek of the East Fork Lewis River, and Mill Creek of Salmon Creek during activities associated with evaluation of the benefits and risks of juvenile wild fish rescue programs. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 118.

Table 118. Steelhead take table for juvenile fish rescue research evaluation to be conducted in tributaries of the East Fork Lewis River and Salmon Creek, LCR, Washington, from spring 2017 – spring 2018 (NMFS 2017) (egg/fry encounters/mortality added to juveniles).

MPG	Population (State)	Encountered[1]	Mortality	Adult equivalent	Average % of recent spawning population
Cascade Summer	East Fork Lewis (WA)	4,200	92	3	0.3%
Cascade Winter	East Fork Lewis (WA)	4,200	92	3	0.7%
	Salmon Creek (WA)	4,200	92	3	unknown

[1] encounters are for eggs/fry and juveniles/smolts combined.

Using a similar approach to estimate effects based on adult equivalents, we estimate that this RM&E activity will reduce the productivity of the East Fork Lewis River summer steelhead natural population by 0.3% and the East Fork Lewis River winter steelhead natural population by 0.7%. Effects on the Salmon Creek steelhead natural population are unknown. These levels are negligible, aside from the unknown effect to the Salmon Creek population, which is a sustaining population with a recovery goal of low viability (NMFS 2013e). The goal of the program is to rescue natural-origin fish that would otherwise perish because of summer low flows, and this should mitigate for any impacts to these populations. Furthermore these activities will reduce the likelihood of injury and/or mortality during the in-stream and out-migrant surveys by following the five best management practices described above in the LCR Chinook Salmon ESU review of this RM&E activity. Therefore NMFS concludes these expected take levels do not pose a risk to the viability of LCR steelhead.

Additional RM&E activities funded through the Proposed Action which do not result in take of LCR steelhead are:

- Population abundance and spawning composition of LCR steelhead. Surveys would occur but any adult steelhead observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Harvest monitoring in mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no take associated with these sampling activities. Therefore NMFS concludes these activities to have no effect on LCR steelhead.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish. These activities occur outside the range of LCR coho salmon, therefore, NMFS concludes that these activities will have no effect on the LCR steelhead.
- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR steelhead and there is no anticipated take associated with these sampling activities. Therefore NMFS concludes these activities would have no effect on the LCR steelhead.

MCR Steelhead DPS

MCR steelhead will be encountered during the following RM&E activities in the Klickitat River: spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis encounters. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 119.

Table 119. Natural-origin MCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities funded through the Proposed Action in the Klickitat River (NMFS 2017).

DPS	MPG	Population (State)	Encountered	Mortality	Adult[1] equivalent	Average % of recent spawning population
MCR Steelhead	Cascade Eastern Slope Tributaries	Klickitat River (adults)	Up to 1,005	Up to 26	26	1.5%
		Klickitat River (juveniles)	Up to 2,150	Up to 100	1	0.1%

[1] SAR of 1.45% was used to calculate adult equivalent.

Similar to the other RM&E effects determinations made above, we estimated the total adult equivalents calculated using SARs for converting juveniles and calculating the percentage of the spawning population the mortalities may have accounted for, using the most recent 5-year average of total spawners in the associated watershed, in this case the Klickitat River (Table 76). We estimate these removals represent less than 2% (1.6% for adults and juveniles combined) of the Klickitat River's natural-origin steelhead spawning population's total 5-year recent average. Therefore NMFS concludes these expected take levels are negligible and do not pose a risk to the viability of the MCR steelhead populations individually or collectively.

All other RM&E activities funded through the Proposed Action occur outside the range of MCR steelhead and there is no anticipated take associated with these sampling activities. Therefore NMFS concludes these activities have no effect on the MCR steelhead.

Snake River Basin Steelhead DPS

Snake River steelhead will be encountered during the following RM&E activities on the Klickitat River: spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. Up to 50 adult natural-origin Snake River Basin steelhead will either be captured, handled, tagged, and/ or sampled, and up to two adults will be killed. Relative to the annual abundance of Snake River Basin steelhead described in Section 2.2.1.12, NMFS concludes these expected take levels are negligible and do not pose a risk to the viability of the Snake River steelhead natural populations, either individually or collectively.

All other RM&E activities funded through the Proposed Action occur outside the range of Snake River Basin steelhead and there is no anticipated take associated with these sampling activities. NMFS therefor concludes these activities will have no effect on the Snake River.

2.4.2.5 Factor 6. Construction, operation, and maintenance of facilities that exist

NMFS (2017) details and analyzes the likely effects on ESA-listed species from the construction, operation, and maintenance of the hatchery facilities (i.e., facilities and operations) funded through the Proposed Action. Negative effects from facilities and operations include the following: the diversion of surface waters that affects streamflows used by fish, water intakes that kill or injure fish, return water that contains pollutants or that increases water temperatures, stream channel alteration and armoring, landscaping that thins or removes riparian vegetation, and hard surfaces that reduce infiltration and contribute contaminants to streams and rivers, e.g., motor vehicle oils, greases and other materials which effect embryo, juvenile, and adult survival.

Each facility that is required to operate under a NPDES permit does so, or in the case of the DRNPs, has applied for a permit. Effluent from each facility is monitored weekly to ensure compliance with permit requirements. Several acclimation sites do not need a NPDES permit because rearing levels are below permit minimums (see Section 1.3). Any sediment from the maintenance of instream structures at hatchery facilities would be localized and temporary and would not be expected to affect ESA-listed anadromous fish species.

For the Proposed Action, the primary source of effects on ESA-listed species is from the withdrawal of water from various sources and water intakes that do not meet current NMFS screening criteria (NMFS 2011b), but many of these facilities do meet earlier standards (NMFS 1996c; 2008a). Table 120 identifies those facilities needing improvements, the improvements needed, and the status of improvement directed activity. For these facilities, the Proposed Action requires that the operators submit to NMFS, by January 1, 2019, a comprehensive plan, for NMFS concurrence, that remedies the required improvements in Table 120.

Table 120 identifies those facilities needing improvements, the improvements needed, and status of improvement directed activity. For these facilities, operators that will be required to submit to NMFS, by January 1, 2019, a comprehensive plan that describes how they will repair, modify, or improve fish passage barriers and/or water intake screens.

Table 120. Hatchery facilities needing improvements (NMFS 2017).

Hatchery Facility	**Improvement Needed**	**Priority**
Grays River Hatchery	Primary intake does not meet criteria and dewaters section of stream between intake and hatchery outfall.	High
Fallert Creek Hatchery (Kalama R.)	Fallert Creek intake lost in 2016 flood will need to be updated to meet current criteria and to provide passage for NOR adults. Mainstem Kalama River pump screens have been updated but may not meet 2011 criteria	Med
Clackamas Hatchery	Mainstem Clackamas River intake does not meet criteria – new intake in River Mill Dam reservoir expected to be completed in 2017	Med
Klaskanine Hatchery	Mainstem Intake #1 does not meet current criteria, provide adult passage and Intakes #2 and #3.	Low

NF Toutle Hatchery	Surface intake – feasibility study completed in 2012, awaiting funding.	Med
Beaver Creek Hatchery (Elochoman R.)	Elochoman River intake being upgraded, expected to be completed in 2017.	Med
Kalama Falls Hatchery	Intake screens updated in 2006, may not meet 2001 criteria – considered low priority.	Low
Washougal Hatchery	Intake screens do not meet current criteria	Med
Klickitat Hatchery	Surface intake structure does not meet current criteria – currently under negotiations on remodel of intake	Low

NMFS (2017) describes the effects of the operation of various hatchery facilities on ESA-listed species. The majority of the effects on listed species are considered a "low negative". A facility is considered to have a "low negative" impact if the intake screens are operated to meet current NMFS screening criteria, hatchery water withdrawals are consistent with established water rights and in-stream flow requirements, the facilities are operated to maintain minimum flows between the intake structure and the hatchery outfall, and barriers to adult passage are operated to minimize delay and handling effects. These facilities have essentially minimized the effects of their operations on the ESA-listed species.

NMFS (2017) also identifies some facilities as having a "negligible effect". Facilities identified as such use water from non-anadromous sources, (e.g.; from above natural barriers, from wells, natural springs, and/or non-fish bearing streams), the facilities do not use surface water (e.g.; net-pens), and/or use relatively small amounts of stream flow over a short distance for a limited period of time (e.g.; small acclimation ponds).

NMFS (2017) finds that for the following ESUs/DPSs, hatchery facilities and operations included in the Proposed Action have a negligible or low negative effect: UCR spring-run Chinook Salmon ESU; Snake River spring/summer-run Chinook Salmon ESU; Snake River fall-run Chinook Salmon ESU; Snake River Sockeye Salmon ESU; UCR Steelhead DPS; UWR Steelhead DPS; and Snake River Basin Steelhead DPS. NMFS finds that further review and analysis for these ESUs/DPS is not warranted. The SRKW DPS is not directly affected by the operation of any of the hatchery facilities funded under the Proposed Action, because they do not occupy the freshwater areas where interaction may occur under this factor, therefore NMFS has determined there will be no effects to this ESA-listed species via this factor.

Facilities and operations identified as having a moderate or high negative effect are discussed below.

Pacific Eulachon Southern DPS

The majority of the hatchery facilities funded through the Proposed Action are not located within Pacific Eulachon DPS designated critical habitat. Those few that are located within designated critical habitat operate intake screens during periods of the year when adult and juvenile eulachon are not present in the river. As a result no effects on the Pacific Eulachon Southern DPS are expected from the operation of these facilities.

LCR Chinook Salmon ESU

Facilities and operations listed in Table 120 above may effect ESA-listed LCR Chinook salmon, except for the Klickitat Hatchery, which is located outside the ESU geographical boundary. The intake structure at the Grays River hatchery effects the Grays River fall Chinook salmon natural population through an intake structure that did at one time meet NMFS' 1996 screening criteria, but may not now due to shifting stream sediment loads and past flood events. In the ½ mile bypass reach between the intake and hatchery outfall, the intake removes up to 50% of the instream flows during the winter months and can dewater the entire section during the summer months. The removal of the water reduces spawning, rearing, and migration habitat within the West Fork of the Grays River. These effects are limited to the West Fork of the Grays River thus limiting the impacts to that tributary and not affecting habitat in the rest of the subbasin. Due to the adverse effects from the operation of this intake structure, full implementation of the plan to upgrade the facility must be completed by January 1, 2022, or NMFS will cease funding the operation of this facility. An alternative to a complete remodel of this facility is to move production to other facilities and only used this facility for adult collection and acclimation and release such that the intake in question is not used.

In the Kalama River, fall Chinook salmon do not, nor were they known to historically, migrate above the Kalama Falls or the Fallert Creek intake structures and thus would not be affected. The mainstem Kalama River intake at the Fallert Creek hatchery is operated only in the summer months when fall Chinook salmon juveniles are not present, but may have an effect on juvenile LCR spring Chinook salmon, though conditions in the lower Kalama River during the summer months are not conducive to juvenile rearing due to elevated river temperatures.

The operation of the North Fork Toutle, Beaver Creek, and Washougal hatchery facilities can also effect LCR fall Chinook salmon. The North Fork Toutle intake screens have not been updated since 1978 and do not meet current NMFS criteria. A feasibility plan for upgrading the intake was developed in 2012 but funds have not been available to complete the project. Flows in the bypass reach are sufficient such that requirements for minimum flows are not necessary.

The Beaver Creek hatchery intake on Beaver Creek currently meets NMFS criteria, however, the intake structure on the Elochoman River does not, and as a result has not been used in recent years. The Elochoman River intake is scheduled to be upgraded in 2017, minimizing any effects from the intake screens, and minimum flow requirements have been established in the bypass reach. The effects of the Washougal Hatchery intake on natural LCR fall Chinook salmon are expected to be minimal because the intakes are above the upper extent of the fall Chinook salmon spawning reach.

Intake structures at the Klaskanine and Clackamas hatcheries are not expected to have an effect on LCR fall Chinook salmon because fall Chinook salmon do not migrate above or past the facilities.

UWR Chinook Salmon ESU

Clackamas Hatchery is the only hatchery facility funded under the Proposed Action that would have an effect on the UWR Chinook Salmon ESU. The Clackamas Hatchery intake structure currently does not meet NMFS criteria, though impacts are expected to be small. During the period of peak withdrawals the hatchery takes less than 3% of the river flow, even during the low flow summer months, limiting the potential for natural juvenile fish to be entrained on the screens. Installation of a new intake screen compliant with NMFS criteria in the River Mill Dam reservoir upstream of the hatchery is expected to be completed in 2017. The new intake structure will remove more flow but is not expected to have a measurable impact on rearing and migration habitat in the bypass reach. The current intake structure will be maintained and may be used as a backup in emergency situations.

LCR Coho Salmon ESU

The LCR Coho Salmon ESU is affected by the operation of the same hatchery facilities affecting the LCR Chinook salmon ESU and the effects are the same except for the operations at Fallert Creek and Klaskanine hatcheries. At Fallert Creek Hatchery the intake structure on Fallert Creek does not meet NMFS criteria and the hatchery facility blocks passage of coho salmon above the hatchery into Fallert Creek. This limits the spatial distribution of the coho salmon population in the Kalama River and possibly its productivity. The intake structure was recently damaged due to flooding. Plans are being developed to upgrade the intake structure to meet NMFS criteria and to evaluate the potential for upstream passage. Similarly, the Klaskanine Hatchery intake #1 does not meet NMFS criteria, having an effect on outmigrating juvenile coho salmon that encounter the screen. The hatchery intake structure blocks upstream passage and all NOR coho salmon are collected and transported above the two other hatchery intake structures (#2 and #3). Impacts can occur if adult coho salmon fall back downstream of the two upstream intake structures and become trapped due to these intake structures not incorporating upstream passage. The hatchery operators will be required to develop a plan for screening intake #1 and evaluating passage at the other intakes. Impacts are localized to the North Fork Klaskanine River above the hatchery which represents only a small proportion of the habitat within the Youngs Bay coho salmon population, which is considered a sustaining population with a low viability goal in recovery planning (NMFS 2013e, Table 3-1).

Impacts on LCR coho salmon can also occur at the Washougal Hatchery due to screens not meeting current NMFS criteria and because coho salmon spawn above the hatchery. These impacts are expected to be small because the intake is screened, but it is unclear if the approach velocities exceed current NMFS criteria. NMFS (2017) will require the operator to develop a plan to evaluate and determine if the screens need to be upgraded.

CR Chum Salmon ESU

Impacts on the CR Chum Salmon ESU are expected to be similar to those identified for the LCR Chinook salmon ESU. Impacts on chum salmon from the operation of the hatchery facilities funded under the Proposed Action would be expected to be less than those identified for fall Chinook salmon because the natural distribution of chum salmon in the LCR is less than that observed for fall Chinook salmon limiting the potential for interactions between chum salmon and these facilities and operations. Any improvements to the hatchery facilities listed in the table above would be expected to also to reduce impacts on chum salmon where the two overlap.

LCR Steelhead DPS

Impacts on LCR Steelhead are similar to those identified for the LCR Chinook Salmon and LCR Coho Salmon ESUs where the steelhead DPS' distribution overlaps that of the two ESUs. Improvements in the North Fork Toutle, Kalama Falls, Fallert Creek, Washougal, and Clackamas hatchery facilities and operations would also benefit LCR steelhead populations.

MCR Steelhead DPS

The Klickitat Hatchery is the only facility funded under the Proposed Action that is operated within the MCR Steelhead DPS geographic boundary. The current Klickitat River intake does not meet NMFS screening criteria and does not prevent juvenile fish from entering the rearing ponds. This can delay downstream migration if the listed steelhead juveniles are actively migrating. Delay would occur until all of the fish are released from the pond. The intake is operated beginning in the spring removing a small proportion (>3%) of the Klicktat River to supplement water supplied from Wonder Springs. The Yakama Nation, NMFS (Mitchell Act), and the Bonneville Power Administration are currently in negotiations on a remodel of the Klickitat Hatchery that would include upgrades or modifications to the mainstem intake facility.

Summary

The effects of these facilities and operations on the listed ESUs/DPSs do not rise to the level where they would be expected to limit the abundance and productivity of individual populations within the ESUs/DPSs except possibly the Grays River salmon populations. The other facilities and operations affecting listed salmon and steelhead populations are either scheduled to be upgraded such that effects are reduced or have intake screens in place that may not currently meet current criteria for approach and sweeping velocities, but these facilities only affect that proportion of the natural-origin juvenile outmigrants that encounter the intake screen. The adverse effects on those juvenile migrants that encounter the screens are not expected to reduce the abundance or spatial distribution of the ESA-listed populations such that these impacts would jeopardize the likelihood of survival and recovery of the listed ESU/DPS.

2.4.2.6 Factor 7. Fisheries that exist because of the hatchery program

Fisheries are not a part of the Proposed Action. However, there are fisheries that exist because of the Proposed Action. Certain terminal fisheries within the tributaries of the LCR downstream of Bonneville Dam meet the "but for" test, meaning these fisheries would not occur "but for" the Proposed Action. The majority (in some cases 100%) of the hatchery salmon and steelhead produced in these tributaries are a direct result of current Mitchell Act funding, and this will continue under the Proposed Action. While NMFS can analyze the effects of these fisheries, we are not authorizing them through this consultation. Fisheries existing outside of these terminal tributary areas, those in the mainstem Columbia River and the Pacific Ocean would exist with or without the Proposed Action and have previously been evaluated in separate biological opinions (NMFS 2008e; 2012d; 2014d).

Pacific eulachon and SRKW, as a result of the Proposed Action, will not be affected by interrelated fisheries. These fisheries target salmon or steelhead in the terminal freshwater areas when neither of these species are present, and salmon that maybe incidentally taken during these fisheries would have already passed through areas of interaction with SRKW, therefore, NMFS has determined there will be no effects to these ESA-listed species via this factor under the Proposed Action.

NMFS expects no effects under this factor on the UCR spring–run Chinook Salmon ESU, Snake River spring/summer-run Chinook Salmon ESU, Snake River fall-run Chinook Salmon ESU, UWR Chinook Salmon ESU, CR Chum Salmon ESU, SR Sockeye Salmon ESU, LCR Steelhead DPS, UCR Steelhead DPS, Snake River Basin Steelhead DPS, MCR Steelhead DPS, and the UWR Steelhead DPS as a result of the Proposed Action (Table 90). Any fisheries encountering these species throughout the Action Area have current consultations in place and these effects are described in the Environmental Baseline (Section 2.3.5).

Effects of this factor on ESA-listed species are described in the following sections.

LCR Chinook Salmon ESU

Hatchery releases of Chinook salmon in the Sandy River, Washougal River, Kalama River, Big Creek, and Grays River are 100% funded by the Proposed Action. Fisheries targeting hatchery Chinook salmon therefore exist in these terminal rivers as a result of the Proposed Action. Terminal fisheries were analyzed in 2003 (NMFS 2003b) for their effects to LCR Chinook Salmon, where NMFS determined that WDFW and for their effects to LCR Chinook Salmon, where NMFS determined that WDFW and ODFW adequately addressed the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon in the relevant FMEPs. These FMEPs limited tributary harvest levels of managed fisheries to achieve the 5,700 escapement goal for bright fall-run Chinook salmon. The FMEPs expected that fisheries in terminal areas would continue to implement mark selective fisheries (MSFs[39]) with the advent of mass-marking hatchery releases. The plans also kept harvest rates limited to those below the rate developed during the PFMC process described above in the Ocean Harvest Section for fall-run tule Chinook salmon (see Section 2.3.5.1) However, in 2012 NMFS evaluated an alternate management approach for the LCR Chinook Salmon ESU in an ABM[40] (abundance-based

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[39] Mark-selective fisheries only target hatchery salmon identified by external marks allowing fisheries to exclude or release unmarked natural-origin fish.

[40] As discussed in Section 2.3.5, an ABM (or abundance-based management) matrix is where a tier of associated harvest or exploitation rate is set based on the abundance of fish, generally with lower abundances resulting in lower rates and vice versa for increased abundances.

management approach matrix (NMFS 2012d) for the tule component of the ESU. While this new approach of using an ABM matrix resulted in weak-stock management to the degree possible at the time, by reducing the allowable exploitation rate when abundance is low, it also reduced extinction risk to the LCR tule components of the LCR Chinook salmon ESU by approximately 4% (NMFS 2012d). This action was evaluated with a population specific risk evaluation, based in large part using data on the same populations affected by the Proposed Action analyzed in this opinion. These effects are captured in the baseline (Section 2.3). This short review helps frame our expectations relative to pre-terminal fisheries analyses that inform the interrelated effects of terminal fisheries.

Terminal area fisheries are not currently included in the calculated exploitation rate tiers as part of the ABM matrix approach that NMFS evaluated in 2012 (NMFS 2012d). The two vectors of effect are removal of hatchery fish from terminal areas via MSFs, so the ability to affect pHOS levels, and incidental mortality of natural-origin fish via encountering fish while trying to access hatchery returning fish. As discussed in Section 2.2.1.2 and elsewhere, these natural populations still have high levels of hatchery fish (i.e., pHOS) on the spawning grounds. This indicates that terminal area fisheries are not achieving high levels of success for capturing adult hatchery returns or fisheries are restricted for other reasons. The ABM matrix approach was considered equivalent to a long-term effect of a fixed exploitation rate of 37% on the tule component of the ESU, a decrease from the 49% rate incorporated into NMFS' 2003 evaluation of FMEPs addressing the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon (NMFS 2003b). Preterminal fishery restrictions increasing fish back to terminal areas exists where management of fisheries for a 5,700 escapement goal for bright fall-run Chinook salmon in the Lewis River has resulted in consistent and increasing large escapements that exceed the minimum goal (Table 22). Therefore, assuming the same level of terminal area fishing pressure authorized under NMFS's 2003 evaluation (NMFS 2003b) the resulting decrease in pre-terminal fisheries has passed more fish, both hatchery and natural-origin, into the terminal areas. Here NMFS is not authorizing or examining a take level for fisheries, as they are not part of the Proposed Action, but instead is simply ensuring it is incorporating their interrelated effects.

As part of the Proposed Action, new weirs will be implemented, notably in every river mentioned at the beginning of this section, except for Big Creek and Kalama River (which both have hatchery weirs). In the recent past, state-managed fisheries upstream of weirs have been closed as weirs have removed harvestable hatchery fish at their location. NMFS expects this practice to continue where it implements weirs as part of its Proposed Action (except at the lower Washougal River weir because the operation of the weir there is primarily for broodstock collection rather than pHOS control in the Washougal River). Because new weirs are needed to control hatchery strays, terminal fishery pressure in these specific areas is likely to decrease from current levels. Therefore, the negative effects of terminal fisheries are included in the baseline, but as a result of the proposed action those effects are likely to be reduced as a result of implementation of the Proposed Action, and the effects to natural-origin populations from incidentatl mortality associated from catch and releasing natural-origin fish while targeting hatchery-origin fish will decrease as areas upstream of weirs are restricted to fishing.

In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Proposed Action, to submit detailed updated FMEPs evaluating fishery effects on each LCR Chinook salmon natural population for ESA authorization.

LCR Coho Salmon ESU

Hatchery releases of coho salmon in the Sandy River, Washougal River, Kalama River, Big Creek, Klaskanine River, and Grays River are 100% funded by the Proposed Action. Fisheries targeting hatchery coho salmon therefore exist in these terminal rivers as a result of the Proposed Action. Terminal fisheries in these areas have not been analyzed in separate opinions for their effects on ESA-listed species. However, similar to Chinook salmon, NMFS has available information relative to pre-terminal fisheries analyses that inform the interrelated effects of terminal fisheries. Here NMFS is not authorizing or examining take levels for fisheries, as they are not part of the Proposed Action, but instead is simply ensuring it is incorporating their associated interrelated effects.

In 2014 NMFS evaluated an updated harvest matrix the PFMC proposed for LCR coho salmon. The PFMC proposed to manage fisheries, including fisheries in the mainstem Columbia River up to Bonneville Dam, based on exploitation rate limits using two levels of parental escapement and five levels of marine survival (NMFS 2014d). As described in Section 2.3.5, NMFS evaluated this strategy in a 2014 biological opinion and concluded that PFMC Fisheries managed via this manner were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (NMFS 2014d). While terminal area fisheries are not currently included in the calculated exploitation rate tiers in the coho harvest matrix, the resulting escapements that currently contribute to LCR coho salmon population status are the result of any fisheries implemented at both the preterminal and terminal levels. These escapements were used for evaluating the proposed alterations to the coho harvest matrix. Similar to the previous subsection on LCR Chinook salmon immediately above, this brief review of baseline effects for LCR coho salmon (discussed in more detail in Section 2.3.1), directly informs our expectations for interrelated effects of fishing in the terminal areas.

While it is unclear if fishing pressure has changed in the terminal areas during the timeframe similar to LCR Chinook salmon, LCR coho salmon harvest rates have been reduced substantially over the last two decades and this has resulted in the level of escapements captured in Section 2.2.1.7. The two vectors of effect are the same as we described for Chinook salmon, removal of hatchery fish from terminal areas via MSFs, so the ability to affect pHOS levels, and incidental mortality of natural-origin fish via encountering fish while trying to access hatchery returning fish. As discussed in Section 2.2.1.7 and elsewhere, these natural populations still have high levels of hatchery fish (i.e., pHOS) on the spawning grounds. This indicates that terminal area fisheries are not achieving high levels of success for capturing adult hatchery returns or fisheries are restricted for other reasons.

As part of the Proposed Action, extended weir operations will be implemented, notably for coho in the Elochoman River. In the recent past, state-managed fisheries upstream of weirs have been closed as weirs have removed harvestable hatchery fish at their location. NMFS expects this practice to extend where it implements weirs as part of its Proposed Action, and therefore terminal fishery pressure in these specific areas is likely to decrease from levels that currently may be occurring. Therefore, terminal fishery effects are likely to be reduced as a result of implementation of the Proposed Action, and effects to natural-origin populations from incidental mortality associated with catch and releasing natural-origin fish while targeting hatchery-origin fish will decrease as areas upstream of weirs are restricted to fishing.

In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Proposed Action, to submit detailed updated FMEPs evaluating fishery effects on each LCR coho salmon natural population for ESA authorization.

2.4.2.7 Effects to SRKW

The Proposed Action may affect SRKW indirectly by reducing the availability of prey species. This analysis focuses on effects to Chinook salmon availability in the ocean because best available information indicates that Chinook salmon, particularly large Chinook salmon, are a preferred prey source for SRKW and Chinook salmon abundance is correlated with vital rates of the whales. The Proposed Action would reduce tule fall Chinook salmon hatchery production and the abundance of tule fall Chinook salmon in the ocean and we evaluated the short-term effects of this reduction on SRKW, defined here as the length of time it will take to implement reductions in hatchery tule Chinook salmon production. As described in the BA (NMFS 2017), the implementation would occur over five years, during which the reduction in Chinook salmon hatchery production would occur in a series of steps. We also evaluated the long-term effects, defined here as following the full implementation of the Proposed Action and over the time period when any potential benefits to wild salmon are realized, which could take decades. Although the long-term effects remain general due to the uncertainty surrounding the precise time it will take for any possible benefits to be fully realized, we have none the less divided the indirect effects into this time structure because the indirect effects will largely change through time and will be different over the short- and long-term.

Here we describe the potential effects of the reduced hatchery production on SRKW based on the best scientific information about SRKW predominant consumption of Chinook salmon, their energetic requirements, and the availability of Chinook salmon coast-wide and at the mouth of the Columbia River. We considerd the reduction in hatchery Chinook salmon caused by the Proposed Action in the context of the relationship between Chinook salmon abundance and SRKW population dynamics. Lastly, we evaluated the potential long-term benefits of wild Chinook salmon to SRKW.

Relationship between Chinook Abundance and SRKW Population Dynamics

Statistical correlations between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of SRKW have been outlined in several papers and examined in great detail (e.g., Hilborn et al. 2012). In addition to examining whether any fundamental linkages between vital rates and prey abundance are evident, another primary purpose of many of these analyses has been aimed at distinguishing which Chinook salmon stocks, or group of Chinook salmon stocks, may be the most closely related to these vital rates for SRKW. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential, as most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. If anything, large aggregations of Chinook salmon stocks that reflect abundance on a coast-wide scale appear to be as equally or better correlated with SRKW vital rates than any specific or smaller aggregations of Chinook salmon stocks, including those that originate from the Fraser River that have been positively identified as key sources of prey for SRKW during certain times of the year in specific areas (see Hilborn et al. 2012; Ward et al. 2013). However, there are still questions about the diet preferences of SRKW throughout the entire year, as well as the relative exposure of SRKW to various Chinook or other salmon stocks during the summer and fall. Given the available information, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKW may be as influential on their vital rates as any other relationships with any specific stocks. In this analysis we also consider reductions in available Chinook salmon in a more localized area at the mouth of the Columbia River to identify the potential for local depletion of prey.

NMFS has been developing a risk assessment framework relating Chinook salmon abundance to SRKW population dynamics that will help evaluate the impacts of salmon management on SRKW. At this time, development of the framework is on a coast-wide scale and intended for broad applicability across actions that impact salmon. NMFS' work to develop the risk assessment is ongoing. The best available science suggests that changes in Chinook salmon abundance are likely to directly influence the SRKW population, given there is clear evidence that survival and fecundity rates appear to be relatively well correlated with Chinook salmon abundance levels. Our analysis examines the effects of short- and long-term effects of the action on the prey available to SRKW and how that may influence the health of individual SRKW and the DPS.

Degree of Spatial and Temporal Overlap in Distributions of SRKW and Salmon

In the short term, the Proposed Action will continue to fund hatcheries that provide prey for SRKW, but at a reduced rate from previous years during time periods when the spatial distribution of affected Chinook salmon and SRKW overlap. Here we describe that overlap.

SRKW spend the majority of the summer months in the inland waters of Washington and British Columbia, whereas in non-summer months they are observed less often in the inland waters. Detection rates in coastal waters using passive acoustic recorders further reveal that SRKW spend more time off the Columbia River and Westport, particularly in the spring, than previously anticipated (Hanson et al. 2013). Satellite-linked tagging data (NWFSC unpubl. data) that spanned from late December through mid-May and were collected over the course of several years (2012 – 2016) indicate that J pod moved primarily between the northern Strait of Georgia and the entrance of the Strait of Juan de Fuca and only had limited occurrences in the coastal waters, whereas K and L pods traveled along the coast from the Strait of Juan de Fuca to Pt. Reyes, California.

Differences in adult salmon life histories and locations of their natal streams affect the distribution of salmon across the SRKW coastal range. For those originating from the Columbia River, salmon range as far north as Alaska, however, the primary areas of overlap with SRKW may be in British Columbia along Vancouver Island and down the Washington and Oregon coasts to central Oregon (Weitkamp 2010). The large majority of Chinook salmon that would be affected by the Proposed Action, the early-type fall Chinook salmon commonly referred to as tule Chinook, are a significant contributor to catch off Washington and northern Oregon. This stock makes up an increasing percentage of the salmon catch in marine areas closer to the mouth of the Columbia River. However, information on their distribution has been collected only when salmon fisheries are open (May through September for Pacific Ocean fisheries). Mature fish enter the Columbia River en masse approximately from the end of July through August. Their range is less well known during the seasons when fisheries are closed, late fall through early spring (Oct-April).

From 2009 – 2015, 55 scale and tissue samples were collected from SRKW predation events in coastal waters (NWFSC unpubl. data). Just over 78% of the samples were Chinook salmon. Furthermore, genetic analysis of the data indicate that Columbia River Chinook salmon, including tule Chinook salmon, are a part of the coastal diet of SRKW. Based on these data, and the degree of spatial and temporal overlap in the distribution of SRKW and Chinook salmon, we conclude that tule Chinook are included in the diet for at least most SRKW (particularly K and L pod members) during portions of the year when SRKW occur in coastal waters off Washington and Oregon.

Prey Availability and Food Energy Needs in Coastal Waters

In order to understand the short-term effects of the Proposed Action, we assessed the SRKW food energy needs from Chinook salmon using the best available information on their diet composition, metabolic needs, and time spent in coastal waters. Noren (2011) developed estimates of the potential range of daily energy expenditure and prey energy requirements for SRKW for all ages and both sexes. NMFS combined this information with the population census data to estimate daily energetic requirements for all members of the Southern Resident population, based on the current estimate of 79 whales in the DPS. The model provides a range in daily energy requirements, which represents uncertainty in the estimates.

We focused on the maximum estimates for several reasons. The maximum and minimum field metabolic rates (FMRs, or daily energy expenditure) reported by Noren (2011) fall within the range of FMRs of killer whales, based on daily activity budgets. Thus, the maximum of this reported range from Noren (2011) used in this biological opinion represent realistic values for killer whales. The FMRs and resulting calculated daily prey energy requirements from Noren

(2011) do not account for the increased energetic cost of body growth in juvenile whales or the increased cost of lactation in females who are nursing calves. Although the costs of these physiological processes are not precisely known, they could significantly affect the daily prey energy requirements of specific individuals that fall within these categories. For example, prey consumption rates in lactating females can increase 1.5–2 times over consumption rates of non-lactating females (Kriete 1995; Kastelein et al. 2002; Kastelein et al. 2003a; Kastelein et al. 2003b). By using the maximum daily prey energy requirements, our calculations account for energetic costs in the population that may be underestimated by Noren (2011). This approach is also reasonable because the maximum prey energy needs are still within the normal range of adult and non-lactating female killer whales that do not have increased energetic burdens due to the physiological processes of growth and lactation.

Hanson and Emmons (2010) provided a compilation of SRKW sightings specific to each pod in inland waters (January 2003 to December 2009). For purposes of this analysis, we assumed that SRKW occurred west of the Strait of Juan de Fuca (in coastal waters) on days they were not sighted in inland waters, primarily because the population is highly visible in inland waters. Because the geographic distribution of the pods differ (with K and L pod members observed spending more time in coastal waters than J pod members), we analyzed the effects of reduced prey availability at both the pod level and population level. We computed the daily energy requirements by pod based on the age and sex structure of all individuals in each pod, and multiplied the daily energy requirements of each pod by the number of days in the model time step that the pod was in coastal waters.

Noren (2011) had estimated that SRKW (population of 82 at the time) subsisting entirely on Chinook salmon would need approximately 792-951 fish per day or up to 347,000 fish per year, based on an average energy value for Chinook salmon of 16,386 kcal per fish. It is important to note these are just estimates of food energy requirements and can vary depending on the fish species and fish population consumed. Chinook salmon have the highest value of total energy content of the anadromous salmonids because of their larger body size and higher energy density (O'Neill et al. 2014). For a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). More realistically, SRKW consume a variety of fish and likely require fewer Chinook salmon than estimated here. Bearing this in mind, we developed estimates of caloric needs in coastal waters using updated information on salmon and SRKW to put in context the reduction of the whales' prey from the action.
Based on the distribution of SRKW and estimated annual prey energy requirements (in kcal) for each pod, we estimate that SRKW need over 3 billion kcal when not in inland waters. J pod likely needs almost 900 million kcal of energy when not in inland waters, whereas K and L pod's coastal energy requirements are likely between 1 and 2 billion kcals. The total energy value (in kcal per fish) of adult Chinook salmon is correlated with mass and lipid content and varies among populations (O'Neill et al. 2014). Given the estimated prey energy requirements and a more recent estimate of the average total energy content of Chinook salmon (average is 13,409 kcal per fish; O'Neill et al. 2014), SRKW would need approximately 300,000 Chinook salmon per year to meet their energy needs when in coastal waters. If we assume only K and L pods are affected by the Proposed Action because of their more coastal distribution compared

to J pod, the SRKW would need approximately 215,000 adult Chinook salmon in coastal waters to meet their energy needs (assuming their diet is 100% Chinook, which is an overestimate based on coastal prey data).

Short-term Reductions in Prey Availability

To evaluate the effects of the Proposed Action we have estimated percent reductions of food energy in a localized area off the mouth of the Columbia River and across the coastal range of SRKW. Our estimates reflect annual and seasonal variability in Chinook salmon ocean abundance. The Proposed Action will continue to provide prey to SRKW, but the 24% reduction in hatchery production will result in measurable adult prey reductions of an average of approximately 25,000 adult equivalents per year in future years as the Chinook salmon mature. This reduction may result in 1-4% fewer adult Chinook salmon in the localized area off the mouth of the Columbia River. This reduction in hatchery production of 25,000 adult equivalents per year is equivalent to almost 300 million kcals (25,000 fish * 13,409 kcal/fish) of food energy. This calculated reduction is probably a high estimate of the prey loss to SRKW for two reasons. First, whales like larger Chinook salmon, and some of these fall Chinook will return at 2 or 3 years of age rather than 4, so would be less attractive. Second, it assumes that all these tule Chinook salmon are potential prey items, but the extent to which SRKW prey on tule fall Chinook is unknown.

The PFMC provides ocean abundance estimates for Chinook salmon that originate from the U.S. systems (PFMC 2016a). Between 2008 and 2016, escapement forecasts for Columbia River Chinook salmon stocks ranged from approximately 741,000 to 1,960,800 fish; Puget Sound stocks ranged from 150,600 to 269,800 fish; Washington coast stocks ranged from 65,500 to 115,900 fish, and Oregon and California coast stocks ranged from 142,200 to 1,651,800 fish. The average total Chinook salmon abundance from these sources was approximately 2,035,778 fish. Therefore, a 24% reduction in tule Chinook salmon (or approximately 25,000 adults) would be a small portion (or approximately 1%) of the total estimated ocean escapement that may be available to SRKW. While the average total Chinook salmon escapement estimate does reflect many of the significant populations of Chinook salmon along the U.S. coast, this does not include any totals from significant Canadian Chinook populations that are likely encountered by SRKW to some degree, in particular Fraser River and West Coast Vancouver Island stocks. Therefore, the reduction in Columbia River tule Chinook would likely be less than 1% of the available Chinook salmon across the SRKW range.

These estimates of prey reduction are also considered maximum reductions for several other reasons. As hatchery production is reduced, overall salmon abundance is reduced which may result in some reductions in fisheries. Continued but reduced abundance of harvestable Chinook salmon may be associated with lower catches and possibly lower annual fishing quotas. In addition it is unlikely that SRKW would encounter and consume all 25,000 adult equivalent fish annually because the spatial and temporal distributions of whales and fish are not entirely overlapping; there is a low probability that all 25,000 of these particular Chinook salmon would be intercepted by SRKW across their vast range in the absence of the Proposed

Action. There are also additional salmon predators that might encounter and consume these specific Chinook salmon.

Because there is no available information on SRKW foraging efficiency, it is difficult to quantify the effect of these small reductions in prey available to the SRKW coast wide. A change in the localized prey base off the mouth of the Columbia River (an area of *suggested* importance to the whales) from the reductions in hatchery production could result in SRKW abandoning this area in search of more abundant prey or expending substantial effort to find depleted prey resources. This could result in a potential increase in energy demands which would have the same effect on an animal's energy budget as reductions in available energy, such as one would expect from reductions in prey.

Given the degree of prey reduction and general overlap in SRKW and Chinook salmon distributions described above, in the short term, the Proposed Action is likely to benefit SRKW with continued production, but the reduced hatchery levels will result in a net adverse effect on them. When prey is reduced, SRKW would likely need to spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources. As a chronic condition it can lead to reduced body size and condition of individuals, and lower reproductive and survival rates of a population (e.g., Trites and Donnelly 2003).

Very poor condition is detectable by a depression behind the blowhole that presents as a "peanut-head" appearance. There have been several SRKW that have been observed with the "peanut-head" condition, and the majority of these SRKW died relatively soon after this observation. More recently, photographs of whales from an unmanned aerial system (i.e., a drone) have been collected and individual whales in poor condition have been observed. None of the SRKW that died following these observations were subsequently recovered, and therefore a definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition. Regardless of the cause(s) of death, it is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females (e.g., Daan et al. 1996; Gamel et al. 2005) and juveniles (e.g., Trites and Donnelly 2003; Noren et al. 2009) which have been studied extensively. Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey availability. Ford and Ellis (2006) report that SRKW engage in prey sharing about 76% of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (*i.e.*, if the most successful foragers did not share with other individuals). Therefore, although cause of death for these specific individuals is unknown, poor nutrition could contribute to additional mortality in this population.

Long-term effects on SRKW

As described above in Sections 2.4.2.1 through 2.4.2.6, it would be expected that where there are self-sustaining, moderately abundant, natural-origin populations of Chinook salmon that a significant reduction in the level of hatchery-origin spawners may increase the per-spawner productivity level in the population in the long run. However, with the current habitat conditions, immediate and meaningful increased productivity or abundance is not certain, and increases in abundance of natural-origin Chinook salmon may only occur over extended periods in the future (i.e., decades). There is and will be continued monitoring in place to assess the status and trend in natural-origin Chinook salmon and the indirect effects on SRKW.

There are not many examples of program modifications similar to the proposed hatchery reductions that are expected to reduce the ecological and genetic effects of hatchery fish on ESA-listed natural-origin fish. However, the recovery of Hood Canal Summer chum salmon involved hatchery programs identified as affecting recovery (fall chum, fall Chinook, coho, and pink salmon programs) being reduced or eliminated in the 1990s. Abundance of wild and hatchery origin summer chum markedly increased in the mid-2000s after these changes in hatchery programs were implemented (reviewed in Kostow 2012). In 2015, escapement of Hood Canal summer chum was 32,569, which was up from 2,429 in 1994. Additionally, in order to protect natural-origin Oregon Coast coho salmon hatchery releases of juvenile coho dropped from 34 million in 1981 to 1.6 million in the early 2000s. Productivity of natural-origin coho was lowest during the periods of highest hatchery spawner densities and increased when the number of smolts released from hatcheries along with the number of hatchery fish spawning in the wild decreased (reviewed in Buhle et al. 2009).

While the time frame and magnitude of the improvements for natural-origin Chinook salmon are difficult to quantify, supporting recovery of salmon is an important action identified in the Recovery Plan for SRKW (NMFS 2008f). The phased approach for monitoring and implementing reductions in hatchery production will provide opportunities to evaluate this action and will also phase in reductions in prey and impacts to SRKW over a number of years. After implementation it will also take several years before the reductions are realized as SRKW preferentially feed on older adult Chinook salmon. Ongoing monitoring and recovery actions for both listed Chinook salmon and the SRKW are ongoing and intended to improve the outlook for both species. As additional information is available on the status of the salmon and SRKW populations, we will update our assessments to inform evaluation of this and other future actions.

Conclusion

In summary, the Proposed Action will continue to benefit SRKW by providing prey. The reduction in hatchery releases will adversely affect SRKW in the short term, but in the long term may be beneficial. Tule fall Chinook salmon are likely part of the diet for at least most SRKW during portions of the year when SRKW occur in coastal waters off Washington and Oregon. The proposed 24% reduction in hatchery production, which equates to an average of 25,000 adult equivalents per year, will cause measurable adult prey reductions (1 - 4% fewer adult Chinook off the mouth of the Columbia River). The short-term reductions annually (that could last several decades), may cause SRKW to spend more time foraging, which may increase energy expenditure and can cause nutritional stress, leading to reduced body size and condition of individuals which could lead to lower reproductive and survival rates of a population. The effects of reduced prey availability would be greater off the mouth of the Columbia River and would be much smaller magnitude of effect across the range of SRKW. These reductions however, are small and are likely an overestimate as they don't account for all available Chinook salmon (and other known prey) in the SRKW range or potential reductions in fisheries that may affect overall abundance of Chinook salmon. It is also unlikely that SRKW would have encountered and consumed all the fish in the absence of the Proposed Action. Over the long term the action may be beneficial as its purpose is to improve the status of listed Chinook salmon, however, it is not clear how long it will take for any benefits to be realized.

LCR Coho Salmon ESU

Hatchery releases of coho salmon in the Sandy River, Washougal River, Kalama River, Big Creek, Klaskanine River, and Grays River are 100% funded by the Proposed Action. Fisheries targeting hatchery coho salmon therefore exist in these terminal rivers as a result of the Proposed Action. Terminal fisheries in these areas have not been analyzed in separate Opinions for their effects on ESA-listed species. However, similar to Chinook salmon, NMFS has available information relative to pre-terminal fisheries analyses that inform the interrelated effects of terminal fisheries. Here NMFS is not authorizing or examining take levels for fisheries, as they are not part of the Proposed Action, but instead is simply ensuring it is incorporating their associated interrelated effects.

In 2014 NMFS evaluated an updated harvest matrix the PFMC proposed for LCR coho salmon. The PFMC proposed to manage fisheries, including fisheries in the mainstem Columbia River up to Bonneville Dam, based on exploitation rate limits using two levels of parental escapement and five levels of marine survival (NMFS 2014d). As described in Section 2.3.5, NMFS evaluated this strategy in a 2014 Opinion and concluded that PFMC Fisheries managed via this manner were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (NMFS 2014d). While terminal area fisheries are not currently included in the calculated exploitation rate tiers in the coho salmon harvest matrix, the resulting escapements that currently contribute to LCR coho salmon population status are the result of any fisheries implemented at both the preterminal and terminal levels. These escapements were used for evaluating the proposed alterations to the coho salmon harvest matrix. Similar to the previous subsection on LCR Chinook salmon immediately above, this brief review of baseline effects for LCR coho salmon (discussed in more detail in Section 2.3.1), directly informs our expectations for interrelated effects of fishing in the terminal areas.

While it is unclear if fishing pressure has changed in the terminal areas during the timeframe similar to LCR Chinook salmon, LCR coho salmon harvest rates have been reduced substantially over the last two decades and this has resulted in the level of escapements captured in Section 2.2.1.7. The two vectors of effect are the same as we described for Chinook, removal of hatchery fish from terminal areas via MSFs, so the ability to affect pHOS levels, and incidental mortality of natural-origin fish via encountering fish while trying to access hatchery returning fish. As discussed in Section 2.2.1.7 and elsewhere, these natural populations still have high levels of hatchery fish (i.e., pHOS) on the spawning grounds. This indicates that terminal area fisheries are not achieving high levels of success for capturing adult hatchery returns or fisheries are restricted for other reasons.

As part of the Proposed Action, extended weir operations will be implemented, notably for coho salmon in the Elochoman River. In the recent past, state-managed fisheries upstream of weirs have been closed as weirs have removed harvestable hatchery fish at their location. NMFS expects this practice to extend where it implements weirs as part of its Proposed Action, and therefore terminal fishery pressure in these specific areas is likely to decrease from levels that currently may be occurring. Therefore, terminal fishery effects are likely to be reduced as a result of implementation of the Proposed Action, and effects to natural-origin populations from incidental mortality associated with catch and releasing natural-origin fish while targeting hatchery-origin fish will decrease as areas upstream of weirs are restricted to fishing.

In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Proposed Action, to submit detailed updated FMEPs evaluating fishery effects on each LCR coho salmon natural population for ESA authorization.

2.4.2.8 Effects to SRKW

The Proposed Action may affect SRKW indirectly by reducing the availability of prey species. This analysis focuses on effects to Chinook salmon availability in the ocean because best available information indicates that Chinook salmon, particularly large Chinook salmon, are a preferred prey source for SRKW and Chinook salmon abundance is correlated with vital rates of the whales. The Proposed Action would reduce tule fall Chinook salmon hatchery production and the abundance of tule fall Chinook salmon in the ocean and we evaluated the short-term effects of this reduction on SRKW, defined here as the length of time it will take to implement reductions in hatchery tule Chinook salmon production. As described in the BA (NMFS 2017), the implementation would occur over five years, during which the reduction in Chinook salmon hatchery production would occur in a series of steps. We also evaluated the long-term effects, defined here as following the full implementation of the Proposed Action and over the time period when any potential benefits to wild salmon are realized, which could take decades. Although the long-term effects remain general due to the uncertainty surrounding the precise time it will take for any possible benefits to be fully realized, we have none the less divided the indirect effects into this time structure because the indirect effects will largely change through time and will be different over the short- and long-term.

Here we describe the potential effects of the reduced hatchery production on SRKW based on the best scientific information about SRKW predominant consumption of Chinook salmon, their energetic requirements, and the availability of Chinook salmon coast-wide and at the mouth of the Columbia River. We considered the reduction in hatchery Chinook salmon caused by the Proposed Action in the context of the relationship between Chinook salmon abundance and SRKW population dynamics. Lastly, we evaluated the potential long-term benefits of wild Chinook salmon to SRKW.

Relationship between Chinook Abundance and SRKW Population Dynamics

Statistical correlations between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of SRKW have been outlined in several papers and examined in great detail (e.g., Hilborn et al. 2012). In addition to examining whether any fundamental linkages between vital rates and prey abundance are evident, another primary purpose of many of these analyses has been aimed at distinguishing which Chinook salmon stocks, or group of Chinook salmon stocks, may be the most closely related to these vital rates for SRKW. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential, as most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. If anything, large aggregations of Chinook salmon stocks that reflect abundance on a coast-wide scale appear to be as equally or better correlated with SRKW vital rates than any specific or smaller aggregations of Chinook salmon stocks, including those that originate from the Fraser River that have been positively identified as key sources of prey for SRKW during certain times of the year in specific areas (see Hilborn et al. 2012; Ward et al. 2013). However, there are still questions about the diet preferences of SRKW throughout the entire year, as well as the relative exposure of SRKW to various Chinook or other salmon stocks during the summer and fall. Given the available information, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKW may be as influential on their vital rates as any other relationships with any specific stocks. In this analysis we also consider reductions in available Chinook salmon in a more localized area at the mouth of the Columbia River to identify the potential for local depletion of prey.

NMFS has been developing a risk assessment framework relating Chinook salmon abundance to SRKW population dynamics that will help evaluate the impacts of salmon management on SRKW. At this time, development of the framework is on a coast-wide scale and intended for broad applicability across actions that impact salmon. NMFS’ work to develop the risk assessment is ongoing. The best available science suggests that changes in Chinook salmon abundance are likely to directly influence the SRKW population, given there is clear evidence that survival and fecundity rates appear to be relatively well correlated with Chinook salmon abundance levels. Our analysis examines the effects of short- and long-term effects of the action on the prey available to SRKW and how that may influence the health of individual SRKW and the DPS.

Degree of Spatial and Temporal Overlap in Distributions of SRKW and Salmon

In the short term, the Proposed Action will continue to fund hatcheries that provide prey for SRKW, but at a reduced rate from previous years during time periods when the spatial distribution of affected Chinook salmon and SRKW overlap. Here we describe that overlap.

SRKW spend the majority of the summer months in the inland waters of Washington and British Columbia, whereas in non-summer months they are observed less often in the inland waters. Detection rates in coastal waters using passive acoustic recorders further reveal that SRKW spend more time off the Columbia River and Westport, particularly in the spring, than previously anticipated (Hanson et al. 2013). Satellite-linked tagging data (NWFSC unpubl. data) that spanned from late December through mid-May and were collected over the course of several years (2012 – 2016) indicate that J pod moved primarily between the northern Strait of Georgia and the entrance of the Strait of Juan de Fuca and only had limited occurrences in the coastal waters, whereas K and L pods traveled along the coast from the Strait of Juan de Fuca to Pt. Reyes, California.

Differences in adult salmon life histories and locations of their natal streams affect the distribution of salmon across the SRKW coastal range. For those originating from the Columbia River, salmon range as far north as Alaska, however, the primary areas of overlap with SRKW may be in British Columbia along Vancouver Island and down the Washington and Oregon coasts to central Oregon (Weitkamp 2010). The large majority of Chinook salmon that would be affected by the Proposed Action, the early-type fall Chinook salmon commonly referred to as tule Chinook, are a significant contributor to catch off Washington and northern Oregon. This stock makes up an increasing percentage of the salmon catch in marine areas closer to the mouth of the Columbia River. However, information on their distribution has been collected only when salmon fisheries are open (May through September for Pacific Ocean fisheries). Mature fish enter the Columbia River en masse approximately from the end of July through August. Their range is less well known during the seasons when fisheries are closed, late fall through early spring (Oct-April).

From 2009 – 2015, 55 scale and tissue samples were collected from SRKW predation events in coastal waters (NWFSC unpubl. data). Just over 78% of the samples were Chinook salmon. Furthermore, genetic analysis of the data indicate that Columbia River Chinook salmon, including tule Chinook salmon, are a part of the coastal diet of SRKW. Based on these data, and the degree of spatial and temporal overlap in the distribution of SRKW and Chinook salmon, we conclude that tule Chinook are included in the diet for at least most SRKW (particularly K and L pod members) during portions of the year when SRKW occur in coastal waters off Washington and Oregon.

Prey Availability and Food Energy Needs in Coastal Waters

In order to understand the short-term effects of the Proposed Action, we assessed the SRKW food energy needs from Chinook salmon using the best available information on their diet composition, metabolic needs, and time spent in coastal waters. Noren (2011) developed estimates of the potential range of daily energy expenditure and prey energy requirements for

SRKW for all ages and both sexes. NMFS combined this information with the population census data to estimate daily energetic requirements for all members of the Southern Resident population, based on the current estimate of 79 whales in the DPS. The model provides a range in daily energy requirements, which represents uncertainty in the estimates.

We focused on the maximum estimates for several reasons. The maximum and minimum field metabolic rates (FMRs, or daily energy expenditure) reported by Noren (2011) fall within the range of FMRs of killer whales, based on daily activity budgets. Thus, the maximum of this reported range from Noren (2011) used in this Opinion represent realistic values for killer whales. The FMRs and resulting calculated daily prey energy requirements from Noren (2011) do not account for the increased energetic cost of body growth in juvenile whales or the increased cost of lactation in females who are nursing calves. Although the costs of these physiological processes are not precisely known, they could significantly affect the daily prey energy requirements of specific individuals that fall within these categories. For example, prey consumption rates in lactating females can increase 1.5–2 times over consumption rates of non-lactating females (Kriete 1995; Kastelein et al. 2002; Kastelein et al. 2003a; Kastelein et al. 2003b). By using the maximum daily prey energy requirements, our calculations account for energetic costs in the population that may be underestimated by Noren (2011). This approach is also reasonable because the maximum prey energy needs are still within the normal range of adult and non-lactating female killer whales that do not have increased energetic burdens due to the physiological processes of growth and lactation.

Hanson and Emmons (2010) provided a compilation of SRKW sightings specific to each pod in inland waters (January 2003 to December 2009). For purposes of this analysis, we assumed that SRKW occurred west of the Strait of Juan de Fuca (in coastal waters) on days they were not sighted in inland waters, primarily because the population is highly visible in inland waters. Because the geographic distribution of the pods differ (with K and L pod members observed spending more time in coastal waters than J pod members), we analyzed the effects of reduced prey availability at both the pod level and population level. We computed the daily energy requirements by pod based on the age and sex structure of all individuals in each pod, and multiplied the daily energy requirements of each pod by the number of days in the model time step that the pod was in coastal waters.

Noren (2011) had estimated that SRKW (population of 82 at the time) subsisting entirely on Chinook salmon would need approximately 792-951 fish per day or up to 347,000 fish per year, based on an average energy value for Chinook salmon of 16,386 kcal per fish. It is important to note these are just estimates of food energy requirements and can vary depending on the fish species and fish population consumed. Chinook salmon have the highest value of total energy content of the anadromous salmonids because of their larger body size and higher energy density (O'Neill et al. 2014). For a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume approximately 2.7 coho salmon, 3.1 chum salmon, 3.1 sockeye salmon, or 6.4 pink salmon (O'Neill et al. 2014). More realistically, SRKW consume a variety of fish and likely require fewer Chinook salmon than estimated here. Bearing this in mind, we developed estimates of caloric needs in coastal waters using updated information on salmon and SRKW to put in context the reduction of the whales' prey from the action.

Based on the distribution of SRKW and estimated annual prey energy requirements (in kcal) for each pod, we estimate that SRKW need over 3 billion kcal when not in inland waters. J pod likely needs almost 900 million kcal of energy when not in inland waters, whereas K and L pod's coastal energy requirements are likely between 1 and 2 billion kcals. The total energy value (in kcal per fish) of adult Chinook salmon is correlated with mass and lipid content and varies among populations (O'Neill et al. 2014). Given the estimated prey energy requirements and a more recent estimate of the average total energy content of Chinook salmon (average is 13,409 kcal per fish; O'Neill et al. 2014), SRKW would need approximately 300,000 Chinook salmon per year to meet their energy needs when in coastal waters. If we assume only K and L pods are affected by the Proposed Action because of their more coastal distribution compared to J pod, the SRKW would need approximately 215,000 adult Chinook salmon in coastal waters to meet their energy needs (assuming their diet is 100% Chinook, which is an overestimate based on coastal prey data).

Short-term Reductions in Prey Availability

To evaluate the effects of the Proposed Action we have estimated percent reductions of food energy in a localized area off the mouth of the Columbia River and across the coastal range of SRKW. Our estimates reflect annual and seasonal variability in Chinook salmon ocean abundance. The Proposed Action will continue to provide prey to SRKW, but the 24% reduction in hatchery production will result in measurable adult prey reductions of an average of approximately 25,000 adult equivalents per year in future years as the Chinook salmon mature. This reduction may result in 1-4% fewer adult Chinook salmon in the localized area off the mouth of the Columbia River. This reduction in hatchery production of 25,000 adult equivalents per year is equivalent to almost 300 million kcals (25,000 fish * 13,409 kcal/fish) of food energy. This calculated reduction is probably a high estimate of the prey loss to SRKW for two reasons. First, whales like larger Chinook salmon, and some of these fall Chinook will return at 2 or 3 years of age rather than 4, so would be less attractive. Second, it assumes that all these tule Chinook salmon are potential prey items, but the extent to which SRKW prey on tule fall Chinook is unknown.

The PFMC provides ocean abundance estimates for Chinook salmon that originate from the U.S. systems (PFMC 2016a). Between 2008 and 2016, escapement forecasts for Columbia River Chinook salmon stocks ranged from approximately 741,000 to 1,960,800 fish; Puget Sound stocks ranged from 150,600 to 269,800 fish; Washington coast stocks ranged from 65,500 to 115,900 fish, and Oregon and California coast stocks ranged from 142,200 to 1,651,800 fish. The average total Chinook salmon abundance from these sources was approximately 2,035,778 fish. Therefore, a 24% reduction in tule Chinook salmon (or approximately 25,000 adults) would be a small portion (or approximately 1%) of the total estimated ocean escapement that may be available to SRKW. While the average total Chinook salmon escapement estimate does reflect many of the significant populations of Chinook salmon along the U.S. coast, this does not include any totals from significant Canadian Chinook populations that are likely encountered by SRKW to some degree, in particular Fraser

River and West Coast Vancouver Island stocks. Therefore, the reduction in Columbia River tule Chinook would likely be less than 1% of the available Chinook salmon across the SRKW range.

These estimates of prey reduction are also considered maximum reductions for several other reasons. As hatchery production is reduced, overall salmon abundance is reduced which may result in some reductions in fisheries. Continued but reduced abundance of harvestable Chinook salmon may be associated with lower catches and possibly lower annual fishing quotas. In addition it is unlikely that SRKW would encounter and consume all 25,000 adult equivalent fish annually because the spatial and temporal distributions of whales and fish are not entirely overlapping; there is a low probability that all 25,000 of these particular Chinook salmon would be intercepted by SRKW across their vast range in the absence of the Proposed Action. There are also additional salmon predators that might encounter and consume these specific Chinook salmon.

Because there is no available information on SRKW foraging efficiency, it is difficult to quantify the effect of these small reductions in prey available to the SRKW coast wide. A change in the localized prey base off the mouth of the Columbia River (an area of *suggested* importance to the whales) from the reductions in hatchery production could result in SRKW abandoning this area in search of more abundant prey or expending substantial effort to find depleted prey resources. This could result in a potential increase in energy demands which would have the same effect on an animal's energy budget as reductions in available energy, such as one would expect from reductions in prey.

Given the degree of prey reduction and general overlap in SRKW and Chinook salmon distributions described above, in the short term, the Proposed Action is likely to benefit SRKW with continued production, but the reduced hatchery levels will result in a net adverse effect on them. When prey is reduced, SRKW would likely need to spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources. As a chronic condition it can lead to reduced body size and condition of individuals, and lower reproductive and survival rates of a population (e.g., Trites and Donnelly 2003).

Very poor condition is detectable by a depression behind the blowhole that presents as a "peanut-head" appearance. There have been several SRKW that have been observed with the "peanut-head" condition, and the majority of these SRKW died relatively soon after this observation. More recently, photographs of whales from an unmanned aerial system (i.e., a drone) have been collected and individual whales in poor condition have been observed. None of the SRKW that died following these observations were subsequently recovered, and therefore a definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition. Regardless of the cause(s) of death, it is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females (e.g., Daan et al. 1996; Gamel et al. 2005) and juveniles (e.g., Trites and Donnelly 2003; Noren et al. 2009) which have been studied extensively. Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey availability. Ford and Ellis (2006) report that SRKW engage in prey sharing about 76% of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (*i.e.*, if the most successful foragers did not share with other individuals). Therefore, although cause of death for these specific individuals is unknown, poor nutrition could contribute to additional mortality in this population.

Long-term effects on SRKW

As described above in Sections 2.4.2.1 through 2.4.2.6, it would be expected that where there are self-sustaining, moderately abundant, natural-origin populations of Chinook salmon that a significant reduction in the level of hatchery-origin spawners may increase the per-spawner productivity level in the population in the long run. However, with the current habitat conditions, immediate and meaningful increased productivity or abundance is not certain, and increases in abundance of natural-origin Chinook salmon may only occur over extended periods in the future (i.e., decades). There is and will be continued monitoring in place to assess the status and trend in natural-origin Chinook salmon and the indirect effects on SRKW.

There are not many examples of program modifications similar to the proposed hatchery reductions that are expected to reduce the ecological and genetic effects of hatchery fish on ESA-listed natural-origin fish. However, the recovery of Hood Canal Summer chum salmon involved hatchery programs identified as affecting recovery (fall chum salmon, fall Chinook salmon, coho salmon, and pink salmon programs) being reduced or eliminated in the 1990s. Abundance of wild and hatchery origin summer chum salmon markedly increased in the mid-2000s after these changes in hatchery programs were implemented (reviewed in Kostow 2012). In 2015, escapement of Hood Canal summer chum salmon was 32,569, which was up from 2,429 in 1994. Additionally, in order to protect natural-origin Oregon Coast coho salmon hatchery releases of juvenile coho salmon dropped from 34 million in 1981 to 1.6 million in the early 2000s. Productivity of natural-origin coho salmon was lowest during the periods of highest hatchery spawner densities and increased when the number of smolts released from hatcheries along with the number of hatchery fish spawning in the wild decreased (reviewed in Buhle et al. 2009).

While the time frame and magnitude of the improvements for natural-origin Chinook salmon are difficult to quantify, supporting recovery of salmon is an important action identified in the Recovery Plan for SRKW (NMFS 2008f). The phased approach for monitoring and implementing reductions in hatchery production will provide opportunities to evaluate this action and will also phase in reductions in prey and impacts to SRKW over a number of years. After implementation it will also take several years before the reductions are realized as SRKW preferentially feed on older adult Chinook salmon. Ongoing monitoring and recovery actions for both listed Chinook salmon and the SRKW are ongoing and intended to improve the outlook for both species. As additional information is available on the status of the salmon and SRKW populations, we will update our assessments to inform evaluation of this and other future actions.

<u>Conclusion</u>

In summary, the Proposed Action will continue to benefit SRKW by providing prey. The reduction in hatchery releases will adversely affect SRKW in the short term, but in the long term may be beneficial. Tule fall Chinook salmon are likely part of the diet for at least most SRKW during portions of the year when SRKW occur in coastal waters off Washington and Oregon. The proposed 25% reduction in hatchery production, which equates to an average of 25,000 adult equivalents per year, will cause measurable adult prey reductions (1-4% fewer adult Chinook off the mouth of the Columbia River). The short-term reductions annually (that could last several decades), may cause SRKW to spend more time foraging, which may increase energy expenditure and can cause nutritional stress, leading to reduced body size and condition of individuals which could lead to lower reproductive and survival rates of a population. The effects of reduced prey availability would be greater off the mouth of the Columbia River and would be much smaller magnitude of effect across the range of SRKW. These reductions however, are small and are likely an overestimate as they don't account for all available Chinook salmon (and other known prey) in the SRKW range or potential reductions in fisheries that may affect overall abundance of Chinook salmon. It is also unlikely that SRKW would have encountered and consumed all the fish in the absence of the Proposed Action. Over the long term the action may be beneficial as its purpose is to improve the status of listed Chinook salmon, however, it is not clear how long it will take for any benefits to be realized.

2.4.3 Effects of the Action on Critical Habitat

Negligible effect: This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined funding the operation of the hatchery programs will have a negligible effect on PCEs in the Action Area. There may be a small beneficial effect on critical habitat from the introduction of marine-derived nutrients resulting from naturally spawning hatchery fish in their respective tributaries. Marine-derived nutrients can also come from the outplanting of hatchery carcasses. As described in Section 2.4.1.2, the hatchery 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. These marine-derived nutrients can increase the growth and survival of the ESA-listed species by affecting PCEs associated with juvenile rearing such as increasing forage species (i.e., aquatic and terrestrial insects), aquatic vegetation, and riparian vegetation to name a few.

Other possible effects on critical habitat from the Proposed Action would occur in freshwater migration corridors. Indications that the handling of natural-origin adults at the weirs could contribute to pre-spawning mortality would be monitored by the evaluation of carcasses that are recovered during spawning ground surveys. The hatchery facilities requiring additional construction or disturbance of riparian or streambed habitat would have a plan in place by

2019, and each subsequent action would be consulted on independently to determine effects to designated critical habitat.

Effects of water withdrawal and effluent are expected to be small and transitory through continued funding of hatchery facilities. Hatchery intakes are screened to prevent fish removal from streams, and where facilities require upgrades to reduce impingement on screens plans will be in place by 2019, or funding will cease. Juvenile rearing and migratory habitat may be affected by the removal of water from stream reaches between the hatchery intake and hatchery outfall (where the water returns to the river). Removal of a small proportion of the river flow is expected to have a negligible effect no matter the distance between the intake and outflow. Minimum flow requirements are maintained in those sections of streams where the water withdrawal removes a substantial proportion of the flow during specific times of the year. Minimum flow requirements protect migration corridors and provide rearing habitat for juvenile fish.

Habitat impacts from the installation and operation of the weirs are expected to be limited to the weir location, and to be of a short duration. Habitat will be temporarily impacted by the placement of the weirs. Each weir is designed to be installed and removed annually, eliminating the requirement for permanent structures in the river. When the weirs are operational, they will impact the PCEs for migration as follows:

- The installation of weirs can disturb the substrate, increasing the potential for increasing suspended solids and sediment, but these effects are expected to be minimal because the installation of the weir affects only a small section of the stream bed, the weirs are temporary limiting the duration of effects, and high flows that occur after weir removal will remove any evidence of weir placement.
- The impacts on designated critical habitat from the installation of “permanent” weirs (those with hard structures within the stream) have already occurred and the effects of these weirs are described below.
- The installation of the weirs in any river where funded, could potentially lead to the handling of the majority of natural-origin ESA-listed salmon returning to the respective basin. Monitoring associated with spawning ground surveys would be used to determine if the presence of the weirs caused natural-origin ESA-listed salmon or steelhead to spawn downstream of the weirs.
- Weirs in any river could potentially lead to the handling of the majority of natural-origin ESA-listed salmon returning to that basin. Monitoring associated with spawning ground surveys would be used to determine if the presence of the weirs caused natural-origin ESA-listed salmon or steelhead to spawn downstream of the weirs.
- The weirs, based on their installation date, may encounter out-migrating winter steelhead kelts (fish that have already spawned So long as annual installation takes place after June, kelts would be unlikely to be encountered and expected to be uncommon because winter steelhead spawning is usually completed by early May (Schroeder et al. 2013). Adult winter steelhead would not be expected to be encountered during weir operations because they return after the weirs are removed and before the weirs are installed.

Indications that the handling of natural-origin adults at the weirs could contribute to pre-spawning mortality would be monitored by the evaluation of carcasses that are recovered during spawning ground surveys. In the future, if effects to natural-origin fish exceed those expected above daily handling and tagging effects, they will be mitigated through adjustments in weir design and placement, the use of trained personnel, and operations that minimize the time salmon and steelhead are held or delayed at the weirs (NMFS 2017).

Additionally as described in the Sections above, the proposed hatchery program would have a negligible effect on designated critical habitat for the following reasons:

- No new construction of hatchery facilities is proposed.
- The proposed hatchery programs would slightly increase the level of marine derived nutrients into the watersheds where the hatchery fish return to, which would be expected to increase the available resources to spur the growth rate of juvenile anadromous ESA-listed fish and improve their survival during the long seaward migration from their freshwater rearing habitats.
- The water diversion at each acclimation facility (Coweeman Pond, South Fork Toutle R. CGAAP, and Gobar Pond in Washington; and Clear Creek, and Foster Creek in Oregon) is screened to protect juvenile fish from entrainment and injury.
- Three hatchery facilities with screened intakes already meet NMFS's most current guidelines to protect juvenile fish from entrainment and injury: Skamania Hatchery, Kalama Falls Hatchery, and Beaver Creek Hatchery.
- While the Grays River Hatchery, Fallert Creek Hatchery, and the Elochoman River intake at Beaver Creek Hatchery do not currently meet NMFS criteria for protecting juvenile fish, they are screened to prevent permanent removal of fish from each watershed. Each hatchery facility also diverts less than 4% of stream flow, with most actually diverting 2%, of the water from the river they are located. These small levels will not affect passage or rearing capacity for ESA-listed anadromous fish populations.
- Access to habitat in the Kalama River above the Kalama Falls Hatchery will continue to be provided to natural-origin salmon and steelhead.
- Access to habitat in Big Creek above the Big Creek Hatchery will continue to be provided to natural-origin salmon.
- The Vancouver Trout Hatchery does not divert surface water, so it does not have the potential to affect ESA-listed anadromous fish.
- Any sediment from the maintenance of instream structures at hatchery facilities would be localized and temporary and would not be expected to affect ESA-listed anadromous fish species.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the

Proposed Action are not considered in this Section because they require separate consultation pursuant to Section 7 of the ESA.

Some 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 area are described in the environmental baseline (Section 2.3).

For the purpose of this analysis, the Action Area is described in Section 1.4. Future Federal actions, including the ongoing operation of the hydropower system, hatcheries, fisheries, and land management activities will be reviewed through separate Section 7 consultation processes. Non-Federal actions that require authorization under Section 10 of the ESA, and are not included within the scope of this consultation, will be evaluated in separate Section 7 consultations.

2.5.1 Development

Provided below is a bulleted list of development trends taken from ISAB (2007a); 2007b), ISAB (2016) and the LCREP (Leary et al. 2005). These trends cannot be quantified because some of the development projects are in the early stages of permitting and planning.

- Human populations are increasing primarily in urban metropolitan areas, with smaller increases in rural areas
- The regional population is projected to double by 2100 from 13.5 million to 27 million
- Freshwater withdrawals for domestic, industrial, commercial, and public uses are increasing, whereas withdrawals for irrigation purposes are decreasing due to the conversion of agricultural lands to residential areas
- Forests are being converted for development, which is resulting in forest fragmentation
- Mining in the Columbia River Basin is focused on sand and gravel with the removal occurring along or within rivers
- Electrical demand continues to increase by approximately 1 percent per year
- New port infrastructure projects continue to result in loss of aquatic habitat

In the future as the per capita income of individuals continues to increase, the value society places on fish, wildlife, ecosystem services and other natural "public goods" may rise (ISAB 2016). Therefore, we anticipate that future development will be mindful of ESA-listed species and although future projects are likely to have adverse effects, they will perhaps be less harmful than in the past.

One example of a largescale project reasonable foreseeable to occur is the proposed construction and operation of a Oregon Liquefied Natural Gas (Oregon LNG) export terminal on the northern portion of the East Skipanon Peninsula near the confluence of the Skipanon and Columbia Rivers in Warrenton, Oregon. The proposed Oregon LNG Terminal would be located at River Mile (RM) 11.5 of the Columbia River within an approximate 96-acre parcel of land that is owned by the state of Oregon and leased to the Port of Astoria by the Oregon

Department of State Lands. Oregon LNG holds a long-term sublease with the Port of Astoria for the entire land parcel. The project received land use approval from the City of Warrenton, and the Port of Astoria approved a lease for the project. Upon completion, which the developer anticipates to occur in 2019, the terminal would operate as a marine loading terminal with two full-containment, 160,000-cubic-meter, LNG storage tanks and facilities to support ship berthing and cargo loading. Oregon Pipeline, an affiliated company, is planning the construction of an 87-mile pipeline to connect the terminal to the Williams Northwest Pipeline in 14 Woodland, Washington. The project is currently being reviewed by permitting agencies.

2.5.2 Habitat and Hydropower (taken from NMFS (2014f))

Habitat restoration efforts are supported by Federal, state, and local agencies; tribes; environmental organizations; and communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. The larger, more region-wide, restoration and conservation efforts, either underway or planned throughout the Columbia River Basin, are presented below. These actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably likely to occur, funding levels may vary on an annual basis. However, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish passage at hydropower sites will result in a net benefit for salmon and steelhead compared to the current conditions. Some examples of major non-federal funding entities are detailed below.

Northwest Power Planning and Conservation Council – Fish and Wildlife Program
The Fish and Wildlife Program was developed for the 31 dams within the Columbia River Basin that USACE (21 dams) and BOR (10 dams) operate. Due to construction and operation of these dams, the Northwest Power Act requires the NPCC to prepare to implement a program to protect, mitigate, and enhance fish and wildlife habitat and related spawning grounds affected by hydroelectric development. In 2013, the Council approved recommendations for 83 projects in Oregon, Washington, and Idaho. The program budget averages $143 million per year for funding projects. Funding is allocated for spill and flow management to support fish survival, predator control, fish habitat improvements, funding support for the Fish Passage Center, and designation of new protected areas.

State of Idaho – ESA Section 6 Cooperative Agreement
The state of Idaho's Department of Lands is pursuing an ESA Section 6 Cooperative Agreement. This forestry program, if approved, would apply to forestry management and timber harvest on state and private lands (voluntary) in the Salmon and Clearwater Basins in Idaho. The intent of the cooperative agreement is to develop forest management practices that would better protect aquatic habitat for ESA-listed fish.

State of Oregon – Oregon Plan for Salmon and Watersheds
The Oregon Plan for Salmon and Watersheds includes voluntary restoration actions by private landowners, monitoring, and scientific oversight that is coordinated with state and Federal agencies and tribes. The Oregon Legislature allocates monies drawn from the Oregon Lottery

and salmon license plate funds, which have provided $100 million and $5 million, respectively, to projects benefiting water, salmon, and other fish throughout Oregon. Projects include reducing road-related impacts on salmon and trout streams by improving water quality, fish habitat, and fish passage; providing monitoring and education support; helping local coastal watershed councils; and providing staff technical support.

State of Washington – Governor's Salmon Recovery Office

The Governor's Salmon Recovery Office arose from Washington's Salmon Recovery Act, and it includes the Salmon Recovery Funding Board (SRFB). SRFB has helped finance more than 900 salmon recovery projects focused on habitat protection and restoration. SRFB administers two grant programs (general salmon recovery grants and Puget Sound Acquisition and Restoration grants). Municipalities, tribal governments, state agency non-profit organizations, regional fisheries enhancement groups, and private landowners may apply for these grants. The LCFRB Recovery Plan (Plan) provides an integrated regional strategy for returning all LCR salmon and steelhead populations to healthy and harvestable levels (LCFRB 2010a; NMFS 2013e). The Plan identifies goals, objectives, targets, benchmarks, strategies, measures and actions intended to: 1) reverse long term declining trends in salmon and steelhead numbers; 2) provide a trajectory leading to recovery of these species to healthy and harvestable levels within 25 years; and 3) periodically refine recovery efforts with checkpoints and course corrections throughout implementation. The integrated strategy provides overarching guidance for developing complementary measures across and among each of the manageable impacts in order to balance demands and expectations among all affected parties. Threat-specific guidance addresses each of the seven categories of threat: subbasin stream habitat and watershed conditions; estuary and mainstem habitat; tributary and mainstem hydropower configuration and operation; in basin and out-of-basin harvest; mitigation and conservation hatcheries; and ecological interactions including non-native species, food web, and predation; and climate and ocean effects.

Specific to hatchery and harvest management, the Lower Columbia Conservation and Sustainable Fisheries Plan (CSF Plan) (WDFW and LCFRB 2015) provides the framework for implementing recovery plan hatchery and harvest actions. The goal of the CSF Plan is to: 1) support efforts to recover salmon and steelhead populations to heathy, harvestable levels; and, 2) sustain important fisheries. The CSF Plan encompasses the tenets of the recovery plan, and acknowledges that an "all H" (Habitat, Hatcheries, Harvest, Hydro) approach to recovery is necessary. The CSF Plan identifies:

- background information on recovery planning efforts;
- population assessments and recovery objectives;
- species summaries and recovery targets;
- hatchery and harvest impacts on natural populations;
- hatchery and harvest reform;
- detailed hatchery and harvest actions;
- projected fitness improvements;
- implementation actions; and
- monitoring and adaptive management;

The CSF Plan describes how hatchery and fishery reform will occur in the LCR. Implementation of reform actions are guided by an adaptive management approach whereby actions are implemented, population responses measured, and adjustments are implemented as necessary to achieve goals in the Plan.

2.5.3 Miscellaneous

Numerous environmental organizations, communities, and tribes have contributed to salmon habitat restoration and conservation efforts. These projects are often funded by in-kind matches with funding provided by NOAA's Cooperative Research Program, Pacific Coastal Salmon Recovery Fund, the three states' salmon recovery funds, and other sources. The projects vary, ranging from small- to large-scale efforts that include habitat conservation, creation, enhancement, restoration, and protection. These projects may also be initiated and developed under recovery plans prepared for threatened and endangered species. Project examples include donating conservation easements, excavating new tidal channels, removing invasive species, stabilizing streambanks, installing or upgrading culverts, removing barriers to fish migration, planting riverbanks, conserving water, restoring wetlands, and managing grazing to protect high-quality aquatic habitat, among others.

Pacific Coastal Salmon Recovery Fund (PCSRF)
The PCSRF was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007c). The states of Washington, Oregon, California, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes, receive PCSRF appropriations from NMFS each year. As described above in the environmental baseline, the fund supplements existing state, tribal and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery. The PCSRF has made substantial progress in achieving program goals, as indicated in annual Reports to Congress, workshops, and independent reviews and NMFS considers the projects completed by the states and tribes as cumulative effects.

NOAA Restoration Center Programs
NMFS has completed ESA consultation on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004a). These include participation in the Damage Assessment, Remediation, and Restoration Program (DARP); Cooperative Research Program (CRP); and the Restoration Research Program. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration which NMFS considers as cumulative effects.

2.5.4 Hatcheries and Harvest

It is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the analysis area will change over time. Although adverse effects will continue, these changes are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery and harvest programs funded and operated by non-federal agencies and tribes in the Columbia Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Although adverse effects on natural-origin salmon and steelhead will likely not be completely eliminated, effects would be expected to decrease from current levels over time to the extent that hatchery programs are reviewed and approved by NMFS under the ESA. 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
- Decreased use of isolated hatchery programs
- Increased use of integrated hatchery programs for conservation purposes
- Incorporation of new research results and improved best management practices for hatchery operations
- Creation of wild fish only areas
- Changes in the species propagated and released into streams and rivers and in hatchery production levels
- Termination of programs
- Increased use of marking of hatchery-origin fish
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches

A final concern with LCR fall Chinook salmon is that although pHOS in the Grays River is expected to easily meet the interim pHOS objective of 50%, most of the hatchery-origin fish on the spawning grounds in the Grays drainage are returnees from the non-Mitchell Act "Select Area Bright" (SAB) program, which currently releases 2.2 million fish from facilities in the Klaskanine River drainage and Youngs Bay. These fish, although they are fall Chinook salmon, are not tules, and are distinctly non-native, having originated in the Rogue River in southern Oregon. Past effects of the SAB on the ESU are included in the Environmental Baseline. As strays, returning adults from this program occur in appreciable numbers on spawning grounds in the Grays River drainage. Genetic analysis of juvenile Chinook salmon produced in the Grays indicates that although some fish of mixed ancestry are found, most fish are identifiable as Columbia tules or as Rogue River fish, not hybrids between the two (Roegner et al. 2011). This is remarkable given that these two groups of fish have been spawning in substantial numbers in the Grays for more than two decades. This may indicate that even though both groups are spawning in the Grays watershed, there may be little interbreeding between them, as is known to occur elsewhere between tule and fall Chinook salmon of different life histories (Smith and Engle 2011). From the standpoint of the "pulse checking" exercise, presence of these non-native fish is probably not a concern. However, from the standpoint of overall diversity, use of this stock within the LCR Chinook Salmon ESU is problematic unless it can be shown that that the effect on ESU diversity from these fish is no greater than from natural levels of straying from the Rogue River. NMFS has communicated with the hatchery program operator (ODFW), the funding agency (BPA), and with different stakeholder groups and expects that new information will be available in 2017 upon which to better evaluate threats from the program to LCR Chinook salmon diversity. Unless it is determined, with reasonable certainty, that, effects of the Rogue River Chinook hatchery programs are no greater than would be expected from natural levels of straying between the Rogue River in southern Oregon and LCR tributaries, these state operated programs will seek an alternative broodsource that originates from the LCR and terminate the Rogue River programs.

2.5.5 Climate Change

The ESA-listed species NMFS determined to be affected by the Proposed Action (see Table 9) are likely to be adversely affected by climate change (see Section 2.2.3). A decrease in winter snow pack would be expected to reduce spring and summer flows and increase water temperatures throughout the Columbia River Basin. Warmer temperatures may also increase the probability of higher sediment loads in tributaries due to more rain-on-snow events on the upper slopes of various mountain ranges throughout the basin releasing sediment that is no longer protected by winter snow pack. Reduced summer flows and higher water temperatures would be expected to reduce the habitat quality and habitat quantity needed for juvenile rearing and for adult holding, making those areas in the upper basin more essential for the persistence and recovery of the ESA-listed populations. Habitat quantity and quality may be degraded as annual flows are reduced and water temperatures increase as a result of climate change. These climate change effects on the quantity and quality of habitat in the Action Area would be expected over the next 50 years to reduce the spatial distribution of the populations because some sections of individual tributaries may become too warm for rearing, as well as reducing their productivity unless the natural-origin populations can adapt to these changes. These effects are assumed in the status of the ESA-listed species affected by the Proposed Action NMFS also considered climate change in development of the preferred alternative during the NEPA review. The Proposed Action addresses this by aligning future Mitchell Act funding decisions for hatchery operations with recovery plans, primarily by ensuring that the allowable level of genetic effects , especially in LCR steelhead and Chinook and coho salmon permits natural populations to improve in productivity, abundance, and diversity, which will allow them to adapt to both current and changing environments. As explained in Section 2.2.3, Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations.

2.5.6 Summary

NMFS anticipates that human development activities will continue to have adverse effects on listed species in the Action Area. On the other hand, NMFS is also certain that available scientific information will continue to grow at a fast pace and tribal, public, and private support for salmon recovery will remain high and this will fuel the upward trend in habitat restoration and protection actions as well as hatchery, harvest, and hydropower reforms that are likely to result in improvements in fish survival.

2.6 Integration and Synthesis

The Integration and Synthesis Section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this Section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the Proposed Action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species. 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, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.4.2., 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 threats posed by each factor of the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciable reduce the likelihood of survival and recovery of the listed species.

2.6.1 Pacific Eulachon Southern DPS

NMFS most recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction (79 FR 20802). Factors that limit the DPS have been, and continue to be, climate change impacts on both freshwater and ocean habitat as well as habitat alteration and degradation from a variety of activities. However, after taking into account the current viability status of the species, the Environmental Baseline, and cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the Pacific Eulachon Southern DPS in the wild, based on the summarized rationale below.

Effects range from discountable to negligible for these categories of hatchery actions (see Section 2.4.2). Specifically, for the Proposed Action, only two of the factors NMFS analyzes, hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds causing superimposition of eulachon spawning areas and hatchery fish and the progeny of naturally spawning hatchery fish predating on eulachon would have any effect. As discussed above, only the winter steelhead programs released in the Kalama, Elochoman, Grays, and Coweeman Rivers would interact with eulachon in spawning areas because of temporal overlap. The differences in preference for spawning substrates between eulachon and steelhead

(Section 2.2.1.10) would be expected to provide spatial separation on the spawning grounds eliminating the potential for any meaningful interactions leading to redd superimposition.

The potential for interactions between eulachon and hatchery juveniles may occur where the two species spatially and temporally overlap. To minimize these potential overlaps, WDFW will implement the following BMPs so that hatchery fish move quickly out of the Kalama, Elochoman, Grays, and Coweeman Rivers. These BMPs include rearing juveniles to the sizes and under conditions identified in the HGMPs, and acclimating hatchery juveniles prior to release. These actions will facilitate returning fish homing to their release sites low in each watershed and limit the potential for spawning ground interactions. Rearing fish to the sizes identified in the HGMPs will achieve maximum smolting condition, therefore the majority of hatchery fish will rapidly migrate out of the freshwater subbasins where they are released. Based on these proven techniques, there is little reason to expect that the Proposed Action will likely result in competitive interaction between fish from the hatchery programs in the Proposed Action and eulachon in the freshwater subbasins of the LCR.

While predation by juvenile hatchery-origin fish on eulachon is possible, by employing the aforementioned BMPs and producing actively migrating smolts, co-occurrence of the two species and adverse effects is expected to be negligible. Research indicates hatchery fish are 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). Coupled with the small size and transparency of the emergent eulachon fry, the distribution of eulachon fry in the water column, and the rapid emigration of eulachon juveniles from these rivers post spawning this will aid in ensuring levels of predation on eulachon will be negligible.

Following these BMPs will also reduce the propensity for steelhead released to residualize (Section 2.4.2 - Pacific Eulachon). In addition to monitoring for spawning superimposition, WDFW will document the presence of hatchery juveniles in these rivers as part of the juvenile outmigration monitoring and results will be reported annually. NMFS will monitor this data, and in addition, will monitor emerging science and information related to interactions between hatchery fish and Pacific Eulachon in the migration corridor, estuary, and ocean and will consider that re-initiation of consultation, under Section 7, is required in the event that new information reveals effects of the action that may affect ESA-listed eulachon or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Considering all potential interactions between eulachon and the proposed hatchery operations, effects of the Proposed Action are negligible, because of the slight temporal overlap between the species and the brief time that rapidly outmigrating salmon and steelhead smolts would co-occur with eulachon. Therefore, NMFS concludes that the Proposed Action will not appreciably reduce the likelihood of survival and recovery of Pacific Eulachon in the wild by reducing their reproduction, number, or distribution.

2.6.2 Upper Columbia / Snake River ESUs/DPSs

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with the natural spring Chinook salmon populations. Because none of the programs included in the Proposed Action occur in the UCR and only one occurs in the Snake Basin (a coho salmon program that propagates an unlisted species, coho salmon), we concluded that facility, RM&E and genetic effects were nonexistent for the seven ESUs/DPSs discussed here. Thus, the only effects to consider in our integration and synthesis for each of these listed species are ecological effects, which can affect the abundance and productivity VSP parameters (Section 2.4.1).

2.6.2.1 Chinook Salmon ESUs

Best available information indicates that the UCR Chinook Salmon ESU, is at high risk and remains endangered (NWFSC 2015). The Snake River Fall Chinook Salmon ESU and the Snake River Spring/Summer Chinook Salmon ESU remain threatened after our most recent status review (NWFSC 2015). 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, added to the effects of all human activities in the Action Area, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed Chinook salmon ESUs in the wild.

Our effects analysis showed that the ecological impact of the hatchery releases themselves, based on the most up-to-date interactions modelling available, is small; less than three percent of the natural-origin Chinook salmon juvenile outmigrants produced in the basin are potentially lost to competition and predation as they migrate downstream and mix with fish produced by the hatchery programs included in the Proposed Action. However, an increase in spawners or juveniles due to hatchery-origin fish spawning in the wild is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in these ESUs (Section 2.4.1).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for each ESU describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect Chinook salmon and NMFS expects this trend to continue.

2.6.2.2 Steelhead DPSs

Best available information indicates that the UCR Steelhead and Snake River Basin Steelhead DPSs are at high risk, and moderate to high risk of extinction, respectively, and remain threatened under the ESA (NWFSC 2015). Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture, residential development, historical forest management, and harvest continue to threaten UCR steelhead (UCSRB 2007). After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that effects of the Proposed Action added to the effects of all human activities in the Action Area on these ESA-listed DPSs will not appreciably reduce the likelihood of survival and recovery of ESA-listed steelhead in the wild.

Our effects analysis showed that the ecological impact of the hatchery releases themselves, based on interactions modelling, is small; less than one percent of the natural-origin juvenile steelhead produced in the basin are likely to be lost to competition and predation as they migrate downstream out to the ocean and mix with fish produced by hatchery programs included in the Proposed Action. However, an increase in spawners or juveniles due to hatchery-origin fish spawning in the wild is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to productivity and abundance VSP parameters in these DPSs (Section 2.4.1)

Mitchell Act funded hatchery programs pose a low risk to the diversity and productivity of UCR steelhead populations through gene flow. Gene flow from only one Mitchell Act funded program is a possibility, and the distance from release site to the UCR watersheds and marking scheme make the possibility of gene flow at appreciable levels very unlikely.

The same is true of RM&E activities. The activities capture and possibly delay a small number of Snake River Basin steelhead, and may on occasion kill a few of these fish, which may effect to the spatial structure VSP parameter (Section 2.4.1), but the effect is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of the species survival and recovery in the wild; making sure the programs comply with best management practices; provide information on population status; provide information on the performance of the hatchery programs and their interactions with respective natural populations; and coordinate with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with reducing extinction risk and promoting recovery of target species while not disadvantaging non-target species.

Added to the Species' Status, Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans describe, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead

DPSs. Such actions are improving habitat conditions, and hatchery and harvest practices to protect steelhead and NMFS expects this trend to continue.

2.6.2.3 Snake River Sockeye Salmon ESU

NMFS recent status review affirmed the status of this ESU as endangered due to the high risk of extinction (NWFSC 2015). Factors that limit the ESU have been the legacy effects of historical commercial fisheries, poor ocean conditions, survival through the Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures. Improvements in fish passage, harvest, and habitat conditions have improved survivals, and a specially designed hatchery program has increased abundance and reduced extinction risk in the short-term. All of this has put the Snake River Sockeye Salmon ESU on an improving trend but there is still much to do because the ESU is vulnerable to catastrophic loss and effects to genetic diversity. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the Snake River Sockeye Salmon ESU in the wild.

Our effects analysis showed that the ecological impact of the hatchery releases themselves, based on the most up-to-date interactions modelling, could result in up to about a 16% loss of natural-origin sockeye salmon produced in the interior Columbia River Basin from competition and predation as they migrate downstream and mix with fish produced by the hatchery programs included in the Proposed Action. However, Snake River sockeye salmon are one of two sockeye salmon ESUs in the Columbia Basin, with the vast majority of natural sockeye salmon production coming from the unlisted Upper Columbia Sockeye Salmon ESU. Zabel (2015) estimates that the proportion of ESA-listed Snake River sockeye salmon is less than 3% of all the sockeye salmon juveniles that survive to Bonneville Dam. Thus the odds of a released hatchery-origin juvenile coming into contact with sockeye salmon from the listed ESU is very low, less than a 1 in 30 chance.

Regarding hatchery-origin fish spawning naturally, an increase in spawners or juveniles due to hatchery-origin fish spawning in the wild is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.4.1).

Added to the Species' Status, Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Federally approved recovery plan (NMFS 2015b) for Snake River Basin Sockeye Salmon describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed sockeye salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect Snake River sockeye salmon and NMFS expects this trend to continue.

2.6.3 Mid-Columbia ESUs/DPSs

2.6.3.1 Mid-Columbia Steelhead DPS

NMFS recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction (NWFSC 2015). Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the Mid-Columbia Steelhead DPS in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects on the abundance, spatial structure, and diversity VSP pamameters of the MCR Steelhead DPS were negligible for hatchery operations and small for trapping because even though the current Klickitat River intake does not meet NMFS screening criteria and does not prevent juvenile fish from entering the hatchery rearing ponds, the effect is expected to be minimal because the intake is only operated beginning in the spring prior to the peak migration of natural-origin juvenile fish. These effects are expected to be addressed as the Yakama Nation, NMFS (Mitchell Act), and the Bonneville Power Administration are currently working on a remodel of the Klickitat Hatchery that will include upgrades or modifications to the mainstem intake facility. Less than 10 adult steelhead volunteer into the adult holding ponds during spring Chinook salmon broodstock collection and these are released back into the river unharmed, as a result, broodstock collection has a negligible effect on the abundance VSP parameter (Section 2.4.1) of the MCR Steelhead DPS.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill a small number of fish, but the effect is small. The risk to the abundance and productivity VSP parameters (Section 2.4.1) of the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of the species survival and recover in the wild; making sure the programs comply with best management practices; provide information on the performance of the hatchery programs and their interactions with the natural population; and coordinate with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with reducing extinction risk and promoting recovery of target species while not disadvantaging non-target species.

This leaves the biological interactions of the hatchery programs with natural steelhead populations. Our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is small—less than one percent mortality of natural-origin steelhead juveniles throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. NMFS hopes that implementation of new RM&E for juveniles will detect any effect. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this DPS (Section 2.4.1)

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced steelhead. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

The proportion of hatchery fish on the spawning grounds to date is limited for the Klickitat River summer and winter steelhead populations and data available to date indicates that gene flow from the Skamania stock summer steelhead is low, and unlikely to significantly affect the productivity and diversity VSP parameters (Section 2.4.1) of the Klickitat steelhead population or the MCR Steelhead DPS.

Added to the Species’ Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plan for the DPS describes 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 condition, and hatchery and harvest practices to protect MCR steelhead and NMFS expects this trend to continue.

2.6.4 Lower Columbia River ESUs/DPSs

2.6.4.1 LCR Chinook Salmon ESU

NMFS’ recent status review affirmed the status of this ESU as threatened due to a high risk of extinction (NWFSC 2015). Factors that limit the ESU have been, and continue to be the combination of severe habitat loss and degradation, including the construction and operation of dams on tributary streams, and harvest and hatchery management, followed by the construction and operation of mainstem Columbia River hydropower dams and ecological factors including predation and environmental variability. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Chinook Salmon ESU in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects on the abundance, spatial structure, and diversity VSP pamameters of the LCR Chinook Salmon ESU were negligible for hatchery operations and small for trapping because only small numbers of natural-origin fish will be impacted by broodstock collection for isolated programs, and for integrated programs, broodstock collection is limited to 30% of the natural-origin run. For the two integrated programs the impacts to the abundance, productivity, and diversity VSP parameters (Section 2.4.1) from the removal of NOR adults, are actually less than 30% and the reduction in abundance is partially mitigated by integrated hatchery fall Chinook salmon spawning naturally. Furthermore these programs would act as a genetic resource, supporting the diversity VSP parameter, for the Toutle River and Washougal River fall Chinook salmon populations. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill a number of fish, but the effect to the abundance and productivity VSP parameters (Section 2.4.1) of the LCR Chinook Salmon ESU is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of species survival and recovery in the wild; making sure the programs comply with best management practices;; provide information on the performance of the hatchery programs and their interactions with the natural population; and coordinate with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with reducing extinction risk and promoting recovery of target species while not disadvantaging non-target species.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is small—less than six percent mortality of natural-origin Chinook salmon juveniles throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. But it is NMFS' intent that the implementation of RM&E for juveniles may be able to detect this effect and NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters (Section 2.4.1) of this ESU.

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced Chinook salmon. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

Most of the changes in hatchery production and operations in the Proposed Action are aimed at reducing the genetic influence of hatcheries on LCR Chinook salmon. While the Proposed Action will continue to cause effects to LCR Chinook salmon through genetic influence, the net reduction of those effects over past levels is profound. Henceforth, all Mitchell Act funded production in this ESU will use only within ESU, and preferably within MPG broodstock, creating opportunities for increased among-MPG and among-ESU genetic diversity, a substantive improvement over environmental baseline conditions. Perhaps more significantly, through the Proposed Action, hatchery fish straying and pHOS will be greatly reduced in streams identified in the ESA adopted recovery plan as critical to LCR Chinook salmon recovery. To accomplish the needed reductions in straying and high pHOS levels, Mitchell Act funded tule Chinook salmon production in this ESU will be reduced 24%. This, combined with enhanced and new weir action to remove excess returning hatchery-origin adults, is expected to quickly reduce pHOS to levels consistent with recovery viability levels in the Cascade MPG. In the Coast MPG, pHOS reductions will be initially reduced to intermediate levels, during which the status of natural production will be assessed in order to put these populations on a recovery trajectory. It is important to realize, however, that the extent to which these populations have been genetically compromised as a result of hatchery influence is not known. In addition, our understanding of what level of hatchery influence may consistent with viability is limited, based on modeling rather than empirical evidence. Therefore, although we can say with confidence that the recovery-level standards for pHOS will be a big reduction in risk compared to the Environmental Baseline, and based on the currently best available science should be compatible with ESU viability, it is possible as part of the Proposed Action that further reductions in hatchery influence will be needed, in combination with attention to and reductions in other limiting factors, to achieve viability.

In summary, the Proposed Action will, through program release size adjustments, weir operations to remove excess returning hatchery, and use of appropriate broodstocks, reduce the effects of Mitchell Act hatchery production to levels that will promote the productivity, abundance, and diversity of LCR Chinook salmon populations. Moreover, it does this in a phased manner, initially targeting the populations deemed most important for recovery of the LCR Chinook Salmon ESU, and implementing research to clarify the status of others so that appropriate action can be taken to bring them to recovery levels. These actions will increase the ability of the populations to respond to improvements in habitat and other measures described in the recovery plan for the ESU. The relative improvements in the productivity, abundance, and diversity VSP parameters (Section 2.4.1), brought about by implementation of the changes from past hatchery operations required by the Proposed Action, collectively increase the resilience of the LCR Chinook Salmon ESU to the challenges of climate change.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect LCR Chinook salmon and NMFS' expects this trend to continue.

2.6.4.2 UWR Chinook Salmon ESU

NMFS recent status review affirmed the status of this ESU as threatened due to a moderate to high risk of extinction (NWFSC 2015). Factors that limit the ESU have been, and continue to be, dams that block access to major production areas, loss and degradation of accessible spawning and rearing habitat, and degraded water quality and increased water temperatures. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the UWR Chinook Salmon ESU in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. In terms of facility effects, the Clackamas Hatchery intake structure currently does not meet NMFS criteria, but impacts to the abundance and spatial structure VSP parameters (Section 2.4.1) are small. At peak water withdrawal, the hatchery takes less than 3% of the river flow, limiting the potential for juvenile fish to be entrained on the screens. A new intake screen, compliant with NMFS criteria and expected to be completed in 2017, will remove more flow but is not expected to have a measurable impact on rearing and migration habitat in the bypass reach.

No effect on this ESU is expected from RM&E activities associated with the Proposed Action.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature, is small—less than six percent mortality of natural-origin Chinook salmon juveniles originating throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. The implementation of RM&E in the Proposed Action may be able to detect this effect and NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters (Section 2.4.1) of this ESU.

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced spring Chinook salmon. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

Based on current recovery standards for hatchery genetic influence, the Proposed Action poses little risk to the productivity and diversity VSP parameters (Section 2.4.1) for the Clackamas spring Chinook salmon population, or to the ESU. pHOS levels are under 10%, appropriate for a primary population being affected by an isolated hatchery program.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect UWR Chinook salmon and NMFS' expects this trend to continue.

2.6.4.3 LCR Coho Salmon ESU

NMFS recent status review affirmed the status of this ESU as threatened due to a high risk of extinction (NWFSC 2015). Factors that limit the ESU have been, and continue to be the combination of severe habitat loss and degradation, including the construction and operation of dams on tributary streams, and harvest and hatchery management, followed by the construction and operation of mainstem Columbia River hydropower dams and ecological factors including predation and environmental variability. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Coho Salmon ESU in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects on on the abundance, spatial structure, and diversity VSP pamameters of LCR Coho Salmon ESU were negligible for hatchery operations and small for trapping because only small numbers of natural-origin fish will be impacted by broodstock collection for isolated programs, and for integrated programs, broodstock collection is limited to 30% of the natural-origin run, which limits impacts to the abundance, productivity VSP parameters (Section 2.4.1). Furthermore these integrated programs would act as a genetic resource, supporting the diversity VSP parameter, (Section 2.4.1). In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill a small number of fish, but the effect to the abundance and productivity VSP parameters (Section 2.4.1) of the LCR Coho Salmon ESU is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of species survival and recovery in the wild; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and combining with RM&E programs elsewhere to provide much needed information on how to use hatchery programs in attempting to reduce extinction risk and promote recovery of target species while not disadvantaging non-target species.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is small—less than 10 percent mortality of natural-origin coho salmon juveniles originating throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS hopes that new RM&E included in the Proposed Action for juveniles will be able to detect this effect. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and reconsideration of program size may be needed in the future to limit impacts to these VSP parameters (Section 2.4.1) of this ESU.

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced coho salmon. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

Most of the changes from current conditions in the Proposed Action are aimed at reducing the current level of genetic influence of hatcheries on Lower Columbia coho salmon. As with LCR Chinook salmon, the Proposed Action continues to fund programs which result in genetic influence, but the reduction of these effects through the proposed changes is profound. Henceforth, all Mitchell Act funded production in this ESU will use only within ESU, and preferably within MPG broodstock, creating opportunities for increased among-MPG and among-ESU genetic diversity, a substantive improvement over environmental baseline conditions. Although overall production of coho salmon in the ESU will actually slightly increase as a result of the Proposed Action, reprogramming combined with enhanced and new weir action to remove excess returning hatchery-origin adults is expected to quickly reduce pHOS to levels consistent with recovery viability levels in both the Coast and Cascade MPGs. It is important to realize, however, that the extent to which these populations have been genetically compromised as a result of hatchery influence is not known. In addition, our understanding of what level of hatchery influence may be consistent with viability is limited, based on modeling rather than empirical evidence. Therefore, although we can say with confidence that considering the recovery-level standards for pHOS the net effect of the Proposed Action will be a big reduction in risk compared to the Environmental Baseline, and based on the currently best available science should be compatible with ESU viability, it is possible as part of the Proposed Action that further reductions in hatchery influence will be needed to achieve viability.

In summary, the Proposed Action will, through program release size adjustments, weir operations to remove excess returning hatchery, and use of appropriate broodstocks, reduce the effects of Mitchell Act hatchery production to levels that will promote the productivity, abundance, and diversity of LCR coho salmon populations. Moreover, it does this in a phased manner, initially targeting the populations deemed most important for recovery of the LCR Coho Salmon ESU. These actions will increase the ability of the populations to respond to improvements in habitat and other measures described in the recovery plan for the ESU. The relative improvements in the productivity, abundance, and diversity VSP parameters (Section 2.4.1), brought about by implementation of the Proposed Action, collectively increase the resilience of the LCR Coho Salmon ESU to the challenges of climate change.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed coho salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect LCR coho salmon and NMFS' expects this trend to continue.

2.6.4.4 CR Chum Salmon

NMFS recent status review affirmed the status of this ESU as threatened due to a high risk of extinction (NWFSC 2015). Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat including the estuary, impacts of main stem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the CR Chum Salmon ESU in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects on the abundance, spatial structure, and diversity VSP pamameters of the CR Chum Salmon ESU are negligible for hatchery operations and small for trapping.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill fish, but the effect effect to the abundance and productivity VSP parameters (Section 2.4.1) of the CR Chum Salmon ESU is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the survival and recovery status of the species; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and combining with RM&E programs elsewhere to provide much needed information on how to use hatchery programs in attempting to reduce extinction risk and promote recovery of target species while not disadvantaging non-target species.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is moderate— an estimated 8 to 16% mortality of natural-origin chum salmon juveniles that originate throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS hopes that the new RM&E in the Proposed Action for juveniles will be able to detect this effect. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and reconsideration of hatchery program size may be needed in the future to limit impacts to these VSP parameters (Section 2.4.1) of this ESU.

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced chum salmon. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

The Mitchell Act funded chum salmon hatchery program supports the ESU in what HSRG (2014) calls the recolonization stage. At this stage, demographic concerns outweigh any risk posed by hatchery-induced selection, so no pHOS/PNI standards are being applied at this time. However, to continue to be consistent with recovery, the program will in time develop a local stock, and move to PNI-based management, but at this time benefits of the hatchery program outweigh the risks.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed chum salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect salmon and steelhead and NMFS' expects this trend to continue.

2.6.4.5 LCR Steelhead DPS

NMFS recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction (NWFSC 2015). Factors that limit the DPS have been, and continue to be, hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors including predation and environmental variability. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Steelhead DPS in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects on the abundance, spatial structure, and diversity VSP pamameters of the LCR Steelhead DPS were negligible for hatchery operations and small for trapping because only small numbers of natural-origin fish will be impacted by broodstock collection for isolated programs, and for integrated programs, effects to the abundance, productivity, and diversity VSP parameters (Section 2.4.1), broodstock take is limited to 30% of the natural-origin run. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill fish, but the effect to the abundance and productivity VSP parameters (Section 2.4.1) of the LCR Steelhead DPS is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the survival and recovery status of the DPS; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and combining with RM&E programs elsewhere to provide much needed information on how to use hatchery programs in attempting to reduce extinction risk and promote recovery of target species while not disadvantaging non-target species.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is small—less than one percent mortality of natural-origin steelhead juveniles that originate throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS hopes that new RM&E included in the Proposed Action for juveniles will be able to detect this effect. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive hatchery adult management, and reconsideration of hatchery program size may be needed in the future to limit impacts to these VSP parameters (Section 2.4.1) of this DPS.

The proposed programs will also contribute to marine-derived nutrient input in the Columbia River Basin at by increasing the number of naturally-spawning salmonid carcasses into the future, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced steelhead. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

The genetic effects of the Proposed Action on LCR steelhead is a considerably more complex situation than that for LCR Chinook or LCR coho salmon. Similarly, the effects of the action include the continuation of programs that cause genetic influence, but like Chinook salmon and coho salmon the Proposed Action will reduce those levels of effects through important changes to how Mitchell Act-funded hatcheries will operate going forward. Possibly the most significant changes to overall fishery management in the Proposed Action is the elimination of Mitchell Act funding of the Chambers Creek early winter steelhead (EWS) stock from the LCR region. However, with the exception of two integrated programs, Kalama River and Clackamas River (in the UWR DPS), the same style of management used with the Chambers Creek stock, that of genetically different from the wild fish in the streams in which they are planted, is planned to continue. Although this approach has been questioned, NMFS has recently concluded that programs using this approach with these specialized stocks did not pose significant risk to the Puget Sound Steelhead DPS, provided that measured gene flow is 2% or less.

The Proposed Action includes switching isolated programs from the Chambers Creek stock to a new EWS stock to be developed from the Kalama integrated steelhead program, and then to transition to the new stock immediately or through a temporary use of the Eagle Cr. Stock. NMFS considers temporary use of the Eagle Cr. stock low risk as it will be a significant improvement over the Chambers Creek stock, it has origins in the LCR instead of Puget Sound, and will be used for a very limited time. Use of this single new EWS stock in several populations, and ongoing use of the summer steelhead equivalent, the Skamania summer steelhead stock, imposes an among-population diversity impact: to the extent that gene flow does occur and is not balanced by genetic drift, diversity among populations receiving gene flow from either stock will be decreased. However, given the overall downsizing of steelhead hatchery efforts in the LCR, including the termination of several steelhead hatchery programs and the creation of new genetic reserve streams that receive no hatchery releases, it is NMFS' opinion that the release of fish from a single hatchery stock into multiple populations in the LCR does not pose a significant risk to the productivity or diversity VSP parameters of the LCR Steelhead DPS.

The Clackamas wild winter steelhead hatchery program is well integrated with a PNI meeting the recovery standard for primary populations, so poses little risk. The level of gene flow from the Clackamas summer steelhead program into the Clackamas winter steelhead population is not known, but is likely to be low. At this point, the Clackamas summer steelhead program does not appear to pose a substantial risk to the diversity or productivity VSP parameters of the LCR Steelhead DPS, but this conclusion must be revaluated soon in the light of new data.

In summary, the Proposed Action will, through program release size adjustments, and use of appropriate broodstocks, reduce the effects of Mitchell Act hatchery production to levels that will promote the productivity, abundance, and diversity of LCR steelhead populations. These actions will increase the ability of the populations to respond to improvements in habitat and other measures described in the recovery plan for the DPS. The relative improvements in the productivity, abundance, and diversity VSP parameters (Section 2.4.1), brought about by implementation of the Proposed Action collectively increase the resilience of the LCR Steelhead DPS to the challenges of climate change.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes 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 LCR steelhead and NMFS' expects this trend to continue.

2.6.4.6 UWR Steelhead DPS

NMFS recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction (NWFSC 2015). Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest. After taking into account the current viability status of the 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 added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the UWR Steelhead DPS in the wild.

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. We concluded that facility effects to the abundance, spatial structure, and diversity VSP pamameters of on the UWR Steelhead DPS were negligible for hatchery operations and small for trapping because only small numbers of natural-origin fish will be impacted by broodstock collection for isolated programs, and for integrated programs, broodstock take is limited to 30% of the natural-origin run. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The same is true of RM&E activities. The activities capture and possibly delay fish, and on occasion kill fish, but the effect to the abundance and productivity VSP parameters (Section 2.4.1) of the UWR Steelhead DPS is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the survival and recovery status of the DPS; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and combining with RM&E programs elsewhere to provide much needed information on how to use hatchery programs in attempting to reduce extinction risk and promote recovery of target species while not disadvantaging non-target species.

The biological interactions of the hatchery programs with natural anadromous fish populations in our analysis shows that the ecological impact of the hatchery releases themselves, based on interactions modelling and the current scientific literature is small—less than one percent mortality of natural-origin steelhead juveniles originating throughout the Columbia Basin. Ecological risks due to increased abundance associated with naturally spawning hatchery fish is possible, although this is identical to the situation that would occur with increased natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS hopes that new RM&E included in the Proposed Action for juveniles will be able to detect this effect. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive hatchery fish adult management, and reconsideration of hatchery program size may be needed in the future to limit impacts to these VSP parameters (Section 2.4.1) of this DPS.

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmonid carcasses over the level that would be present in the absence of that program, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.4.1) in watershed areas, enhancing food resources for naturally-produced steelhead. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The Recovery Plan for the ESU describes 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 UWR steelhead and NMFS expects this trend to continue.

2.6.5 SRKW DPS

This Section discusses the effects of the action in the context of the status of the species, the environmental baseline, and cumulative effects, and offers our opinion as to whether the effects of the Proposed Action are likely to jeopardize the continued existence of the SRKW.

The SRKW DPS was listed as endangered under the ESA in 2005 (70 Fed. Reg. 69903, November 18, 2005) and critical habitat was designated in 2006 (71 Fed. Reg. 69054, November 29, 2006). Several factors identified in the final recovery plan for SRKW may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together. For example, disturbance from vessels makes it more difficult for SRKW to locate and capture prey, which can cause them to expend more energy and catch less food. Although it is not clear which threat or threats are most significant to the survival and recovery of SRKW, it is important to acknowledge all threats.

The SRKW DPS is composed of one small population which has had a variable growth rate, is at risk from inbreeding, and has a high extinction risk, depending on the survival rate and probability of catastrophic events. Recent analyses show a general decline in post-reproductive females and an increase in reproductive females since the beginning of the annual censuses. Although there has been an increase in reproductive females, the probability of a reproductive female between the ages of 21 to 27 giving birth has decreased over time.

Our effects analyses focused solely on the likely reduction in Chinook salmon prey available to the whales as a result of the Proposed Action because the best available information indicates that Chinook salmon are SRKW primary prey. Additionally, statistical correlations between various Chinook salmon abundance indices and the vital rates of SRKW have been outlined in several papers and examined in great detail (e.g., Hilborn et al. 2012; Velez-Espino et al. 2014). The best available science suggests that changes in Chinook salmon abundance are likely to directly influence the SRKW population, given there is clear evidence that survival and fecundity rates appear to be relatively well correlated with Chinook salmon abundance levels. Furthermore, tule Chinook salmon are likely a part of the diet for at least most SRKW (particularly K and L pod members) during portions of the year when SRKW occur in coastal waters off Washington and Oregon.

Based on the distribution of SRKW and estimated annual prey energy requirements (in kcal) for each pod, we estimate that SRKW need over 3 billion kcal when not in inland waters, or approximately 300,000 Chinook salmon per year to meet their energy needs when in coastal waters. The proposed 24% reduction in hatchery production will result in measurable adult prey reductions of an average of approximately 25,000 adult equivalents per year in future years as the Chinook salmon mature (or approximately 300 million kcals of food energy). Recent escapement forecasts for Columbia River Chinook salmon stocks ranged from approximately 741,000 to 1,960,800 fish. Therefore, this reduction may result in 1-4% fewer adult Chinook salmon in the localized area off the mouth of the Columbia River, and would be a small portion (or approximately 1%) of the total estimated ocean escapement that may be available to SRKW. These estimates of prey reduction are also considered maximum reductions for several reasons. For example, as hatchery production is reduced, overall salmon abundance is reduced which may result in some reductions in fisheries.

When prey is reduced, SRKW would likely need to spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. The phased approach included in the Proposed Action for implementing reductions in hatchery production and for effects monitoring will provide opportunities to evaluate this action and will also phase in reductions in prey and impacts to SRKW over a number of years. After implementation it will also take several years before the reductions are realized as SRKW preferentially feed on older adult Chinook salmon. Monitoring and recovery actions for both listed Chinook salmon and SRKW are ongoing and intended to improve the status of both species.

In summary, the Proposed Action will adversely affect SRKW in the short term, but in the long term may be beneficial. Tule Chinook salmon are likely part of the diet for at least most SRKW during portions of the year when SRKW occur in coastal waters off Washington and Oregon. In general, the continuation of hatchery programs means that SRKW will continue to benefit from the availability of prey associated with these hatcheries. The proposed 24% reduction in hatchery production, which equates to an average of 25,000 adult equivalents per year, will cause measurable adult prey reductions (1-4% fewer adult Chinook salmon off the mouth of the Columbia River). The short-term reductions annually (that could last several decades), may cause SRKW to spend more time foraging, which may increase energy expenditure and can cause nutritional stress, leading to reduced body size and condition of individuals which could lead to lower reproductive and survival rates of a population. The effects of reduced prey availability would be greater off the mouth of the Columbia River and would be a much smaller magnitude of effect across the range of SRKW. These reductions however, are small and are likely an overestimate as they don’t account for all available Chinook salmon (and other known prey) in the SRKW range or potential reductions in fisheries that may affect overall abundance of Chinook salmon. It is also unlikely that SRKW would have encountered and consumed all the fish in the absence of the Proposed Action. Over the long term the action may be beneficial as its purpose is to improve the status of listed Chinook salmon, however, it is not clear how long it will take for any benefits to be realized.

2.6.6 Critical Habitat

Critical habitat for the ESA-listed species is described in Section 2.2.2 of this Opinion. After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not impair PCEs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes. In reviewing the Proposed Action and after conducting the effects analysis (Section 2.4.2), NMFS has determined that the Proposed Action will not impair PCEs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes as described below. The hatchery water diversion and the discharges pose varying effects on designated critical habitat in the Action Area (Section 2.4.2). Existing hatchery facilities have not contributed to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity and no new facilities are proposed.

The only effects on critical habitat from the Proposed Action would occur in freshwater migration corridors. Hatchery intakes of each acclimation facility are screened to prevent juvenile fish from injury and impingement or permanent removal from streams. Minimum flows will be maintained between the hatchery intakes and the outfalls, thus providing for fish migration through each respective geographic location. Facilities that would require additional construction or disturbance of riparian or streambed habitat, and any effects of water withdrawal and effluent are expected to be small and transitory.

Habitat impacts from the installation, operation and removal of weirs are expected to minor due to movement of gravel during installation. These impacts to the stream bottom are limited to the footprint of the weir and would not be discernable after the first high water event after removal. The weirs are designed to be installed and removed seasonally (during a several month period) and will impact the PCEs for migration by handling of the majority of natural-origin ESA-listed species.

If installed by the first of June, the weirs may disrupt the downstream migration of winter steelhead kelts (fish that have already spawned and that are returning to the ocean).The actual number of kelts encountered is unknown but expected to be low because winter steelhead spawning is usually completed by early May, reducing the potential for kelts to be present when the weirs are operational. Winter steelhead kelts have not been observed weirs in the Coweeman and Elochoman Rivers, for example.

At the Kalama Falls Hatchery, delay in upstream migration caused by the Proposed Action is expected to be negligible and will not adversely impact salmon or steelhead placed above the hatchery. The numbers of salmon and steelhead affected will be small because water flows that would provide for passage are fully utilized to attract migrating fish into the facility. Impacts would be expected to be temporary while operations ensure that natural-origin fish can bypass the facility to reach their primary spawning grounds.

The reduction in flow adjacent to the Skamania Hatchery, Kalama Falls Hatchery, and the Beaver Creek intake at Beaver Creek Hatchery is not expected to reduce habitat quantity or quality to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults.

While the Grays River Hatchery, Fallert Creek Hatchery, and the Elochoman River intake at Beaver Creek Hatchery do not currently meet NMFS criteria for protecting juvenile fish from entrainment and injury they are screened to prevent permanent removal of fish from each watershed. For the majority of the hatchery facilities under the Proposed Action, each hatchery facility generally diverts less than 4% of the surface water from the adjacent stream, with most actually being less than 2% of the flow. These small levels will not affect passage or rearing capacity for ESA-listed anadromous fish populations in the adjacent vicinities. There are exceptions where facilities remove a larger proportion of the flow, and for these facilites, water withdrawals are managed to maintain minimum flow levels within the reach from the intake to the hatchery outfall that provides for adult and juvenile migration and rearing.

The Vancouver Trout Hatchery does not divert surface water from a body of water known to contain ESA-listed anadromous fish, and thus its water usage would not have any impact on critical habitat. The net pen facilities do not divert surface water, rather they allow for complete pass through, and thus would not have any impact on critical habitat.

Each facility that is required to operate under a NPDES permit does so, or in the case of the DRNPs, has applied for a permit. Effluent from each facility is monitored weekly to ensure compliance with permit requirements. Several acclimation sites do not need a NPDES permit because rearing levels are below permit minimums (see Section 1.3). Any sediment from the maintenance of instream structures at hatchery facilities would be localized and temporary and would not be expected to affect ESA-listed anadromous fish species.

In reviewing the effects of the Proposed Action, on instream habitat, the installation of the weirs would be expected to have minor impacts on the streambed but these impacts would be limited to the weir site and would not be permanent. The operation of the weirs and other hatchery facilities may impact migration PCEs due to delay at these structures and possible rejection. The number of NOR adults delayed is expected to be small and the delay would be for only a short period. Impacts on water quality and quantity, NMFS determined that the impacts from removing up to a possible maximum of 4% water flow for the majority of the facilities and maintaining minimum flows in the bypass reach during the period of time that hatchery operations actually withdraw surface water would not be measurable and are not expected to reduce freshwater rearing habitat area or quality to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults that may be present in the area adjacent to the facilities during the holding and spawning of hatchery-origin fish for the hatchery programs listed in Table 1.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and the critical habitat, the environmental baseline within the Action Area, the effects of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of any species in Table 9; the Southern DPS of Pacific Eulachon, the SRKW DPS, the LCR Chinook Salmon, UCR Chinook Salmon Spring-Run, Snake River Chinook Salmon Spring/Summer-Run, Snake River Chinook Salmon Fall-Run, UWR Chinook Salmon, LCR Coho Salmon, CR Chum Salmon, and Snake River Sockeye Salmon ESUs, and the LCR Steelhead, UCR Steelhead, Snake River Basin Steelhead, MCR Steelhead, and UWR Steelhead DPS, or destroy or adversely modify any designated critical habitat for these species.

2.8 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). For the purposes of this consultation, we interpret “harass” to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or substantially altered.[41] 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. This ITS applies to funding actions considered under the Mitchell Act that are not currently covered by other Opinions.

2.8.1 Amount or Extent of Take

In this Opinion, NMFS has determined that the take of ESA-listed species is expected to occur as a result of the NMFS’ Proposed Action to fund hatchery programs under the Mitchell Act. Under the ESA, the term “take” means “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct”, and for the Proposed Action this would occur when: (1) fish are encountered at weirs and their survival, reproductive success, or spatial distribution is affected and when fish are handled while collecting hatchery fish for broodstock purposes – the Proposed Action does not include the take of ESA-listed natural-origin fish for hatchery broodstock; (2) hatchery fish spawn naturally and when they spawn on top of (i.e., superimposition) spawning areas of fish from a natural population; (3) post-release juvenile hatchery fish use limited food and habitat resources or prey on ESA-listed natural-origin or non-marked hatchery fish; (4) construction, operation, and maintenance of hatchery facilities cause harm (e.g., affect fish habitat); (5) RM&E activities handle, injure, or otherwise effect the survival, reproductive fitness and spatial distribution of the fish; and (6) through reductions in prey availability to SRKW.

2.8.1.1 Encounters with natural-origin and hatchery-origin fish at adult collection facilities, including the operation of weirs

In the course of collecting hatchery-origin fish for hatchery broodstock, the Proposed Action will fund activities that result in the annual handling of adult natural-origin fish, by species, as described in Section 2.4.2 of the Opinion.

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[41] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as “to trouble, torment, or confuse by continual persistent attacks, questions, etc.” The U.S. Fish and Wildlife Service defines “harass” in its regulations as an intentional or negligent act or omission that creates 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 (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the U.S. Fish and Wildlife interpretation of the term.

For the purposes of this statement, NMFS proposes to administer funds in a way that the expected handling associated with the collection of hatchery broodstock will not exceed those numbers identified in either table listed below (Table 121 or Table 122), and this represents the quantified level of take associated with broodstock collection, including the operation of weirs. These are fish that volunteer to the respective hatchery facility by watershed, or are trapped at weirs located at the specified watershed; all natural-origin salmon and steelhead must be released, unharmed, immediately upstream of the site or transported to the expected release location. Take associated with the handling identified in the tables below is expected, including take that results in mortality.

Table 121. Maximum number of natural-origin adults and jacks for each species authorized to be handled at hatchery facilities funded through the Mitchell Act and the maximum authorized incidental mortalities resulting from handling at hatchery facilities (assumes a 3% incidental handling mortality).

Watershed	*Hatchery Facility*	*Natural-Origin fish*	*ESUs/DPSs expected to be collected.*	*Number handled*	*Expected incidental mortalities*
Mainstem Columbia River	Bonneville Hatchery	Fall Chinook	LCR Fall Chinook Salmon; Snake River Fall Chinook	2,250	<23
		Coho	LCR Coho Salmon	1,400	<14
		Chum	CR Chum Salmon	50	1
		Steelhead	LCR, MCR, UCR, and Snake River steelhead	110	<3
		Sockeye	Snake River Sockeye Salmon	<10	1
	Ringold Springs	Steelhead	UCR Steelhead	50	1
Big Creek	Big Creek Hatchery	Fall Chinook	LCR Fall Chinook Salmon	200	<3
		Coho	LCR Coho Salmon	700	<7
		Chum	CR Chum Salmon	200	<3
Youngs Bay	Klaskanine Hatchery and SF Clatsop Co. Fisheries Hatchery	Fall Chinook	LCR Fall Chinook Salmon	20	1
		Coho	LCR Coho Salmon	120	<3
		Chum	CR Chum Salmon	10	1
Clackamas River	Clackamas Hatchery	Steelhead	LCR Steelhead	50	1

Watershed	***Hatchery Facility***	***Natural-Origin fish***	***ESUs/DPSs expected to be collected.***	***Number handled***	***Expected incidental mortalities***
		Spring Chinook	UWR Spring Chinook Salmon	350	<3
North Fork Toutle River	North Fork Toutle Hatchery	Fall Chinook	LCR Fall Chinook Salmon	2,000	<60
		Coho	LCR Coho Salmon	10,000	<100
		Chum	CR Chum Salmon	0	0
		Steelhead	LCR Steelhead (winter)	10	1
Grays River	Grays River Hatchery	Fall Chinook	LCR Fall Chinook Salmon	25	1
		Coho	LCR Coho Salmon	150	<3
		Chum	CR Chum Salmon	50	1
Elochoman River	Beaver Creek	Fall Chinook	LCR Fall Chinook Salmon	20	1
		Coho	LCR Coho Salmon	20	1
		Chum	CR Chum Salmon	20	1
Kalama River	Kalama Falls Hatchery and Fallert Creek Hatchery	Fall Chinook	LCR Chinook Salmon	6,000	<60
		Spring Chinook	LCR Chinook Salmon	500	<5
		Coho	LCR Coho Salmon	3,000	<90
		Chum	CR Chum Salmon	25	1
		Steelhead	LCR Steelhead (summer and winter)	3,400	<34
Washougal River	Washougal Hatchery	Fall Chinook	LCR Fall Chinook Salmon	3,000	<30
		Coho	LCR Coho Salmon	1,000	<10
		Chum	CR Chum Salmon	25	<1
	Skamania Hatchery	Steelhead	LCR Steelhead (summer and winter)	400	<5
Klickitat River	Klickitat Hatchery	Steelhead	MCR Steelhead	10	1

Table 122. Maximum number of natural-origin adults and jacks for each species authorized to be handled at weirs and the maximum mortality limits (assumes a 3% incidental handling mortality).

Watershed	***Species encountered***	***Number handled***	***Expected mortalities***
Grays (MA)	Fall Chinook	750	<23
	Coho Salmon	800	<24
	Chum Salmon	8,500	<225
Skamokawa	Fall Chinook	200	<6
	Coho Salmon	1,425	<43
	Chum Salmon	500	<15
Elochoman (MA)	Fall Chinook	750	<23
	Coho Salmon	800	<24
	Chum Salmon	1,000	<30
Mill Abernathy Germany	Fall Chinook	210	<6
	Coho Salmon	1,125	<34
	Chum Salmon	250	<8
South Fork Toutle	Fall Chinook	350	<11
	Coho Salmon	5,500	<165
	Chum Salmon	250	<8
	Summer Steelhead	50	<2
Coweeman (MA)	Fall Chinook	1,600	<48
	Coho Salmon	800	<24
	Chum Salmon	100	<3
	Winter Steelhead	300	<9
Cedar Creek	Fall Chinook	400	<12
	Coho Salmon	1,000	<30
	Chum Salmon	250	<8
	Summer Steelhead	50	<2
Washougal (MA)	Fall Chinook	1,200	<36
	Coho Salmon	80	<3
	Chum Salmon	250	<8

Watershed	*Species encountered*	*Number handled*	*Expected mortalities*
	Summer Steelhead	100	<3
Kalama (MA)	Fall Chinook	3,200	<96
	Coho Salmon	150	<5
	Chum Salmon	250	<8
	Summer Steelhead	200	<6
NF Toutle (MA)	Fall Chinook	700	<21
	Coho Salmon	2,300	<70
	Chum Salmon	250	<8
	Summer Steelhead	50	<2

For the purposes of this statement, mortalities during funded broodstock activities will not exceed those identified in Table 121 or Table 122. NMFS will report annually the numbers of adults handled at each funded location and any mortalities incidental to the operation of the facilities or weirs (see Section 2.8.4).

The operation of weirs is expected to result in take of ESA-listed salmon and steelhead due to associated factors such as weir rejection, migration delay, and delayed mortality after release due to collection at the weir (this is in addition to the incidental mortality from handling at the weirs that is identified in Table 122). It is not possible to accurately quantify this take because reliable measurements cannot be made of such factors or their effects. NMFS will therefore rely on surrogate take indicators, discussed below, that attempt to measure the effects of weir rejection, migration delay, and delayed mortality due to handling adult salmon or steelhead at the weirs. These have a rational connection to the amount of take because they reflect operational delay and the effects of weir operation compared to pre-weir conditions.

These surrogate take indicators will act as triggers for NMFS' review which may lead to reinitiation of the ESA consultation or refinement of the Proposed Action. There is a high level of variability in the natural environment in the rivers and locations for each weir, as they range from tributaries near the mouth of the Columbia River upstream to tributaries near Bonneville Dam. Furthermore, even excluding the effects of these types of local environmental conditions coupled with weather events, there is natural variability due to the factors outside each location that affect the survival and productivity of the natural-origin populations. These outside factors affect smolt-to-adult survival as illustrated by the variations in survival manifested in changes in the abundance of natural-origin adults returning as seen across the years in Section 2.2.1 for each ESU or DPS. Variability is also seen in things like spawning distribution (Schroeder et al. 2013; Whitman et al. 2014), time of first spawning and peak spawning (Whitman et al. 2014) for any run of salmon or steelhead. Surrogate take indicators attempt to identify changes to the natural populations that are due to the operation of the weirs by comparing things such as redd distribution and pre-spawning mortality before and after the operation of the weirs. Because of the natural variability described above, it is difficult to determine if the changes in these types of comparisons are due to the operation of the weirs or to changes in the natural environment.

Due to this natural variability, for each of the surrogate take indicators below, NMFS will use a three-year running mean beginning in 2020. NMFS will also monitor annual reports (Section 2.8.4) to determine if the surrogate take indicators have been exceeded in a single year and whether that exceedance would be such that the three-year moving average could not be achieved.

2.8.1.2 Surrogate for Weir Rejection

Weir operation may affect spawning distribution due to delay and weir rejection (see Section 2.4.1). Weir rejection cannot be reliably observed and quantified, because there is no realistic way to accurately survey weir rejection as it is occurring. Therefore NMFS will rely on a surrogate take indicator measuring the extent to which spawning distribution is changing, likely attributable to the weirs.

Determining and quantifying changes in spawning distribution is a reasonable surrogate for weir rejection, because weir rejection tends to lead to increased spawning downstream of the weir. Not all change in distribution is attributable to the presence of weirs, but a change beyond a certain level likely exceeds natural variability, and therefore can be reasonably attributed to weirs. Additionally, changes in spawning distribution can be observed and measured in a reasonably reliable manner. Therefore, NMFS will be required to ensure funding recipients monitor spawning distribution in the vicinity of each weir.

The Proposed Action is expected to result in no more than a 10% relative increase in the distribution of spawning of natural-origin salmon and steelhead below the weirs. In recent years, redd distribution has been estimated for specific stream sections (as this is how most pHOS estimates have been compiled in Section 2.2.1), and comparing the incidence of spawning in those stream sections can be used to determine if the operation of the weirs is affecting spawning distribution. The proposed weir locations are generally within the lower sections of each tributary to the Columbia River. To apprehend changes to spawning distribution caused by placement of weirs the surrogate take indicator examines the changes in redd distribution by comparing the proportion of redds observed in each of the survey sections with the average proportions that were observed during the five year period prior to weir placement.

For example, if the five-year running proportion of spawning in a survey section was 40 percent of all spawning in a river took place below where a weir was now placed, then the extent of take would be exceeded if the proportion increased to 50 percent in the measurement of spawning distribution in this same reach of the river. As discussed above, the expected level of take in the form of changes in spawning distribution caused by the weirs is minimal, and in any case shall not exceed an absolute increase of 10% in spawning of natural-origin salmon or steelhead in the lower sections of rivers wherever weirs are placed. Therefore, the level of incidental take described here attributable to the Proposed Action would be exceeded when a 3-year running mean of the proportion of redds below a weir site is 110% or more of the mean proportion of redds for that same geographic stretch of river using data 5-years prior to weir installation.

The surrogate serves as a reasonable and reliable measure of incidental take, because if the distribution of redds increases in areas now affected by the weirs compared to the average proportion observed (as a measure of distribution) under natural conditions pre-weir placement, then it is reasonable to conclude that the weirs are causing this change and that salmon or steelhead are choosing to spawn below the weir in greater-than-normal numbers and are doing so because they are having difficulty passing the weirs. Upon reaching such a threshold, NMFS will propose changes to the operation of the weirs to minimize the effects, and NMFS will likely require reinitiation of consultation (Section 0). Where weirs are funded and operated, NMFS will continue to monitor redd distribution within the respective river annually. As described above, a 3-year running mean, beginning as soon as return year 2020, will be used for this surrogate take indicator because this will allow for naturally occurring variations in the proportion of redds in the lower survey sections.

Surrogate for Migration Delay

Take in the form of migration delay due to weir operations cannot be reliably measured. Data are not available on many of the salmon or steelhead migration patterns in the rivers where weirs are to be installed prior to the existence of the weirs. Without knowing what normal migration patterns were in the past, comparisons to migration timing changes due to the presence of weirs cannot be reliably established.

NMFS therefore proposes to rely on a surrogate measure of migration delay, consisting of changes in the date of peak spawning. This is a reasonable surrogate for a delay in migration, because any such delay would likely cause a later date of peak spawning.[42] The date of peak spawning can be reliably measured using data collected during spawning ground surveys.

To ascertain the changes in peak spawning that are caused by operation of the weirs, the surrogate take indicator examines the changes in the peak spawning date by comparing the annual peak spawning date with the range of peak spawning dates observed prior to the operation of the weirs (2010-2017). Take associated with migration delay would be indicated by three consecutive years where the peak spawning date is outside the range observed before weir operation. For example, if the particular population had previously observed peak spawning from February 20 – March 15, and peak spawning after the installation of weirs was outside of that date range for three consecutive years, NMFS would consider the take threshold to have been exceeded. Even if peak spawning remains within the range, NMFS will monitor the trend in the peak spawning date to determine if the operation of the weir is shifting the date away from the pre-weir mean, and may require changes or reinitiate consultation as a result.

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[42] The date of first spawning may be affected by the spawning ground survey schedule and thus NMFS will not use this as a surrogate take indicator. Spawning ground surveys are not conducted daily and thus the scheduling of the earlier surveys may affect the detection of the initiation of spawning. NMFS will monitor the date of first spawning to determine if there is a trend away from the mean observed pre-weir operation.

The surrogate serves as a reasonable and reliable measure of incidental take, because if the peak spawning date is continuously outside the range observed under natural conditions before the weirs were operated, then it is reasonable to conclude that the weirs are causing this change and that salmon or steelhead have altered their date of peak spawning because they are having difficulty passing the weirs. Exceedance of the surrogate would trigger NMFS to propose changes to the operation of the weirs to minimize the effects and NMFS will likely require reinitiation of consultation (Section 2.10).

Surrogate for Delayed Trapping and Handling Mortality

As discussed above, trapping and handling salmonids at weirs can result in impacts that are not manifested until after release. An indication of this delayed mortality is the level of pre-spawning mortality observed in salmonids following release. Generally, pre-spawning mortality can be reliably detected and quantified during spawning ground surveys, where salmon and steelhead carcasses can be used to determine if spawning had occurred prior to death by examining carcasses for retained eggs. However, pre-spawning mortality can occur naturally as well, not solely as a result of trapping and handling.

It is not possible to directly accurately observe and quantify pre-spawning mortality that is attributed to the Proposed Action, because where carcasses indicate pre-spawning mortality, there is no evidence as to the precise cause. This is in addition to incidental handling mortality identified in Table 122. Therefore, NMFS will rely on a surrogate take indicator measuring the change in pre-spawning mortality from past years before weirs were installed. Specifically, the surrogate take indicator for delayed mortality after release is an increase in observed pre-spawning mortality. NMFS expects that the Proposed Action will result in an absolute increase of no more than 5% in pre-spawning mortality from what was measured during previous spawning ground surveys prior to the installation and operation of the weirs. Exceedance of the surrogate in a single year would trigger NMFS to propose changes to the operation of the weirs to minimize the effects and NMFS will likely require reinitiation of consultation (Section 0). This means that if a population experienced an average of 2% pre-spawning mortality prior to installation of weirs, any single year when the amount reached 7% or higher would trigger an exceedance of the allowable incidental take.

This surrogate serves as a reasonable and reliable measure of incidental take, because NMFS expects that the weirs have a minimal effect on pre-spawning mortality, and an absolute change of 5% will allow for naturally occurring annual variability in pre-spawning mortality estimates while still providing protection to the ESA-listed salmon or steelhead. NMFS will ensure, as part of funded salmon or steelhead spawning ground surveys, that funding recipients will annually monitor and report pre-spawning mortality.

For pre-spawning mortality in rivers where there is not a historical baseline and therefore no reliable measure for delayed trapping and handling mortality attributable to the operation of the weirs, NMFS will rely instead on the amount of take by handling at the respective weir. The number of fish handled is a good indicator of pre-spawning mortality because handling and delay can both contribute to pre-spawning mortality. Pre-spawning mortality will be monitored and compared to trends observed to determine if there are impacts from the operation of a specific weir. Pre-spawning mortality will be included as part of the annual spawning survey report. As more data becomes available, NMFS may amend this section to rely on a pre-spawning mortality take indicator.

2.8.1.3 Interactions on the spawning grounds

When hatchery fish are not harvested or do not return to release locations, genetic interactions with listed fish on the spawning grounds can occur, and the result constitutes take of the natural populations. It is not possible to ascertain the exact amount of such take, because it is not possible in most cases to meaningfully observe and measure these genetic interactions. NMFS will therefore rely on a surrogate variable, census pHOS (measured over the entire ESA-listed population), for this form of incidental take. Using pHOS as a surrogate indicator of take is rational because it relates directly to the form of take – genetic interaction due to interbreeding – by measuring the presence of hatchery fish available to interbreed with natural-origin fish. Where available, with respect to steelhead, the surrogate indicator of gene flow will be used instead of pHOS.

Note, there are also PNI goals included in the Proposed Action and analyzed in the effects analysis of this Opinion. Because those goals are not scheduled to be reached until later years, the PNI goals cannot function in the short term as surrogate indicators of take in this Statement, instead of pHOS. However, those remain expected actions, and changes to PNI goals or the ability of hatchery programs to meet PNI goals could constitute a change that leads to reinitiation of this consultation.

The pHOS estimates to be used, as described below, are running arithmetic means. During the course of this consultation, funding grantees such as WDFW have expressed concern over the accuracy of pHOS estimation and have suggested alternatives (WDFW 2016b). There was insufficient time to explore this during the consultation, and NMFS will complete this task of exploring different methods for estimating genetic interactions between hatchery and natural-origin fish during the next six months. The result may be an amendment of the pHOS estimation methodology described below that will provide the same or a better level of protection to the resource as the simple running means, or the replacement of certain threshold in consultations on subsequent Mitchell Act funding distributions. If a better methodology to estimate genetic interactions is found, it will be used rather than the methods described below. For the present, however, NMFS intends the surrogate take variable to be estimated and evaluated as follows:

Chinook salmon

a) Given the age structure of Chinook salmon, the pHOS for a natural population will be calculated as a four-year running arithmetic mean, with year 1 being the first year in which effects of pHOS reduction measures (weir actions and/ or program changes) can be expected to occur. NMFS will determine annually whether take has been exceeded after four years of data become available, unless NMFS determines after two years (of the four-year running mean period) that pHOS is so high that attainment of the mean across four years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Therefore, incidental take by interactions on the spawning grounds of individual populations shall not exceed the following limits:

Table 123. Maximum Chinook salmon pHOS limits by ESA-listed natural population into which hatchery Chinook salmon originating from Mitchell Act funded hatchery programs are known to stray.

Population	***Chinook salmon program type contributing to pHOS in population***	***pHOS limit***
Grays/Chinook Rivers	Isolated fall	50%
Elochoman/Skamokawa Rivers	Isolated fall	50%
Mill/Abernathy/Germany Creeks	Isolated fall	50%
Coweeman River	Isolated fall	10%
Lower Cowlitz River	Integrated fall	30%
Toutle River	Integrated fall	30%
Lewis River	Isolated fall	10%
Washougal River	Integrated fall	30%
Kalama River	Isolated spring	10%
Clackamas River	Isolated spring	10%

Coho salmon

a) Given the age-structure of coho salmon, the pHOS for a natural population will be calculated as a three-year running arithmetic mean, with year 1 being the first year in which effects of pHOS reduction measures (weir actions and/ or program changes) can be expected to occur. NMFS will determine annually whether take has been exceeded once three years of data become available, unless NMFS determines after two years (of the three-year running mean period) that pHOS is so high that attainment of the mean across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Therefore, incidental take by interactions on the spawning grounds shall not exceed the following limits:

Table 124. Maximum coho salmon pHOS limits by ESA-listed natural population where hatchery coho salmon originating from Mitchell Act funded hatchery programs are known to stray.

Population	***Coho salmon program type contributing to pHOS in population***	***pHOS limit***

Grays/Chinook Rivers	Integrated	30%
Elochoman/Skamokawa Rivers	Integrated	30%
Clatskanie River	Isolated	10%
Scappoose River	Isolated	10%
Lower Cowlitz River	Integrated late	30%
Coweeman River	Isolated	10%
South Fork Toutle	Isolated	10%
North Fork Toutle	Integrated late	30%
East Fork Lewis	Isolated	10%
Washougal River	Integrated late	30%
Clackamas River	Isolated late	10%

Steelhead

While pHOS serves as a reasonable and reliable measure of incidental take for salmon species, for steelhead, where the discussion of impacts has become more sharply focused due to the use of stocks that have been selectively bred for an altered life history (Chambers Cr., Skamania, and the new Kalama stock that will be developed as part of the Proposed Action), actual measures of gene flow have emerged as a take surrogate for these types of programs. Therefore, the preferred take surrogate for populations influenced by these types of stocks is usually gene flow, not pHOS. However, this approach has so far only been applied in Puget Sound. Measurement of gene flow from isolated hatchery programs in natural populations affected by Mitchell Act funded hatchery programs has not been attempted, and at this point it is not clear how feasible or successful it will be. Because of this and other complications, as discussed in Section 2.4.2.2.2, we have explored the relationship between pHOS and gene flow, and have determined that over a fairly wide range of conditions a census level pHOS of 0.05 will serve as an adequately conservative alternative to the 2% gene flow surrogate. This means that any exceedance of the pHOS limit, where the gene flow limit has not been calculated, will exceed the allowable take under this Statement. In situations where gene flow is calculated, the limit of pHOS is relegated to limits established for ecological effects discussed below. For other isolated programs and for integrated programs, the same maximum pHOS levels are used as take surrogates for Chinook and coho salmon. Compilation and consideration of the take metric will be as for Chinook and coho salmon, on a four-year time scale. As for those two species, for natural populations influenced by integrated programs, PNI is expected to be at least 67% within three generations, in this case 12 years. Authorized take levels are presented in Table Table 125.

Table 125. Maximum steelhead gene flow and pHOS limits by ESA-listed natural population where hatchery steelhead originating from Mitchell Act funded hatchery programs are known to stray.

Population	*Program type contributing to*	*Gene flow limit*	*Census pHOS limit*

	genetic effects in population		
Coweeman	Isolated	≤2.0%	≤5.0%
SF Toutle	Isolated	≤2.0%	≤5.0%
Kalama	Isolated/integrated	≤2.0%*	≤5.0%**
Salmon Cr	Isolated	≤2.0%	≤5.0%
Clackamas	Integrated winter; isolated summer	N/A	Winter: ≤10.0%; Summer: ≤5.0%
Washougal	Isolated	≤2.0%	≤5.0%
Upper Gorge	Isolated	≤2.0%	≤5.0%
Klickitat (S/W)	Isolated	N/A	≤5.0%
All UCR Pops (Wenatchee, Methow, Entiat, Okanogan)	Isolated	N/A	≤5.0%

**Expected outcome from the isolated component of the Kalama steelhead programs.

NMFS is authorized to issue funds for operators that return stray hatchery-origin fish to their hatchery of origin or, alternatively, use the fish for human consumption, stream fertilization, or to support tribal or recreational harvest in areas not accessible to anadromous salmonids.

NMFS understands that the running mean calculations will not result in measurements for a number of years after the implementation of the Proposed Action. However, since genetic effects result from returning hatchery adults, the effects of the Proposed Action (2016 funding and later) relating to genetic interactions will not take place any sooner than the average time frames described specific to each species running mean calculation. Moreover, the running average will likely be a useful tool into the future beyond the term of this Opinion, since the Mitchell Act program has been in effect for many years, and on that basis one might expect it to continue.

2.8.1.4 Interactions in juvenile rearing and migration areas

Incidental take of ESA-listed salmon and steelhead is expected to occur in the form of interactions between juvenile hatchery and natural-origin fish in juvenile rearing and migratory areas. This form of take concerns interactions (predation, competition, or pathogen transmission, collectively referred to as ecological interactions) between juvenile salmon and steelhead and juvenile hatchery fish. This occurs as smolts emigrate from hatcheries and acclimation ponds and likely transit through the migratory fresh, brackish, and marine waters of the Action Area or as hatchery fish residualize and remain behind. However, it is difficult to quantify this take because ecological interactions cannot be observed directly. NMFS will therefore rely on surrogate take indicators. These take surrogates all work in conjunction with each other.

The first take surrogate is the date of release. This standard has a rational connection to the amount of take expected from ecological interactions because the potential for adverse ecological interactions increases as more overlap occurs between hatchery and natural-origin fish, specifically hatchery-origin yearling fish, for the reasons discussed in Section 2.4.2.3. For this take surrogate, releases of salmon or steelhead yearling smolts should take place after the majority of natural-origin salmon and steelhead have exited the system or have grown to a size in the estuary that they are less likely to be predated upon. NMFS considers, for the purpose of this take surrogate, that the amount of incidental take associated with the release date will have been exceeded if hatchery yearling smolts are released prior to the last week of March for released downstream of McNary Dam, unless the operator has first sought and obtained NMFS concurrence that an earlier smolt release will not increase the temporal overlap with natural-origin fish. The location of release here is associated with the travel time expected to reach the estuary. Absent this showing and NMFS concurrence, releases before the last week of March would result in take beyond the level of this estimate. If NMFS receives information that the emigration of a majority of natural-origin juveniles has shifted to a later time, NMFS will revisit this take surrogate.

A second surrogate estimate of the incidental take caused by ecological interactions is the size of smolt releases. Again, because ecological interactions cannot be observed, NMFS is relying on a series of surrogate measurements. In addition to the timing of releases that determine the extent of potential interaction between hatchery and natural-origin fish, the quantity of fish released, the release location, and the size of smolts released all relate directly to the potential for take through this pathway. As the number of smolts released increases, so does the extent of potential interaction. The choice of location for the release also determines the extent of potential interaction. Finally, the size of the smolts released relates directly to the extent to which any interactions result in harm or mortality to natural-origin fish, because the larger a smolt is upon release, the more likely it could out-compete or prey on others. The limits imposed through these surrogates are as follows:

- Any single release of smolts in numbers that exceed 105% of the targeted release number identified above will be considered to have exceeded the expected incidental take through ecological interactions;
- Any five-year average calculation of smolt releases that exceed 102% of the applicable targeted release number identified above will be considered to have exceeded the expected incidental take through ecological interactions;
- Any change in release location from the locations identified in the HGMPs for the programs included in the Proposed Action will be considered to have exceeded the expected incidental take through ecological interactions;
- Any change from the planned average size of fish released for each program in the Proposed Action will be considered to have exceeded the expected incidental take through ecological interactions.

Finally, take may occur through ecological interactions where hatchery fish residualize and remain in fresh water. This too cannot be reliably observed and quantified, therefore NMFS will rely on a take surrogate consisting of the proportion of hatchery-origin fish that are precocially mature prior to release. This standard has a rational connection to the amount of take expected from ecological interactions because precocious fish are more likely to residualize after release from the hatchery, which would place them in contact with natural-origin fish of a size that makes them vulnerable to predation. The take surrogate can be reliably measured and monitored through assessment of precocious maturation rates prior to releasing each proposed yearling release. While temperatures during rearing of hatchery fish are known to affect maturation and smolting rates, this take limit is also subject to variation similar to release size, given hatchery survival varies with environmental conditions, which necessitates tracking both single-year changes as well as using a running average.

The incidental take through ecological interactions relating specifically to residualization shall have been exceeded if the percent of yearling releases that are determined to be precocially mature exceeds 5% in any one year, or if the 5-year average exceeds 3% at any time. These are levels known to occur through review of other yearling programs (IDFG 2003).

These take surrogates can be reliably measured and monitored through enumeration and tracking of release dates and numbers for hatchery salmon and steelhead. Each of these surrogates represents an independent threshold, meaning that exceedance of any one of these surrogates would result in the applicable program having exceeded the incidental take limits included in this Statement, likely necessitating the reinitiation of consultation.

2.8.1.5 Construction, operation, and maintenance of hatchery facilities (e.g., water intake structures)

NMFS determined that funding hatchery facility operations, resulting in water withdrawals as the result of the operation of individual hatcheries, acclimation facilities and the intake structures, is also expected to cause incidental take of ESA-listed anadromous fish primarily through water withdrawals, where harm can occur when stream flows are reduced by water withdrawals, reducing the quality and quantity of rearing habitat, and inhibiting migration (See Section 2.4.2.5)

It would not be possible to accurately assign take of ESA-listed species to facility effects if operated as described above, since the minimal change in water quality and quantity will be just one factor facing anadromous fish in the river; nor would it be possible to quantify such take, since the effects of water withdrawals on individual fish cannot be detected and counted. Therefore, NMFS will rely on surrogate take indicators for both the water quality and water quantity take pathways.

Regarding water quantity and take resulting from water withdrawals, the surrogate take indicator is water withdrawals will not exceed the current established surface-water right, as limited by minimum instream flow requirements, during any time the hatchery facility is in operation. This level has a rational connection to the amount of take because either taking more water than is described in a water right, or reducing instream flows below minimums, reflects potential changes to the hydrograph of the river where a hatchery facility is located which, if exceeded, are likely to result in a greater amount of take of salmonids or affect designated critical habitat than what is expected to occur under the Proposed Action. This surrogate will be measured by the hatchery operators through monitoring surface water withdrawal levels and through monitoring surface water flows within the stream section between the intake and the hatchery outfall, by month, as measured in cubic feet per second (cfs).

Regarding water quality and potential take through the effects of effluent discharges, the surrogate take indicator is any effluent discharge that exceeds any applicable water quality standard or any term of the NPDES permit issued. Any concurrent effluent discharge NPDES permit violations, or more than two non-concurrent violations, that occur during any five year timespan following the issuance of this Opinion would be considered to have exceeded the level of incidental take from this pathway. This standard has a rational connection to the amount of take because water quality standards are designed to limit discharges into waterways which would result in harm to fish, wildlife and other beneficial uses, and the established limits represent the effects and related take levels expected to result from the Proposed Action.

These surrogates serve as reasonable and reliable measures of incidental take, because the water withdrawals directly cause the take at issue, and are measurable because the hatchery facilities that receive funds as part of the Proposed Action will be required to record and report annual water usage in terms of their percentage withdrawn from their sources and NPDES permit compliance as part of its reporting requirements to NMFS.

2.8.1.6 Research, Monitoring, and Evaluation (RM&E)

NMFS determined that the proposed RM&E activities funded through the Proposed Action are expected to directly and incidentally take juvenile and adult ESA-listed anadromous fish (Section 2.4.2) which will negatively affect the populations encountered. The take associated with the proposed RM&E activities is necessary to verify the Opinion's analysis of effects, compliance with established terms and conditions, and to monitor the status of the natural-origin populations affected by the hatchery programs. The Opinion evaluated nine different RM&E activities as part of the Proposed Action, and each has specific details related to the take expected to occur.

Take in the form of delayed or displaced natural spawning resulting from surveys for spawner distribution and for redd superimposition is not likely to occur. Therefore no take is expected in the LCR tributaries, during surveys determing the abundance of natural-origin fish and hatchery-origin fish on the spawning grounds or during similar surveys in the Klickitat River. Also, as verified through reporting, take is not expected to occur during LCR and tributary fishery monitoring monitoring activites or monitoring of the Nez Perce Tribe's Snake River Coho Salmon Restoration Program activities, which are both funded through the Proposed Action. NMFS continues to expect no level of take to occur during these activities.

NMFS expects that the Proposed Action will result in incidental take in the form of the expected encounters and mortalities associated with the following categories of RM&E:

a. Category: A genetic monitoring project to determine the efficacy of isolated steelhead programs.

NMFS shall administer funds for these programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed the limits identified in the following table(s).

Table 126. The maximum number of natural-origin juvenile fish handled or killed during activities associated with genetic monitoring activities to determine the efficacy of isolated steelhead programs funded through the Mitchell Act.

Species	***Watershed (State)***	***Handled***	***Mortality***
		Juveniles	
Chinook (spring)	Kalama (WA)	2,000	80
Chinook (fall)	Grays/Chinook (WA)	10,000	400
	Elochoman/ Skamokawa (WA)	10,000	400
	Toutle (WA)	20,000	800
	Coweeman (WA)	10,000	400
	Kalama (WA)	8,000	320
	Lewis (WA)	10,000	400
	Salmon (WA)	10,000	400
	Washougal (WA)	10,000	400
Coho	Grays/Chinook (WA)	10,000	400
	Elochoman/ Skamokawa (WA)	10,000	400
	Toutle (WA)	20,000	800
	Coweeman (WA)	10,000	400
	Kalama (WA)	8,000	320
	Lewis (WA)	10,000	400
	Salmon (WA)	10,000	400
	Washougal (WA)	10,000	400
Chum	Grays/Chinook (WA)	100	400
	Elochoman/ Skamokawa (WA)	10,000	400
	Toutle (WA)	20,000	800
	Coweeman (WA)	10,000	400
	Kalama (WA)	8,000	320
Steelhead (summer)	Kalama (WA)	7,400	104
	EF Lewis (WA)	7,400	104
	Washougal (WA)	7,400	104
Steelhead (winter)	SF Toutle (WA)	14,800	208
	NF Toutle (WA)	14,800	208

	Coweeman (WA)	14,800	208
	Kalama (WA)	7,400	104
	EF Lewis (WA)	7,400	104
	Salmon Creek (WA)	14,800	208
	Washougal (WA)	7,400	104

b. Category: Kalama River Research Program.
NMFS shall administer funds for this programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in the following table(s).

Table 127. The maximum number of natural-origin juvenile and adult fish handled or killed during activities associated with the Kalama River Research activities funded through the Mitchell Act.

Species	*Watershed (State)*	*Handled*	*Mortality*	*Handled*	*Mortality*
		Juveniles		*Adults*	
Chinook	Kalama (WA)	1,330	<67	502	<13
Coho	Kalama (WA)	1,300	<65	0	0
Steelhead (summer)	Kalama (WA)	8,000	<550	1,552	<21
Steelhead (winter)	Kalama (WA)	8,000	<550	1,012	1<16

c. Category: Operation of the North Fork Toutle River Fish Collection Facility

NMFS shall administer funds for this programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in the following table.

Table 128. The maximum number of natural-origin adult fish handled or killed during activities associated with the operation of the North Fork Toutle River Fish Collection Facility funded through the Mitchell Act.

Species	*Watershed (State)*	*Handled*	*Mortality*
		Adults	
Chinook	North Toutle (WA)	50	1
Coho	North Toutle (WA)	1,000	<20
Steelhead (summer)	North Toutle (WA)	25	1
Steelhead (winter)	North Toutle (WA)	650	<13

d. Category: Evaluation of the benefits and risks of juvenile wild fish rescue programs.

NMFS shall administer funds for programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in the following table.

Table 129. The maximum number of natural-origin juvenile fish handled or killed during activities in Mason Creek, Rock Creek of the East Fork Lewis River, Mill Creek of the East Fork Lewis River, and Mill Creek of Salmon Creek associated with evaluation of the benefits and risks of juvenile wild fish rescue programs funded through the Mitchell Act.

Species	***Watershed (State)***	***Handled***	***Mortality***
		Juveniles	
Chinook (fall)	Lewis (WA)	10,000	<20
	Salmon (WA)	10,000	<20
Coho	Lewis (WA)	17,000	<540
	Salmon (WA)	15,000	<540
Chum	Lewis (WA)	10	1
	Salmon (WA)	10	1
Steelhead (summer)	EF Lewis (WA)	7,400	<104
Steelhead (winter)	EF Lewis (WA)	14,800	<208
	Salmon Creek (WA)	14,800	<208

e. Category: Klickitat River fishway

NMFS shall administer funds for this programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in the following table.

Table 130. The maximum number of natural-origin juvenile and adult fish handled or killed during activities associated with the Klickitat River fishway monitoring activities funded through the Mitchell Act.

Species	***Watershed (State)***	***Handled***	***Mortality***	***Handled***	***Mortality***
		Juveniles		***Adults***	
Steelhead	Klickitat	2,150	<100	1,005	<26

NMFS shall fund RM&E programs in this category that adhere to annual described methods for performing spawning ground surveys.

Consequently, these numbers, by category, represent the expected take associated with each component of RM&E resulting from funding through the Proposed Action. For the purposes of this statement, encounters and/ or mortalities will not exceed those identified above and represent the quantified level of expected take associated with RM&E activities.

2.8.1.7 Reductions in prey availability

The reduction in production of Columbia River hatchery Chinook salmon that would occur under the Proposed Action could result in some level of harm to SRKW by reducing prey availability, which may cause animals to forage for longer periods, travel to alternate locations, or abandon foraging efforts. The extent of take from this adverse impact is not anticipated to cause take by serious injury or mortality. However, the Proposed Action is expected to result in take in the form of a reduction in available prey. Take by prey reduction cannot be observed; therefore, NMFS will rely on a surrogate measurement of take, in the form of the extent of reduction to adult Chinook salmon populations in the localized area off the mouth of the Columbia River.

The extent of take expected to result from the Proposed Action, as measured by the surrogate, is up to a 4% reduction in adult Chinook salmon abundance immediately off the Columbia River which is attributable to the Proposed Action. This level of take can be reliably measured by calculating the adult equivalents (smolts released multiplied by the expected adult survival estimate) annually produced from hatchery Chinook salmon releases funded through the Proposed Action. The reduction was estimated based on the adult equivalents resulting from reduced hatchery production in the context of the escapement forecasts for Columbia River Chinook salmon stocks ranging from approximately 741,000 to 1,960,800 fish.

2.8.2 Effect of the Take

In Section 2.7 NMFS concluded that the level of anticipated take, coupled with other effects of the Proposed Action, is not likely to jeopardize any species in Table 9; the Southern DPS of Pacific Eulachon, the SRKW DPS, the LCR Chinook Salmon, UCR Chinook Salmon Spring-Run, Snake River Chinook Salmon Spring/Summer-Run, Snake River Chinook Salmon Fall-Run, UWR Chinook Salmon, LCR Coho Salmon, CR Chum Salmon, and Snake River Sockeye Salmon ESUs, and the LCR Steelhead, UCR Steelhead, Snake River Basin Steelhead, MCR Steelhead, and UWR Steelhead DPSs or destroy or adversely modify their designated critical habitat.

2.8.3 Reasonable and Prudent Measures

“Reasonable and prudent measures” are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). “Terms and conditions” implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in Section 7(a)(2) to apply.

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. This Opinion requires that Action Agencies, NMFS to:

1. Administer Mitchell Act funds for implementing the hatchery programs and operating the hatchery facilities as described in the Proposed Action (Section 1.3), and in the supplemented Biological Assessment.
2. Ensure that interactions on the spawning grounds with natural-origin fish from hatchery-origin fish produced through Mitchell Act funded hatchery programs are kept to the lowest feasible levels.
3. Ensure that broodstock practices result in no out-of-MPG broodstock fish produced through Mitchell Act funded hatchery programs are released in areas of LCR ESA-listed conspecific fish.
4. Ensure that studies to address critical research needs to better understand the effects of ecological interactions are implemented.
5. Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to lowest feasible levels.
6. Ensure that take resulting from encounters at adult collection facilities and from the operation of weirs in each tributary basin is minimized.
7. Ensure that hatchery facility water withdrawal screening and facility operations minimize effects on ESA-listed fish and designated critical habitat.
8. Provide reports to SFD annually for all funded hatchery operations, and for all RM&E activities associated with the Proposed Action.
9. Comply with all of the ESA requirements and provisions in the Incidental Take Statement.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Action Agencies 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 following terms and conditions are not complied with, the protective coverage of Section 7(o)(2) will lapse. This Opinion requires that the action agencies (NMFS) to:

1. Administer Mitchell Act funds for implementing the hatchery programs and operating the hatchery facilities as described in the Proposed Action (Section 1.3), and in the supplemented Biological Assessment:

   a. Notify NMFS' SFD, in advance (at least one-month before), any changes in funding administration that result in changes to the Proposed Action.

   b. Notify NMFS' SFD in in advance (at least one-month before), any changes in hatchery program operations and implementation.

2. Ensure that interactions on the spawning grounds with natural-origin fish from hatchery-origin fish produced through Mitchell Act funded hatchery programs are kept to the lowest feasible levels):
   a. NMFS shall ensure that the funding grantee annually submits pHOS survey protocols, gene flow monitoring methods, and RM&E protocols and statements of work on or before January 1 of each year for NMFS concurrence on or before March 1 of each year.
   b. NMFS shall ensure administration of funds through the Mitchell Act results in adherence to pHOS and gene flow levels in Table 123 through Table 125, weir and facility trapping and handling levels in Table 121 and Table 122, and RM&E take at levels specified in Section 2.8.1.6 of the ITS.
      i. NMFS shall require funding grantees to complete a report prior to 2018 demonstrating that programs using the gene flow standard are adhering to the applicable maximum gene flow or pHOS levels specified
      ii. NMFS shall require funding grantees to conduct annual surveys, or other acceptable methods, to determine the timing, abundance, origin, and distribution of Chinook, coho, and chum salmon and summer and winter steelhead that spawn naturally.
   c. NMFS shall require, unless otherwise specified in the *U.S. v. Oregon* agreement (CRFMA), that all juvenile hatchery fish released from Mitchell Act funded hatchery programs be visually marked, or other method of identification, and that operators report annually on the proportion of unmarked fish released from each Mitchell Act program.
   d. Ensure that within three years of Opinion signature that the genetic risk of summer steelhead in the Clackamas Basin is clarified
      i. NMFS shall develop, within three years of Opinion signature, a policy on allowable levels of gene flow into salmon and steelhead populations of hatchery fish with non-native life histories (e.g., summer steelhead into streams where only winter steelhead naturally occur)
   e. NMFS shall require funding grantees to determine pHOS or gene flow in the Clackamas River winter steelhead natural population attributable to the funding of hatchery summer steelhead released in the subbasin
   f. Ensure that studies are implemented to evaluate the natural production status of primary Chinook salmon natural populations in the LCR Coast MPG in response to reduced pHOS.

        i. Convene a multiagency work group within six months of Opinion signature to develop research plans, including hypotheses, response variables, and experimental power
        ii. Ensure that the studies described here are implemented within one year of Opinion signature

3. Ensure administration of funds through the Mitchell Act results in the following broodstock practices:
    a. No future funding is awarded for rearing and releasing Chambers Creek steelhead after the 2017 releases (2016 broodyear), for hatchery programs where ESA-listed steelhead co-occur.
    b. No future funding is awarded for any Chinook and coho salmon hatchery programs that rear or release out-of-MPG hatchery fish in areas of LCR ESA-listed conspecific fish beginning with FY2019 releases.
4. Ensure that studies are implemented to address critical research needs to better understand the effects of ecological interactions:
    a. Develop specific studies in coordination with the NMFS NWFSC and other Federal, state and tribal partners to better understand the effects of ecological interactions on ESA-listed natural-origin salmon and steelhead in freshwater and marine environments within six months of Opinion signature.
    b. Develop a plan within six months of Opinion signature to phase in LCR fall Chinook and coho salmon program changes over a five-year period to reduce impacts to SRKW and facilitate salmon ecological interaction research
5. Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to lowest feasible levels:
    a. NMFS shall require funding grantees to report to NMFS the estimated number, size, release location and proposed release date for all programs funded through the Proposed Action at least 30 days prior to release.
    b. NMFS shall require funding grantees to report to NMFS the estimated proportion of precocial male smolts released annually from each program.
    c. NMFS shall require funding grantees to notify NMFS when the situation may warrant the early release of hatchery fish and/or consideration of options for the handling of infected/diseased fish.
6. Ensure that take resulting from encounters and broodstock collection facilities and from the operation of weirs in each tributary basin is minimized:
    a. NMFS shall require funding grantees to not exceed the number of ESA-listed adults encountered and associated incidental mortalities during broodstock collection activities and to not exceed those numbers provided in Table 121 or Table 122 for weir operation subject to term and condition 1, described above.

    b. NMFS shall require funding grantees to provide, by April 30th prior to installation, annual operating plans for weirs described in the Proposed Action.
    c. NMFS shall require funding grantees to estimate weir rejection, delay, and handling mortalities, by species, for each weir as part of RM&E.
7. Ensure that hatchery facility water withdrawal screening and facility operations minimize effects on ESA-listed fish and designated critical habitat.
    a. Operate surface water withdrawal structures to not exceed established water rights for that facility and to maintain established minimum flow requirements for stream sections between the hatchery intake and the hatchery outfall.
    b. Operate and maintain intake screening structures to meet NMFS screening criteria.
    c. Minimize passage delay for natural-origin adult salmonids that encounter hatchery facility passage barriers.
    d. Minimize the operation of intake structures that do not currently meet NMFS criteria until facilities are upgraded.
    e. By January 1, 2019, develop and submit, for NMFS concurrence, plans for upgrading intake facilities that do not currently meet NMFS 2011 screening criteria.
    f. NMFS shall ensure implementation of the plan for operation and evaluation of the proposed Clackamas Hatchery intake as described in the Clackamas Hatchery Gravity Intake Project, Estacada Lake DDR (ODFW 2016a).
8. NMFS shall annually provide one comprehensive annual report for all Mitchell Act funded programs to NMFS' SFD on or before January 31st for the previous fiscal year. The annual report will include:
    a. Numbers of fish released, release dates and locations, and tag/mark information for each program.
    b. Estimates of the natural spawning distribution, origin, survival and contribution to fisheries and escapements for fish released for each brood year, for each program.
    c. Estimates of pHOS and/or gene flow for all natural ESA-listed salmonid populations that are affected by straying from Mitchell Act funded hatchery programs.
    d. Provide tables for all Mitchell Act funded facilities combined, grouped by State Authority, that include the duration (in days) of each epizootic and magnitude (% of production lost).
    e. Annual water withdrawals for each hatchery/acclimation facility used by the Proposed Action and analyzed by this Opinion, including monthly estimates of the quantity removed and stream flows within the reach between the intake and hatchery outfall.

f. Compliance records with NPDES permitting requirements.

g. The number of fish encountered and killed at each weir and broodstock collection location including the species, origin (hatchery or natural-origin), life-stage, and release condition (unharmed, injured, killed).

h. Estimates of weir rejection, delay, and handling related mortality, by species, for each of the weirs operated under the Proposed Action.

i. Results of RM&E, including important findings, for:
    - i. The Kalama River Research Program;
    - ii. Operation of the North Fork Toutle River Fish Collection Facility;
    - iii. Lower Columbia River and tributary fishery monitoring;
    - iv. Monitoring of the Nez Perce Tribe's Snake River coho salmon Restoration Program;
    - v. Evaluation of the benefits and risks of juvenile wild fish rescue programs;
    - vi. Klickitat River Fishway (Lyle Falls); and
    - vii. USFWS Hatchery Monitoring Program.

All reports, as well as all other notifications required by this Opinion, shall be submitted electronically to the SFD point of contact on this program:

James Dixon (360-534-9329, james.dixon@noaa.gov)

Written materials may also be submitted to:

NMFS – West Coast Region
Sustainable Fisheries Division
510 Desmond Drive, SE, Suite 103
Lacey, Washington 98503-1263

9. Comply with all of the ESA requirements and provisions in the Incidental Take Statement;

NMFS shall require funding grantees to submit letters concurring to the ESA requirements and provisions in the Incidental Take Statement

2.9 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 has identified six conservation recommendations appropriate to the Proposed Action:

1. WDFW and ODFW, in cooperation with NMFS and other entities, should continue to investigate the level and impact of genetic interactions between hatchery-produced salmon and steelhead and ESA-listed Chinook, coho, and chum salmon and summer and winter steelhead within the LCR Basin to identify additional methods to minimize these interactions.
2. WDFW and ODFW, in cooperation with NMFS and other entities, should continue to investigate the level and impact of ecological interactions between hatchery-produced salmon and steelhead and ESA-listed Chinook, coho, and chum salmon and summer and winter steelhead within the LCR Basin and identify additional methods to minimize these interactions.
3. The Kalama River Spring Chinook Salmon Hatchery Program should be converted to an integrated conservation program. Currently the hatchery-origin broodstock of spring Chinook salmon taken at Kalama Falls Hatchery represent the genetic lineage of the natural-origin population in the Kalama River. The current hatchery program does not contribute to altering this decline, but could, given its genetic lineage.
4. NMFS should re-evaluate inclusion of the broodstock from the Kalama River Spring Chinook Salmon Program in the description of the ESA-listed Kalama River spring Chinook salmon population in 5 years if the current program has not begun to incorporate natural-origin fish into the broodstock.
5. NMFS should support that within eight months of Opinion signature a group of recovery planners in Washington and Oregon is convened to clarify the status and recovery expectations for the LCR Gorge Chinook and coho salmon MPGs.
6. In the future, NMFS should require funding grantees to submit updated FMEPs evaluating fishery effects on each LCR Chinook and coho salmon natural populations for ESA authorization in terminal areas that may have interrelated fisheries that are implemented as result of the Proposed Action.

2.10 Reinitiation of Consultation

This concludes formal consultation for NMFS' administration of appropriated funds established by the Mitchell Act in the Columbia River Basin as described in Section 1.3.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In addition, site specific reinitiation is required if implementation of different hatchery operations are funded through the Proposed Action.

2.11 "Not Likely to Adversely Affect" Determinations

NMFS does not anticipate the Proposed Action will take species in Table 8. NMFS has determined that, while the Proposed Action may affect these ESA-listed species, due to their presence in the Columbia River, but the Proposed Action is not likely to adversely affect them. This determination was made pursuant to Section 7(a)(2) of the ESA implementing regulations at 50 CFR 402, and agency guidance for preparation of letters of concurrence[43], and is described here.

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 discountable, insignificant, or completely beneficial[44]. 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.

2.11.1 Green Sturgeon Southern DPS

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 2006b). 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).

The green sturgeon's ability to rebound from population declines may be limited by late age of maturation as they first spawn at age 14 to 20 (Van Eenennaam et al. 2006) and then are thought to subsequently spawn every two to four years (Erickson and Webb 2007). Population recovery may also be impacted by the large number of fisheries green sturgeon potentially interact with as they make rapid, long-distance seasonal migrations along the continental shelf of North America between central California and central British Columbia to summer in bays, estuaries, and rivers and winter in the highly productive, shallow waters north of Vancouver Island (Lindley et al. 2008; Thomas et al. 2013a). Green sturgeon are encountered as fisheries bycatch and while freshwater release mortalities are low, saltwater release mortalities are unknown (Al-Humaidhi et al. 2012).

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[43] Memorandum from D. Robert Lohn, Regional Administrator, to ESA consultation biologists (guidance on informal consultation and preparation of letters of concurrence) (January 30, 2006).

[44] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Act consultation handbook: procedures for conducting section 7 consultations and conferences. March 1998. Final p.3-12.

Major threats to the Southern DPS include alterations to aquatic habit such as barriers to migration, insufficient flows, increased temperatures, and pollution (NMFS 2006b). For example, population models have indicated that Southern Green Sturgeon DPS are stranding in flood diversions in the Sacramento River in numbers that could potentially impact population viability (Thomas et al. 2013b). In addition, historical spawning grounds in the Upper Sacramento River are currently blocked by the Shasta and Keswick Dams (Thomas et al. 2013a).

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

Beginning in 1938 Congress has appropriated funding which is distributed by NMFS to hatcheries in the Columbia River basin through the Mitchell Act. Approximately 63 million salmon and steelhead are released by the hatcheries receiving this finding. The release of hatchery fish 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 including areas where hatchery released fish occur. 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 salmonids, making the potential increase in competition unlikely and therefore inconsequential. Releases of hatchery salmonids could actually benefit food resources for green sturgeon. Green sturgeon feed on benthic invertebrates including amphipods, shrimp, and annelids (Moser and Lindley 2007), and it is possible this forage base would increase with additional salmon-derived nutrients from hatchery released fish into streams (Moore et al. 2007). Other potential effects include the effects of hatchery effluent on water quality and the potential for hatchery fish to introduce pathogens into the environment. We concluded that the effects of hatchery effluent on water quality would be insignificant as treatment of effluent mitigates that impact on water quality. We are not aware of any transmission of pathogens from hatchery salmonids to sturgeon in the wild and concluded that this risk is very unlikely.

Conclusion

Based on this analysis, NMFS concludes that all effects of the Proposed Action are not likely to adversely affect the Southern Green Sturgeon DPS and their designated critical habitat.

Reinitiation

This concludes informal ESA consultation on this action in accordance with 50 CFR 402.14 (b)(1), and MSA consultation in accordance with 50 CFR 600.920 (e)(3). NMFS must reinitiate consultation on this action if new information becomes available, or if circumstances occur that may affect listed species, designated critical habitat, or EFH in a manner, or to an extent, not previously considered.

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

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

This analysis is based, in part, on the EFH assessment provided by the NMFS and descriptions of EFH for Pacific Coast groundfish (PFMC 2014a), coastal pelagic species (CPS) (PFMC 2011b), Pacific Coast salmon (PFMC 2014b); and highly migratory species (HMS) (PFMC 2011a) contained in the fishery management plans developed by the Pacific Fisheries Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

For this EFH consultation, the Proposed Action and Action Area are described in detail above in Sections 1.3 and 1.4. Briefly, the Proposed Action is the implementation of a policy direction for NMFS to use in its funding decisions for hatchery programs in the Columbia Basin. The Action Area includes rivers, streams, and hatchery facilities where hatchery-origin salmon and steelhead occur or are anticipated to occur in the Columbia River Basin, and the Columbia River estuary and plume. The estuarine and offshore marine waters are designated EFH for various life stages of Pacific Coast salmon, Pacific Coast groundfish, coastal pelagic species, and highly migratory species managed by the PFMC.

Pursuant to the MSA, the PFMC has designated EFH for five coastal pelagic species (PFMC 2011b), 13 highly migratory species (PFMC 2011a), over 80 species of groundfish (PFMC 2014a), and three species of federally-managed Pacific salmon: Chinook salmon (*O. tshawytscha*); coho salmon (*O. kisutch*); and Puget Sound pink salmon (*O. gorbuscha*) (PFMC

2014b). The PFMC does not manage the fisheries for chum salmon (*O. keta*) or steelhead (*O. mykiss*). Therefore, EFH has not been designated for these species.

EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10 °C to 26 °C. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2011b).

EFH for highly migratory species range from vertical habitat within the upper ocean water column form the surface to depths generally not exceeding 200 m to vertical habitat within the mid-depth ocean water column, from depths between 200 and 1000 m. These range from coastal waters primarily over the continental shelf; generally over bottom depths equal to or less than 183 m to the open sea, beyond continental and insular shelves. A more detailed description and identification of EFH for highly migratory species in Appendix F of the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species (PFMC 2011a).

EFH for groundfish includes all waters, substrates and associated biological communities from the mean higher high water line, or the upriver extent of saltwater intrusion in river mouths, seaward to the 3500 m depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of Amendment 10 to the Pacific Coast Groundfish Management Plan (PFMC 2014a).

Marine EFH for Chinook, coho, and Puget Sound pink salmon in Washington, Oregon, and California includes all estuarine, nearshore and marine waters within the western boundary of the EEZ, 200 miles offshore. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers, and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

In particular, freshwater EFH for Chinook and coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Marine EFH for Chinook and coho salmon consists of three components, (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Freshwater EFH for pink salmon consists of three components, (1) spawning and incubation; (2) juvenile migration corridors; and (3) adult migration corridors and adult holding habitat. However, pink salmon do not exist in the Columbia River. Marine EFH for pink salmon consists of three components, (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. A more detailed description and identification of EFH for salmon is found in Appendix A to Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014b). Assessment of potential adverse effects to these species' EFH from the Proposed Action is based, in part, on this information.

3.2 Adverse Effects on Essential Fish Habitat

The Proposed Action generally does not have effects on the saltwater components of all species' EFH, though it is likely to have an effect on freshwater EFH for Chinook and coho salmon. Potential effects on freshwater EFH by the Proposed Action (particularly through water withdrawal, effluent discharge, temporary and weir operations, increased competition for spawning and rearing sites, and removal of MDNs) are only likely to occur in areas that spring Chinook and coho salmon spawn naturally and in the migration corridor.

The Proposed Action is not likely to have adverse effects on EFH for the coastal pelagic species and highly migratory species. Of the potential adverse effects listed in PFMC (2011b) and PFMC (2011a), effects of hatchery operations could be analogized to adverse effects of aquaculture. Particularly, effects of organic waste from farms and release of high levels of antibiotics, disease, and escapee are listed as major concerns of aquaculture on coastal pelagic species EFH and highly migratory species EFH. However, these analogous concerns for hatchery operations are not likely to adversely affect coastal pelagic species nor highly migratory species because all relevant facilities would have NPDES permits to minimize effects of organic waste, and antibiotics would be diluted to manufacturer labeling. Concerns of disease transfer from and escapee of salmonid species are not likely to be a concern because coastal pelagic species and highly migratory species are not closely related to the salmonid species; therefore, disease transfer is not likely, and salmonid escapees would not raise concerns of genetic effects on coastal pelagic species and highly migratory species.

The Proposed Action is not likely to have adverse effects on EFH for groundfish. Of the potential adverse effects listed in PFMC (2014a), effects of hatchery operations can have similar effects as commercial and domestic water use. Particularly, effects on water quality is listed as major concern of water use. However, this analogous concern for hatchery operations is not likely to adversely affect groundfish EFH because all relevant facilities would have NPDES permits to minimize effects on water quality. Also, other potential adverse effects on EFH are not applicable to hatchery operations. Altering natural flows and the process associated with flow rates is not a concern associated with hatchery operations because the hatcheries are not altering the flow rate of the Columbia River enough for the effects to be detectable in the groundfish EFH. Affecting prey base and entrapping fish, both from withdrawal of water, is not a potential adverse effect of hatchery operations because water is not withdrawn within the groundfish EFH, so these effects would not occur from hatchery operations. Finally, adverse effects associated with dams are not relevant to hatchery operations because hatchery operations do not affect how dams are operated.

The Proposed Action is likely to affect freshwater EFH for Chinook and coho salmon through funding hatchery facilities that will withdraw stream water at hatchery facilities. As described in Section 2.4.1.6, water withdrawal for hatchery operations can adversely affect salmon (through affecting the EFH) by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects; the minimum flows will be maintained to provide for juvenile and adult migration through the sections of stream from the point of withdrawal to the hatchery outfall, and the intake is screened in compliance with NMFS criteria.

The Proposed Action is likely to affect freshwater EFH for Chinook and coho salmon through the effluent discharge from the hatchery facilities. As described in Section 2.4.1.6, effluent discharge from hatchery facilities can adversely affect water quality by raising temperatures, reducing dissolved-oxygen levels, and potentially affecting pH. The proposed hatchery programs minimize each of these effects through compliance with the NPDES permits, where applicable.

The Proposed Action is likely to affect freshwater EFH for Chinook and coho salmon through the use of temporary and permanent weirs, as described in Section 2.4.1.2. The effects of the operation of the weirs are described above in Section 1.3, and include displaced spawning, migration delay, and increased mortality from handling of fish at the trap. Any effects on EFH associated with weirs would be minimized through implementation of best management practices, including: use of a removable weir structure that rests on the river bottom and banks with minimal disruption of riverine habitat; placement and operation of removable weirs for only when they are needed; continuous surveillance of some weirs by staff residing on-site to ensure proper operation and to safeguard fish trapped; frequent sorting of fish from the trap to minimize trap holding times; and implementation of fish capture and handling methods that protect the health of fish retained as broodstock or released back into the river.

The Proposed Action is likely to affect freshwater EFH for Chinook and coho salmon through increased competition for spawning and rearing sites. The PFMC (2003b) recognized that these effects pertain to EFH because of the concerns about “genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations.” The Opinion describes in considerable detail the impacts hatchery programs might have on natural populations (see Section 2.4.2 above); greater detail on possible effects of hatchery programs can be found in NMFS (2011d). A small proportion of hatchery fish returning to the natal rivers is expected to spawn and may compete for space with Chinook or coho salmon. Some hatchery-origin fish may stray into non-natal rivers but not in numbers that would cause the carrying capacities of natural production areas to be exceeded, or that would result in increased incidence of disease or increases in predators. Predation by adult hatchery-origin fish on juvenile natural-origin salmonids will be limited because of timing differences, because adult salmon stop feeding by the time they reach spawning areas, and because predation by juvenile offspring of hatchery-origin fish on juvenile natural-origin salmonids would not occur for reasons discussed in Section 2.4.2.

The Proposed Action is likely to also affect freshwater EFH for Chinook and coho salmon through harvest in terminal areas. As described in Section 2.4.2.8, effects of harvest is considered here despite fisheries not being part of the Proposed Action because those fisheries would not occur without hatchery-origin fish released as a result of the Proposed Action. These fisheries remove MDNs from the ecosystem because adult hatchery-origin fish that would have otherwise contributed to the nutrients in freshwater EFH would be removed through terminal fisheries. The gears used in these fisheries do not contribute to a decline in the values of estuarine and near shore substrate or deeper water, offshore habitats through gear effects. These fisheries have gone through a separate ESA consultation process, and the effects to Chinook and coho salmon EFH were considered in (NMFS 2012d; 2014d), which are incorporated by reference here.

3.3 Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS believes that the Proposed Action, as described in Section 1.3 and the ITS (Section 2.8, above) includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (2003a) provided an overarching recommendation that hatchery programs:

> "[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

The Opinion explicitly discusses the potential risks of hatchery fish on native fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook and coho salmon in the Action Area (Section 1.4, above). As a result, NMFS has not identified any additional conservation recommendations.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

The NMFS must reinitiate EFH consultation with NMFS if the Proposed Action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. FISH AND WILDLIFE COORDINATION ACT

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.

The following recommendations apply to the Proposed Action: The Opinion explicitly discusses the potential risks of hatchery fish on native fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks in the Action Area (Section 1.4, above). As a result, NMFS has not identified any additional conservation recommendations.

The action agency must give these recommendations equal consideration with the other aspects of the Proposed Action so as to meet the purpose of the FWCA.

This concludes the FWCA portion of this consultation.

5. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This Section of the Opinion addresses these DQA components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

5.1 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 continuing funding, as described in Opinion, for the hatchery programs 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 NMFS (funding entity) and grantees funded by Mitchell Act funds. Other interested users could include the scientific community, resource managers, and stakeholders who benefit from the consultation through the anticipated increase in returns of salmonids to the Columbia River, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of anadromous fish listed in Table 9. This information will improve scientific understanding of hatchery induced selection effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. Individual copies of this Opinion were provided to the NMFS. This Opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts) and on NMFS' West Coast Region web site (http://www.westcoast.fisheries.noaa.gov/). The format and naming adheres to conventional standards for style.

5.2 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.

5.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

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

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

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

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