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

Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin

NMFS Consultation Number: WCR-2015-3607

Action Agencies: National Marine Fisheries Service (NMFS)  
U.S. Army Corps of Engineers (USACE)

Affected Species and Determinations:

<table>
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<tr>
<th>ESA-Listed Species</th>
<th>Status</th>
<th>Is the Action Likely to Adversely Affect Species or Critical Habitat?</th>
<th>Is the Action Likely To Jeopardize the Species?</th>
<th>Is the Action Likely To Destroy or Adversely Modify Critical Habitat?</th>
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### Pacific eulachon (Thaleichthys pacificus)

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### Fishery Management Plan That Describes EFH in the Project Area

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<th>Are EFH Conservation Recommendations Provided?</th>
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Consultation Conducted By: National Marine Fisheries Service, West Coast Region, Sustainable Fisheries Division

Issued By: Barry A. Thomas
Regional Administrator

Date: 12/26/2017
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1. INTRODUCTION

The underlying activities that drive the Proposed Actions by the federal agencies are the funding or issuance of permits for the operation of six hatchery programs rearing and releasing summer/fall and fall (upriver bright) Chinook salmon (see Section 1.3 for details). Four of these programs rear and release summer/fall Chinook salmon in the Upper Columbia River (UCR) Basin, while the other two programs rear and release fall Chinook salmon in the Hanford Reach area, all of which are in Washington State. Because the actions of the federal agencies are subsumed within the effects of the hatchery program operation, the details of each hatchery program are summarized in Section 1.3 of this biological opinion based on a Hatchery and Genetic Management Plan (HGMP), which was submitted to NMFS for review. This introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

NMFS defines integrated hatchery programs as those that are reproductively connected or “integrated” with a natural population, promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species, and are included in a salmon 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” or “segregated.” Isolated programs promote domestication or selection in the hatchery over selection in the wild and culture a stock of fish with different phenotypes (e.g., different ocean migrations and/or spatial and temporal spawning distribution) compared to the natural population.

Table 1. Programs* included in the Proposed Action.

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<th>Program</th>
<th>Date1</th>
<th>Program Type</th>
<th>Program Purpose</th>
<th>Funding Entity</th>
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<td>Chelan Falls Summer/Fall Chinook Salmon</td>
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<td>Create terminal fishery in Chelan River</td>
<td>Chelan PUD</td>
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<td>Wenatchee Summer/Fall Chinook Salmon</td>
<td>September 30, 2009; May 3, 2014</td>
<td>Integrated Supplementation</td>
<td>Create terminal fishery in Wenatchee and Columbia Rivers</td>
<td>Chelan PUD, Grant PUD</td>
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<td>Grant PUD</td>
<td>Section 10</td>
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<td>Wells Hatchery Summer/Fall Chinook Salmon</td>
<td>May 28, 2013; April 4, 2014</td>
<td>Segregated Harvest</td>
<td>Create terminal fishery in Columbia River</td>
<td>Douglas PUD</td>
<td>Section 10</td>
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<td>Priest Rapids Fall Chinook Salmon</td>
<td>August 26, 2005; May 21, 2014</td>
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<td>Create terminal fishery in Columbia River</td>
<td>Grant PUD, USACE</td>
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<td>Ringold Springs Hatchery Fall Chinook Salmon</td>
<td>June 19, 2017</td>
<td>Integrated Harvest</td>
<td>Create terminal fishery in Columbia River</td>
<td>USACE</td>
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Currently, all of the hatchery programs are operated by the Washington Department of Fish and Wildlife (WDFW), with the exception of operation of Wells Hatchery and early juvenile rearing for the Ringold Springs Hatchery Fall Chinook Salmon program.

The first date is for the most recent HGMP. The second date is for the updated proposed action.

1 PUD = Public Utility District; USACE = U.S. Army Corps of Engineers.

1.1. Background

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

NMFS also completed an Essential Fish Habitat (EFH) consultation on the proposed actions, 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. A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

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

A new opinion was completed on March 29, 1999, after UCR steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5% of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia steelhead were added to the list of endangered and threatened species (Smith 1999).
Between 1991 and the summer of 1999, the number of distinct groups of Columbia Basin salmon and steelhead listed under the ESA increased from 3 to 12, and this prompted NMFS to reassess its approach to hatchery consultations. In July 1999, NMFS announced that it intended to conduct five consultations and issue five opinions “instead of writing one biological opinion on all hatchery programs in the Columbia River Basin” (Smith 1999). Opinions would be issued for hatchery programs in the (1) Upper Willamette, (2) Middle Columbia River (MCR), (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS’ first priority (Smith 1999). Between August 2002 and October 2003, NMFS completed consultations under the ESA for approximately twenty hatchery programs in the UCR. For the MCR, NMFS completed a draft opinion, and distributed it to hatchery operators and to funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basin-wide review and planning processes.

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

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

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008h) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008e). The SCA environmental baseline included “the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 7 consultation, the effects of future operations cannot be included in the baseline. In some instances, effects are
ongoing (e.g., returning adults from past hatchery practices) and included in this analysis despite
the fact that future operations cannot be included in the baseline. The Proposed Action does not
encompass hatchery operations per se, and therefore no incidental take coverage is offered
through this biological opinion to hatcheries operating in the region. Instead, we expect the
operators of each hatchery to address its obligations under the ESA in separate consultations, as
required” (see NMFS 2008h, p. 5-40).

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

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

In October 1999, NMFS received a request to operate artificial propagation programs, in the
form of three HGMPs from the WDFW (WDFW 1999a, 1999b, 1999c). These HGMPs
addressed programs in the UCR basin that artificially propagate and release unlisted summer
Chinook salmon, fall Chinook salmon, and sockeye salmon. The summer Chinook salmon
programs are funded by the Chelan and Douglas PUDs. The fall Chinook salmon program is
funded by the Grant PUD and the WDFW. The WDFW operates all the hatchery facilities and is
the lead co-manager of the anadromous fish resources in the state of Washington.

In April 2002, negotiations on three Habitat Conservation Plans (HCPs) were concluded. These
HCPs are long term agreements between NMFS, the PUDs, the WDFW, the USFWS, the
Colville Tribes, the Yakama Nation, and other stakeholders. They provide the PUDs with some
degree of certainty for the long-term operation of these projects and require the PUDs to provide
mitigation for unavoidable loss of natural fish production due to habitat inundation and passage
mortality at the projects via a tributary fund for habitat improvement projects, and artificial
propagation programs. The HCPs were developed to protect five species of anadromous
salmonids, including the listed Upper Columbia River spring Chinook salmon and steelhead. The HCP agreements restrict the PUDs and NMFS from changing the artificial propagation production level during the permit period.

The three HCPs resulted in the formation of the HCP Hatchery Sub-Committees (HSCs) consisting of one representative of each HCP signatory entity. The PR Salmon and Steelhead Settlement Agreement resulted in the formation of the Priest Rapids Coordinating Committee Hatchery Sub-Committee (PRCC HSC). NMFS is represented in the HCP and PRCC HSC forums to ensure activities proposed by the HSCs are consistent with ESA recovery goals and do not operate to the detriment of protected species. The HCP HSCs will develop monitoring and evaluation plans for the hatchery programs, updating them every five years. The PUDs have funded the implementation of the monitoring and evaluation plans. The monitoring plans include data collection and analysis of all salmon life stages within the hatchery environment as well as data collection activities outside the hatchery facilities such as spawning ground surveys, juvenile fish traps, adult traps, and monitoring sites. The HCP HSCs would determine program-specific monitoring activities necessary to evaluate the programs.

The proposed operation of six hatchery programs is described in a series of documents submitted to NMFS by Douglas PUD, Chelan PUD, Grant PUD, WDFW, and USACE (hereafter referred to as applicants). Starting in 2009, the applicants submitted final HGMPs and supplemental information for formal consultation (Table 1) (Chelan PUD 2014; Chelan PUD and Grant PUD 2014; CPUD 2010; DPUD and WDFW 2013; GPUD 2009a; GPUD 2009b; Grant PUD 2014a; Grant PUD 2014b; USACE and WDFW 2017; WDFW and GPUD 2005).

On September 20, 2013, NMFS responded to WDFW’s and the PUDs’ request for an extension to their section 10 permit (1347). This permit was originally issued in 2003 and expired on October 22, 2013. NMFS extended the permit until a new permit could be issued, provided the applicants continue to operate the programs consistent with the expired permit and the terms and conditions of the 2003 Biological Opinion (NMFS 2003).

After updated information were submitted to NMFS in 2017, NMFS reviewed the HGMPs for sufficiency, and issued letters indicating that the HGMPs were sufficient for consultation (Purcell 2017a; Purcell 2017b; Purcell 2017c).

1.3. Proposed Federal Action

“Action,” as applied under the ESA, means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. For EFH consultation, “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).

There are two federal action agencies:

- The Proposed Action for the National Marine Fisheries Service (NMFS) is the issuance of five Endangered Species Act (ESA) section 10(a)(1)(B) permits for the Columbia

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1 Grant PUD is also represented in the PRCC HSC forum.
River summer/fall Chinook salmon and fall Chinook salmon hatchery programs that are funded by the PUDs (Table 1).

- The Proposed Action for the U.S. Army Corps of Engineers (USACE) is the funding of the Ringold Springs Hatchery fall Chinook salmon program and a portion of the Priest Rapids fall Chinook salmon program (Table 1).

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from these Federal actions. The effects of these actions, as well as the PUDs’ funding of some of these programs, are subsumed within the operation of these hatchery programs. Therefore, this Opinion will determine if the actions proposed by the operators comply with the provisions of sections 7 and 10(a)(1)(B) of the ESA. The duration of the Proposed Action of issuance of five Section 10 permits is 10 years from the date of issuance. More information on the management of each program follows in the description below.

NMFS describes a hatchery program as a group of fish that have a distinct purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008e). 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). The proposed hatchery programs allow for mitigation for lost salmon and steelhead habitat and production associated with dam constructions on the Columbia River.

The permits are jointly held by the WDFW and the Chelan, Douglas, and Grant PUDs. The permit would authorize take of listed species incidental to the implementation of summer/fall and fall Chinook salmon artificial propagation programs in the UCR region. Below is a description of the proposed activities.

1.1.1. Chelan, Douglas, and Grant PUD Activities

The Chelan, Douglas, and Grant PUDs propose to provide artificial propagation compensation for summer/fall Chinook salmon for the Chelan Falls, Chelan PUD’s portion of the Wenatchee, and Wells programs per the Habitat Conservation Plans (HCP) (Chelan County Public Utility District 2002a; Chelan County Public Utility District 2002b; Douglas County Public Utility District 2002; NMFS 2008b) and the Methow, Grant PUD’s portion of the Wenatchee, and Priest Rapids program per the Priest Rapids Salmon and Steelhead Settlement Agreement (SSSA) (GPUD 2005). The HCP programs include Chelan Falls summer/fall Chinook Salmon, Chelan PUD’s portion of the Wenatchee summer/fall Chinook Salmon, and Wells Hatchery summer/fall Chinook Salmon (Table 1). The Grant PUD’s portion of the Wenatchee summer/fall Chinook Salmon, Methow summer/fall Chinook Salmon, and Priest Rapids fall Chinook Salmon program are to provide compensation for the SSSA (Table 1). The PUDs and the hatchery operators (currently the WDFW for most programs), propose to operate the hatchery programs according to the terms of section 8 “Hatchery Compensation Plan” of the HCPs, sections 9 and 10 of the SSSA, the ESA section 7 authorization and section 10 permit, and in consultation with the respective HCP Hatchery Committees and Priest Rapids Coordinating Committee Hatchery Subcommittee (PRCC HSC).
The PUDs agree that over the duration of the HCPs and SSSA, new information and technologies would be considered in the monitoring and evaluation of the hatchery programs. The PUDs would implement monitoring and evaluation of the hatchery programs consistent with the HCPs and SSSA and the Federal Energy Regulatory Commission (FERC) settlement agreements, the general objectives and guidelines listed for each plan species in NMFS et al. (1998), and as determined by the respective HCP Hatchery Committees and PRCC HSC consistent with ESA recovery goals.

1.1.2. USACE Activities

The USACE proposes to fund the Ringold Springs Hatchery fall Chinook Salmon program and partially for the Priest Rapids fall Chinook salmon program (1,700,000 smolts), which are part of USACE’s John Day - The Dalles Mitigation Program that mitigates for salmon habitat lost by the construction and operation of John Day and The Dalles dams (USACE and WDFW 2017; WDFW 2010). The program is mostly operated by WDFW (see below). Oregon Department of Fish and Wildlife (ODFW) performs the late incubation and early rearing (i.e., from eyed egg stage to ponding) at Bonneville Hatchery; see NMFS (2017d) for the analysis of operation at Bonneville Hatchery. The consultation with USFWS for the operation at the Bonneville Hatchery was completed in White (2016).

1.1.3. Hatchery Operator Activities

The WDFW is currently the operator for all of the hatchery programs discussed in this opinion, with the exception of Wells Hatchery, the Carlton Acclimation Facility, and late incubation and early rearing for the Ringold Springs Hatchery Fall Chinook Salmon program. The WDFW is also a manager with state statutory authority and state mandates regarding the fishery resources of the state of Washington. The Wells Hatchery and the Carlton Acclimation Facility are operated by Douglas PUD.

The details of the hatchery operations for each program are described below.

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2 NMFS is aware of letters exchanged between DPUD and WDFW that terminated the contract between DPUD and WDFW for hatchery operations at the Wells Hatchery and the Carlton Acclimation Facility as described in the HGMPs. The resolution of this matter is relevant to NMFS' decision to issue a take permit under Section 10(a)(1)(B) of the ESA, and will be addressed in NMFS' record of its decision. However, for the purposes of this Opinion, NMFS will assume that the permits will only be issued, pursuant to NMFS regulations, to an entity which has demonstrated its qualifications to carry out the actions outlined in the HGMPs. Therefore, the discussion of which party will operate the programs is not a factor in this Opinion.
Figure 1. Map of facilities used in the Upper Columbia River Basin in the Proposed Action (Courtesy of Mike Tonseth, WDFW)
### 1.1.3.1. Broodstock Collection and Mating

Table 2. Details of broodstock collection and mating for the six proposed programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Broodstock Numbers&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Collection Method</th>
<th>Collection Location</th>
<th>Collection Duration</th>
<th>Collection Frequency Hours/Day; Days/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall Chinook</td>
<td>358 hatchery-origin</td>
<td>Canal trap; Hatchery trap</td>
<td>Chelan Falls; Canal Trap; Entiat Hatchery; Chief Joseph Hatchery</td>
<td>July 15-Sept 30 at trap; July 1-Sept 15 at hatcheries</td>
<td>24 hr/day, 3 days/week at trap; 24 hr/day, 7 days/week at hatcheries</td>
</tr>
<tr>
<td>Wenatchee Summer/Fall Chinook Salmon</td>
<td>Up to 262 natural-origin</td>
<td>Dam trap</td>
<td>Dryden Dam; Tumwater Dam</td>
<td>July 1-Sept 15</td>
<td>24 hr/day, up to 7 days/week</td>
</tr>
<tr>
<td>Methow Summer/Fall Chinook Salmon</td>
<td>118 natural-origin</td>
<td>Dam trap</td>
<td>Wells Dam</td>
<td>July 1-Sept 15</td>
<td>27 hr/day, up to 7 days/week&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall Chinook Salmon</td>
<td>494, with no more than 10% natural-origin</td>
<td>Hatchery trap; Dam trap</td>
<td>Wells Hatchery; Wells Dam</td>
<td>July 1-Aug 28</td>
<td>24 hr/day, up to 7 days/week at hatchery; 16 hr/day, 3 days/week at dam</td>
</tr>
<tr>
<td>Priest Rapids Fall Chinook Salmon</td>
<td>4,410 adults, including up to 1,323 natural-origin</td>
<td>Hatchery trap; Dam trap; Hook and line</td>
<td>Priest Rapids Hatchery; Priest Rapids Dam; Hanford Reach&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Early Sept-early Dec</td>
<td>24 hr/day, up to 7 days/week at hatchery; 8 hr/day, 4 days/week at dam; 3 days at Reach</td>
</tr>
<tr>
<td>Ringold Springs Hatchery Fall Chinook Salmon</td>
<td>2,113 adults, including up to 634 natural-origin</td>
<td>Hatchery trap; Dam trap; Hook and line</td>
<td>Priest Rapids Hatchery; Priest Rapids Dam; Ringold Springs Rearing Facility; Hanford Reach&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Early Sept-early Dec</td>
<td>24 hr/day, up to 7 days/week at hatchery; 8 hr/day, 4 days/week at dam; 3 days at Reach</td>
</tr>
</tbody>
</table>

<sup>1</sup> Values listed are an approximation. Broodstock numbers are calculated annually, using a rolling 5-year average of in-hatchery performance metrics, and reflect a ~ 99% chance of meeting the program production targets. Such program adjustments are not considered a change in proposed action, provided that any adjustment will not result in a level of effect greater than that analyzed in this Opinion.

<sup>2</sup> Specific hours of operation for this trap are decided annually by the Wells HCP Coordinating Committee.

<sup>3</sup> Natural-origin broodstock is collected in Hanford Reach using hook and line, and natural-origin adults are collected from the dam trap (called Off-Ladder Adult Fish Trap, or OLAFT).

For all the proposed programs, broodstock would be collected throughout the run to ensure that the range of traits associated with return timing are represented, an effort to reduce the potential for inadvertent genetic selection. Traps would be checked daily when in operation and incidentally captured, endangered UCR Chinook salmon and threatened steelhead would be...
removed. Operators would monitor the incidence of, and minimize capture, holding, and handling effects on, listed salmon, steelhead, and bull trout. All incidentally captured listed fish would be handled via water-to-water transfer, if possible, and immediately released upstream of the trap. If water temperature at adult traps during trapping or during implementation of live capture methods exceeded 21°C, trap operation and live capture would cease pending further consultation with NMFS to determine if continued trap operation and live capture would pose substantial risk to ESA-listed species or until temperatures fell below 21°C, with the exception of the Chelan Falls Trap operation.

The operation of Chelan Falls Trap will be up to 24 hours per day, 7 days per week from July 15 through September 30 of each year, subject to the restriction that, from July 15 to July 31, the trap will only be opened for operation by 4:00 p.m. or later. The trap will be checked at a minimum of every 24 hours, and all trapped fish will be removed. When not trapping, the trap will be closed to prevent fish from entering the trap. When trapping in water temperatures greater than 21°C, trapping will cease if an ESA-listed species are encountered, pending further consultation with NMFS or the USFWS to determine if continued trap operation poses substantial risk to listed species. Any incidentally caught spring Chinook salmon, steelhead, or bull trout will be handled carefully and released immediately at the Beebe Bridge Park boat ramp.

To evaluate for whether spring Chinook salmon are trapped in the Chelan Falls Trap, fish that phenotypically appear to be spring Chinook salmon that are collected in the Chelan Falls Trap will be sampled consistent with run composition sampling at other adult trapping facilities (i.e., length, sex, age (scales), origin (hatchery vs. natural), reading of external and internal tags); additionally, genetic samples will be collected and analyzed to verify the frequency of spring Chinook salmon encounters at the Chelan Falls Trap and to determine population/program origin to further differentiate between listed and unlisted components, both of which have the potential to be encountered.

All of the proposed programs exclude age-2 and age-3 (using length at age) fall Chinook salmon and age-3 summer/fall Chinook salmon retained for broodstock to reduce genetic risks/concerns associated with younger age-at-maturity males. Current literature suggests younger age-at-maturity fish produce younger age-at-maturity progeny—decreasing the average age-at-maturity for broodstock and fish spawning in the natural environment. Natural-origin fish would be prioritized for broodstock from the Priest Rapids Hatchery, unless a shortage was expected, and remaining natural-origin adults would be used for Ringold production to incorporate natural-origin broodstock into the Ringold production broodstock. The Priest Rapids Off Ladder Adult Fish Trap (OLAFT) may be operated to collect up to 1,000 natural-origin fish.

1.1.3.2. **Juvenile Rearing and Release**

Juvenile summer/fall and fall Chinook salmon are reared and acclimated in the respective facilities, some of which have different rearing and acclimation sites (Table 3). These programs are operated with a 10 percent buffer in the production level to account for annual variation in smolt production and survival.
Table 3. Details of juvenile rearing and acclimation for the proposed programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Rearing Location(s)</th>
<th>Acclimation Location</th>
<th>Acclimation Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall</td>
<td>Eastbank Hatchery; Chelan Falls Acclimation Facility</td>
<td>Chelan Falls Acclimation Facility</td>
<td>November - April*</td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wenatchee Summer/Fall</td>
<td>Eastbank Hatchery</td>
<td>Dryden Acclimation Pond</td>
<td>March - April</td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow Summer/Fall</td>
<td>Eastbank Hatchery</td>
<td>Carlton Acclimation Facility</td>
<td>October - May*</td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall</td>
<td>Wells Hatchery</td>
<td>Wells Hatchery</td>
<td>October – October - April1</td>
</tr>
<tr>
<td>Chinook Salmon (subyearling)</td>
<td>Wells Hatchery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall</td>
<td>Wells Hatchery</td>
<td>Wells Hatchery</td>
<td>October – October - April1</td>
</tr>
<tr>
<td>Chinook Salmon (yearling)</td>
<td>Wells Hatchery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priest Rapids Fall</td>
<td>Priest Rapids Hatchery</td>
<td>Priest Rapids Hatchery</td>
<td>January - June*</td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ringold Springs Hatchery</td>
<td>Bonneville Hatchery</td>
<td>Ringold Springs Rearing Facility</td>
<td>mid-May - mid-June</td>
</tr>
<tr>
<td>Fall Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The acclimation timing for these programs also include timeframes for juvenile rearing because juvenile rearing and acclimation take place in the same facility.

1 Because this yearling program acclimates the juveniles at the same location as their rearing, the juveniles are at the acclimation location for about 19 months, though the fish are not on surface water for the whole duration.

Fish health staff monitor the fish throughout their rearing cycle for signs of disease. Mortalities are checked daily and live grab samples are taken monthly. Fish are also tested prior to transfer to acclimation sites and before release. Sampling, testing, and treatment/control procedures are outlined in and consistent with IHOT (1995); NWIFC and WDFW (2006); Pacific Northwest Fish Health Protection Committee (PNFHPC) (1989).
Table 4. Details of juvenile release for the proposed programs. CWT = coded-wire tag; PIT = passive integrated transponder.

<table>
<thead>
<tr>
<th>Program</th>
<th>Release life stage and size</th>
<th>Number</th>
<th>Release Timing</th>
<th>Mark</th>
<th>Volitional Release?</th>
<th>Release Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall Chinook Salmon</td>
<td>Yearlings 13 fpp</td>
<td>576,000</td>
<td>April-May</td>
<td>100% Ad+CWT; PIT</td>
<td>No</td>
<td>Chelan River (RM 0.25)</td>
</tr>
<tr>
<td>Wenatchee Summer/Fall Chinook Salmon</td>
<td>Yearlings 18 fpp</td>
<td>500,000</td>
<td>April-May</td>
<td>100% Ad+CWT; PIT</td>
<td>Yes, forced mid-May</td>
<td>Wenatchee River (RM 16.0)</td>
</tr>
<tr>
<td>Methow Summer/Fall Chinook Salmon</td>
<td>Yearlings 13-17 fpp</td>
<td>200,000</td>
<td>April-May</td>
<td>100% Ad+CWT; PIT</td>
<td>No</td>
<td>Methow River (RM 37.5)</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall Chinook Salmon</td>
<td>Subyearlings 50 fpp</td>
<td>484,000</td>
<td>mid-May</td>
<td>100% Ad+CWT</td>
<td>Yes, forced end of May</td>
<td>Columbia River (RM 515)</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall Chinook Salmon</td>
<td>Yearlings 10 fpp</td>
<td>320,000</td>
<td>mid-April</td>
<td>100% Ad+CWT</td>
<td>Yes, forced mid-May</td>
<td>Columbia River (RM 515)</td>
</tr>
<tr>
<td>Priest Rapids Fall Chinook Salmon (GPUD)²</td>
<td>Subyearlings 50 fpp</td>
<td>5,599,504</td>
<td>May-June</td>
<td>100% oolith; 605,429 Ad+CWT; 1,035,146 ad-clip; 605,056 CWT; PIT</td>
<td>No</td>
<td>Columbia River (RM 413)</td>
</tr>
<tr>
<td>Priest Rapids Fall Chinook Salmon (USACE)²</td>
<td>Subyearlings 50 fpp</td>
<td>1,700,000</td>
<td>May-June</td>
<td>100% ad-clipped; PIT</td>
<td>No</td>
<td>Columbia River (RM 413)</td>
</tr>
<tr>
<td>Ringold Springs Hatchery Fall Chinook Salmon</td>
<td>Subyearling 50 fpp</td>
<td>3,500,000</td>
<td>May-July</td>
<td>100% ad-clipped; PIT</td>
<td>Yes, forced after 5 days</td>
<td>Columbia River (RM 352)</td>
</tr>
</tbody>
</table>

¹Not all programs have the option for volitional release due to limited space, or force release is preferred for some programs.
²While these productions are funded by different entities (GPUD and USACE), these production groups have the same broodstock collection methods, rearing timing and location, and release locations.

1.1.3.3. Adult Management

Removal of hatchery fish is expected to occur through ocean, tribal, commercial (zones 1-5), and recreational/sport fisheries, broodstock collection, and surplus/harvest activities at non-target facilities. Each of these removals is expected to reduce the number of hatchery fish spawning in natural spawning areas, thereby reducing the pHOS of the recipient populations. The programs will be managed to attempt to achieve a low pHOS level to the extent possible.

Surplus fish removed at UCR hatcheries may be used to support nutrient enhancement programs in the UCR, given to the tribes or food banks, sold to rendering companies, or used for other hatchery programs as determined by the respective committees. Nutrient enhancement programs are not within the current Proposed Action and will be consulted on in the future, when such
plans are created. Surplus fish from the Priest Rapids program may also be used as broodstock for other hatchery programs, including the Ringold Springs program. Surplus fish from the Ringold Springs program will be donated to food banks if in good condition, sold to rendering companies, used for other hatchery programs as determined by the *U.S. v. Oregon* parties, or disposed of in a landfill. There is the potential for these adults to be used as broodstock for the Ringold Springs program if infrastructure is improved in future years.

1.1.3.4. Facility Operations

All programs return water to the diverted creek or river (minus any leakage and evaporation) along with any groundwater discharge. Water at all facilities is withdrawn in accordance with state-issued water rights. All facilities that rear over 20,000 pounds of fish operate under National Pollutant Discharge Elimination System (NPDES) permits.

The facilities used as part of the proposed hatchery operations are listed in Table 5. Some of these facilities overlap with other hatchery programs, which have already been analyzed. The operation of Eastbank Hatchery was analyzed in NMFS (2016a), the operation of Wells Hatchery was analyzed in NMFS (2017e), and the operation of Bonneville Hatchery was analyzed in NMFS (2017d).

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3 Of note, these programs are likely to be in a form of direct carcass or a carcass analogue. If a nutrient enhancement program proposes to use direct carcass, the distribution will only occur within the space and temporal distribution of its natural counterpart spawning. If the program uses a carcass analogue, there would be no disease concerns because such carcass analogue will be processed to eliminate any pathogens.
Table 5. Details of facility operations for the six proposed programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Facility</th>
<th>Surface Water (cfs)</th>
<th>Ground Water (cfs)</th>
<th>Water Source</th>
<th>Water Diversion Distance</th>
<th>Discharge Location</th>
<th>Instream Structures</th>
<th>NPDES permit?</th>
<th>Compliant with NMFS Screening Criteria?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall</td>
<td>Eastbank Hatchery²</td>
<td>0</td>
<td>55</td>
<td>Eastbank Aquifer</td>
<td>NA</td>
<td>Columbia River</td>
<td>1: Outfall</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chinook Program</td>
<td>Chelan Falls Acclimation Facility</td>
<td>24</td>
<td>0</td>
<td>Chelan River</td>
<td>290 ft.</td>
<td>Chelan River</td>
<td>2: Intake, outfall</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wenatchee Summer/Fall</td>
<td>Dryden Pond</td>
<td>32.2</td>
<td>0</td>
<td>Wenatchee River</td>
<td>135 ft.</td>
<td>Wenatchee River</td>
<td>1: Outfall</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chinook Salmon³</td>
<td>Carlton Acclimation Pond</td>
<td>7.5</td>
<td>For back-up</td>
<td>Methow River</td>
<td>200 ft.</td>
<td>Methow River</td>
<td>2: Intake, outfall</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Methow Summer/Fall Chinook Salmon³</td>
<td>Wells Hatchery⁴</td>
<td>150</td>
<td>38</td>
<td>Columbia River</td>
<td>~650 ft.</td>
<td>Columbia River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall</td>
<td>Wells Hatchery⁴</td>
<td>102</td>
<td>14</td>
<td>Columbia River</td>
<td>2.2 RM</td>
<td>Columbia River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Chinook Program</td>
<td>Priest Rapids Hatchery</td>
<td>70</td>
<td>0</td>
<td>Ringold Springs</td>
<td>NA (out of anadromy)</td>
<td>Columbia River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ringold Springs Hatchery</td>
<td>Ringold Springs Rearing Facility</td>
<td>70</td>
<td>0</td>
<td>Ringold Springs</td>
<td>NA (out of anadromy)</td>
<td>Columbia River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

¹ Older criteria are NMFS (1995a); NMFS (1996). Screens are checked throughout the year. If a screen fails or is determined to be inefficient, it must be replaced with one that meets NMFS’ 2011 fish screen criteria.
² The operation of Eastbank Hatchery was analyzed in NMFS (2016a).
³ These programs also use Eastbank Hatchery for early rearing, which was analyzed in NMFS (2016a).
⁴ The operation of Wells Hatchery was analyzed in NMFS (2017e).
⁵ This program also uses Bonneville Hatchery for early rearing. The operation of Bonneville Hatchery was analyzed in NMFS (2017d).
1.1.3.5. Research, Monitoring, and Evaluation (RM&E)

All programs analyzed in this opinion will implement RM&E consistent with the PUD M&E plan (Hillman et al. 2017a). Differences in program locations and objectives result in differences in RM&E. Many of the RM&E activities that are implemented by the programs are described below:

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

1.1.4. Changes in Proposed Programs Since Last Biological Opinion

Table 6. Summary of changes in programs since the last NMFS biological opinion

<table>
<thead>
<tr>
<th>Program</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall Chinook Program</td>
<td>Moved from Turtle Rock Hatchery to Chelan Falls Acclimation Facility</td>
</tr>
<tr>
<td></td>
<td>Converted 1.62M sub-yearlings to 400,000 yearlings</td>
</tr>
<tr>
<td></td>
<td>Decreased 200K yearling NNI program by 24,000</td>
</tr>
<tr>
<td></td>
<td>Reduced broodstock by 882 (71%)</td>
</tr>
<tr>
<td>Wenatchee Summer/Fall Chinook Salmon</td>
<td>Reduced yearling release by 364,000</td>
</tr>
<tr>
<td></td>
<td>Reduced broodstock by 191 (42%)</td>
</tr>
<tr>
<td>Methow Summer/Fall Chinook Salmon</td>
<td>Reduced yearling releases by 200,000</td>
</tr>
<tr>
<td></td>
<td>Reduced broodstock by 118 (50%)</td>
</tr>
<tr>
<td></td>
<td>Construction of a new overwinter acclimation facility.</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall Chinook Salmon</td>
<td>Rebuilt Wells Hatchery (completed on August 31, 2017). Summer/fall Chinook adults will now be trapped, held and spawned in a new facility that reduces handling, incubated in a new facility with biosecure incubation rooms, early rearing in the new facility, and then subsequent rearing would be conducted using components</td>
</tr>
</tbody>
</table>
of the older facility, including the Bureau Ponds (concrete raceways) and Dirt Ponds.

Priest Rapids Fall Chinook Program
- Reduced 1 million subyearling NNI program to 325,543 subyearling
- Converted 1 million fry program to 273,961 subyearlings
- Reduced broodstock by 300 (6.7%)
- Rebuilding of the hatchery facility.

Ringold Springs Hatchery Fall Chinook Salmon
- Changed broodstock sources from Bonneville Hatchery to broodstock collected at the Priest Rapids Hatchery and the Hanford Reach, starting with brood year 2008.
- Facility improvements, including replacing water supply pipe, and installing predator deterrent measures, and changing the configuration of a pond to accommodate two smaller ponds.

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1 Changes in broodstock levels between pre- and post- NNI recalculation production targets, based on the biological assumptions in the 2017 broodstock protocols.
2 Includes the 1.7 million USACE fall Chinook salmon mitigation at Priest Rapids Hatchery.
3 Implementation of the converted fry program began with the 2013 brood consistent with the timeline identified in the SSSA.

1.4. Interrelated and Interdependent Actions

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. NMFS has not identified any interdependent or interrelated activities associated with the proposed action. The impacts of fisheries in the action area, including those that may target fish produced by the proposed programs, on ESA-listed salmonids are included in the environmental baseline.

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. Section 7(a)(2) of the ESA requires Federal agencies to consult with the FWS, NMFS, or both, to 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. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies’ actions will affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1. Analytical Approach

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to 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. The jeopardy analysis considers both survival and recovery of the species. “To jeopardize the continued existence of a listed species” means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by
reducing the reproduction, numbers, or distribution of that species or reduce the value of designated or proposed critical habitat (50 CFR 402.02).

This biological opinion relies on the definition of “destruction or adverse modification,” which “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (81 FR 7214, February 11, 2016).

The designations of critical habitat for the species considered in this opinion use the terms primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414, February 11, 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

Range-wide status of the species and critical habitat

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

Describing the environmental baseline

The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities in the action area on ESA-listed species. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.
Cumulative effects

Cumulative effects, as defined in NMFS’ implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

Integration and synthesis

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

Jeopardy and adverse modification

Based on the Integration and Synthesis analysis in section 2.6, the opinion determines whether the proposed action is likely to jeopardize ESA protected species or destroy or adversely modify designated critical habitat in Section 2.7.

Reasonable and prudent alternative(s) to the proposed action

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

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

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action described in Table 7. Status of the species is the level of risk that the listed species face based on parameters considered in documents such as recovery plans, status reviews, and ESA listing determinations. The species status section helps to inform the description of the species’ current “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the status and conservation value of critical habitat in the action area and discusses the current function of the essential physical and biological features that help to form that conservation value.

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4 ESA-listed bull trout (Salvelinus confluentus) are administered by the FWS and the proposed hatchery program is currently covered under a separate FWS section 7 consultation (FWS ref # 01E0FW00-2015-F-0154). Take associated with hatchery monitoring and evaluation activities is covered under USFWS TE-702631, sub-permit MCFRO-13.
Table 7. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA-listed species considered in this consultation.

<table>
<thead>
<tr>
<th>Species</th>
<th>Listing Status</th>
<th>Critical Habitat</th>
<th>Protective Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chinook salmon (Oncorhynchus tshawytscha)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Columbia River Spring</td>
<td>Endangered</td>
<td>70 FR 37160; June 28, 2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70 FR 52630; Sept 2, 2005</td>
<td></td>
<td>ESA Section 9</td>
</tr>
<tr>
<td>Snake River Spring/summer</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>64 FR 57399, October 25, 1999</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td>Snake River Fall</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>58 FR 68543, December 28, 1993</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td>Lower Columbia River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52706, September 2, 2005</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td>Upper Willamette River Spring</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52720, September 2, 2005</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td><strong>Sockeye salmon (O. nerka)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snake River</td>
<td>Endangered, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52630, September 2, 2005</td>
<td>ESA Section 9</td>
</tr>
<tr>
<td><strong>Steelhead (O. mykiss)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Columbia River</td>
<td>Threatened</td>
<td>70 FR 37160; June 28, 2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>74 FR 42605; August 24, 2009</td>
<td>70 FR 52630; Sept 2, 2005</td>
<td></td>
</tr>
<tr>
<td>Snake River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52769, September 2, 2005</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td>Middle Columbia River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52808, September 2, 2005</td>
<td>70 FR 47160, June 28, 2005</td>
</tr>
<tr>
<td>Lower Columbia River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52808, September 2, 2005</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td>Upper Willamette River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 52848, September 2, 2005</td>
<td>70 FR 37160, June 28, 2005</td>
</tr>
<tr>
<td><strong>Chum salmon (O. keta)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Columbia River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 37160, June 28, 2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>70 FR 52746, September 2, 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coho salmon (O. kisutch)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Columbia River</td>
<td>Threatened, 79 FR 20802, April 14, 2014</td>
<td>70 FR 37160, June 28, 2005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>81 FR 9252, February 24, 2016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Citations to “FR” are citations to the Federal Register.

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

2.2.1. Status of Listed Species

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

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

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

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

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

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

Chinook salmon (*Oncorhynchus tshawytscha*) have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). ESA-listed UCR spring Chinook salmon are stream-type. Stream-type Chinook salmon spend 2 to 3 years in coastal ocean waters, and enter freshwater in February through April. Spring Chinook salmon also spawn and rear high in the watershed and reside in freshwater for a year.

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

Approximately half of the area that originally produced spring Chinook salmon in this ESU is blocked by dams. What remains of the ESU includes all naturally spawned fish upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State, excluding the Okanogan River (64 FR 14208, March 24, 1999) (Figure 2). The ESU originally included six artificial propagation programs: the Twisp, Chewuch, Methow Composite, Winthrop NFH, Chiwawa, and White River hatchery programs (79 FR 20802, April 14, 2014). Currently, the three Methow Subbasin programs (Twisp, Chewuch, Methow Composite) are considered a single program, with two components: Twisp and Methow (the previous Chewuch and Methow programs combined). Furthermore, a Nason Creek program began in the Wenatchee Subbasin (Grant County PUD et al. 2009b), while the White River releases were discontinued after 2015 (Grant County PUD et al. 2009a).
For the most recent period (2005-2014), abundance has increased for all three populations, but productivity for all three populations remains below replacement (Table 8). Although increases in natural-origin abundance relative to the extremely low levels observed during the mid-1990s are encouraging, overall productivity has decreased to extremely low levels for the two largest populations (Wenatchee and Methow). The predominance of hatchery fish on the spawning grounds, particularly for the Wenatchee and Methow populations, is an increasing diversity risk, and populations that rely on hatchery spawners are not viable (McElhany et al. 2000). Natural-origin fish now make up fewer than fifty percent of the spawners for two of the three populations (Table 8). Based on the combined ratings for abundance/productivity and spatial structure/diversity, all three extant populations and the ESU remain at high risk of extinction (Table 8).
Table 8. Risk levels and viability ratings for natural-origin UCR spring Chinook salmon populations from the North Cascades MPG (NWFSC 2015).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wenatchee River</td>
<td>2000</td>
<td>545 (311-1030)</td>
<td>0.60</td>
<td>35</td>
<td>High</td>
</tr>
<tr>
<td>Entiat River</td>
<td>500</td>
<td>166 (78-354)</td>
<td>0.94</td>
<td>74</td>
<td>High</td>
</tr>
<tr>
<td>Methow River</td>
<td>2000</td>
<td>379 (189-929)</td>
<td>0.46</td>
<td>27</td>
<td>High</td>
</tr>
<tr>
<td>Okanogan</td>
<td>750</td>
<td></td>
<td></td>
<td>Extirpated</td>
<td></td>
</tr>
</tbody>
</table>

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

- past management practices such as the Grand Coulee Fish Maintenance Project
- survival through the FCRPS
- degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters
- spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high quality spawning gravels
- interbreeding and competition with hatchery fish that far outnumber fish from natural populations.

2.2.1.2. Snake River Spring/summer Chinook Salmon ESU

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

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

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for SEWA (SRSRB 2011) requires that the Tucannon River population be at low risk (no more than a 1 percent risk of extinction in 100 years). The Tucannon River population is required to meet highly viable status for delisting of the ESU because the Asotin Creek population is extirpated. The most recent status review by NMFS (NWFSC 2015) maintains that the Tucannon population remains at high risk (Table 9).

There are six extant independent populations of spring/summer Chinook salmon within the Grande Ronde/Imnaha MPG: Wenaha River, Lostine River, Minam River, Catherine Creek, Upper Grande Ronde River, and the Imnaha River. The remaining two populations, Lookingglass and Big Sheep Creeks, are functionally extirpated. The ICTRT criteria call for a minimum of four populations at viable or highly viable status. The potential scenario identified by the ICTRT (2007) would include viable populations in the Imnaha River (run timing), the Lostine/Wallowa River (large size) and at least one from each of the following pairs: Catherine Creek or Upper Grande Ronde (large size); and Minam or Wenaha Rivers. The most recent status review by NMFS (NMFS 2015c) maintains that all extant populations remain at high risk of extinction (Table 9).
Table 9. Risk levels and viability ratings for Snake River spring/summer Chinook salmon populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team. Data are from 2005-2014.

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

2.2.1.3. Snake River Fall Chinook Salmon ESU

Before alteration of the Snake River Basin by dams, Snake River fall-run Chinook salmon exhibited a largely ocean-type life history, where they migrated downstream during their first year. Today, fall-run Chinook salmon in the Snake River Basin exhibit one of two life histories; ocean-type and reservoir-type. Juveniles exhibiting the reservoir-type life history overwinter in the pools created by the dams before migrating out of the Snake River. The reservoir-type life history is likely a response to early development in cooler temperatures (mainly from fish that spawned in the Clearwater River), which prevents juveniles from reaching a suitable size to migrate out of the Snake River and on to the ocean.

The Snake River Fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). All of the hatchery programs are included in the ESU along with a single natural-origin population that is currently viable, with a low risk for abundance/productivity and a moderate risk for spatial structure and diversity.
The recently released Draft NMFS Snake River Fall Chinook Recovery Plan (NMFS 2015d) says that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River fall-run Chinook salmon population. The recovery plan notes that such scenario could be possible if major spawning areas supporting the bulk of natural returns are operating consistent with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning, i.e., low hatchery influence for at least one major natural spawning production area.

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

Considering the most recent information available, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required to achieve delisting status, assuming that natural-origin abundance of the single extant Snake River fall-run Chinook salmon population remains relatively high. An increase in productivity could occur with a further reduction in mortalities across life stages. Such an increase could be generated by actions such as a reduction in harvest impacts (particularly when natural-origin spawner return levels are below the minimum abundance threshold) and/or further improvements in juvenile survivals during downstream migration. It is also possible that survival improvements resulting from various actions (e.g., improved flow-related conditions affecting spawning and rearing, expanded spill programs that increased passage survivals) in recent years have increased productivity, but that increase is effectively masked as a result of the relatively high spawning levels in recent years. A third possibility is that productivity levels may decrease over time as a result of negative impacts of chronically high hatchery proportions across natural spawning areas. Such a decrease would also be largely masked by the high annual spawning levels (NWFSC 2015).

The Snake River Fall-run Chinook Salmon ESU remains at threatened status (NMFS 2015c). Factors that limit the ESU’s survival and recovery include: hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Fond 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2012d).
2.2.1.4. Lower Columbia River Chinook Salmon ESU

On March 24, 1999, NMFS listed the LCR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on April 14, 2014 (Table 7). Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706) (Table 7).

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 10), while the remaining 13 programs are excluded (Jones Jr. 2015). Willamette River Chinook salmon are listed within the Willamette River Chinook Salmon ESU, but they are not listed within the LCR Chinook Salmon ESU. Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. “Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU” (NMFS 2005c). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see Section 2.4.1 (NMFS 2005b).

Table 10. LCR Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NMFS 2013c; NWFSC 2015).

<table>
<thead>
<tr>
<th>ESU Description</th>
<th>Listed under ESA in 1999; updated in 2014 (Table 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threatened</td>
<td></td>
</tr>
<tr>
<td>6 major population groups</td>
<td>32 historical populations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Major Population Group</strong></th>
<th><strong>Populations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascade Spring</td>
<td>Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, NF Lewis (C), Sandy (C,G)</td>
</tr>
<tr>
<td>Gorge Spring</td>
<td>(Big) White Salmon (C), Hood</td>
</tr>
<tr>
<td>Coast Fall</td>
<td>Grays/Chinook, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose</td>
</tr>
<tr>
<td>Cascade Fall</td>
<td>Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, EF Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy River early</td>
</tr>
<tr>
<td>Gorge Fall</td>
<td>Lower Gorge, Upper Gorge (C), (Big) White Salmon (C), Hood</td>
</tr>
<tr>
<td>Cascade Late Fall</td>
<td>North Fork Lewis (C,G), Sandy (C,G)</td>
</tr>
</tbody>
</table>

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 Tule 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.5

Thirty-two historical populations within six MPGs compose the LCR Chinook Salmon ESU. These are distributed through three ecological zones6, which, through a combination of life history types based on run timing and ecological zones, result in the six MPGs, some of which are considered extirpated or nearly so (Table 11). The run-timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Figure 3).

Table 11. Current status for LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013c).

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population (State)</th>
<th>Status Assessment</th>
<th>Recovery Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Target</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Persistence</td>
<td>Persistence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probability¹</td>
<td>Probability</td>
</tr>
<tr>
<td>Cascade Spring</td>
<td>Upper Cowlitz (WA)</td>
<td>VL Primary</td>
<td>H+</td>
</tr>
<tr>
<td></td>
<td>Cispos (WA)</td>
<td>VL Primary</td>
<td>H+</td>
</tr>
<tr>
<td></td>
<td>Tilton (WA)</td>
<td>VL Stabilizing</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td>Toutle (WA)</td>
<td>VL Contributing</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Kalama (WA)</td>
<td>VL Contributing</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>North Fork Lewis (WA)</td>
<td>VL Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Sandy (OR)</td>
<td>M Primary</td>
<td>H</td>
</tr>
<tr>
<td>Gorge Spring</td>
<td>White Salmon (WA)</td>
<td>VL Contributing</td>
<td>L+</td>
</tr>
<tr>
<td></td>
<td>Hood (OR)</td>
<td>VL Primary¹</td>
<td>VH¹</td>
</tr>
<tr>
<td>Coast Fall</td>
<td>Youngs Bay (OR)</td>
<td>L Stabilizing</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Grays/Chinook (WA)</td>
<td>VL Contributing</td>
<td>M+</td>
</tr>
</tbody>
</table>

5 Core populations are defined as those that, historically, represented a substantial portion of the species abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life history characteristics that are no longer found throughout the ESU Myers, J., C. Busack, D. Rawding, and A. Marshall. 2003. Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids. October 2003. NOAA Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 195p.

6 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 ibid., ibid.
<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population (State)</th>
<th>Status Assessment</th>
<th>Recovery Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Persistence Probability</td>
<td>Contribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cascade Fall</td>
<td>Big Creek (OR)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Elochoman/Skamokawa (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Clatskanie (OR)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Mill/Aber/Germ (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Scappoose (OR)</td>
<td>L</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Lower Cowlitz (WA)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Upper Cowlitz (WA)</td>
<td>VL</td>
<td>Stabilizing</td>
</tr>
<tr>
<td></td>
<td>Toutle (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Coweeman (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Kalama (WA)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Lewis (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Salmon (WA)</td>
<td>VL</td>
<td>Stabilizing</td>
</tr>
<tr>
<td></td>
<td>Clackamas (OR)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Sandy (OR)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Washougal (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td>Gorge Fall</td>
<td>Lower Gorge (WA/OR)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge (WA/OR)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>White Salmon (WA)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
<tr>
<td></td>
<td>Hood (OR)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td>Cascade Late Fall</td>
<td>North Fork Lewis (WA)</td>
<td>VH</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Sandy (OR)</td>
<td>H</td>
<td>Primary</td>
</tr>
</tbody>
</table>
LCR Chinook salmon are classified into three life history types including spring runs, early-fall runs (“tules”, pronounced (too-leees)), and late-fall runs (“brights”) based on when adults return to freshwater (Table 12). 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 2013c). 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 2013c).
Table 12. Life history and population characteristics of LCR Chinook salmon.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Life-History Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring</td>
</tr>
<tr>
<td>Number of extant population</td>
<td>9</td>
</tr>
<tr>
<td>Life history type</td>
<td>Stream</td>
</tr>
<tr>
<td>River entry timing</td>
<td>March-June</td>
</tr>
<tr>
<td>Spawn timing</td>
<td>August-September</td>
</tr>
<tr>
<td>Spawning habitat type</td>
<td>Headwater large tributaries</td>
</tr>
<tr>
<td>Emergence timing</td>
<td>December-January</td>
</tr>
<tr>
<td>Duration in freshwater</td>
<td>Usually 12-14 months</td>
</tr>
<tr>
<td>Rearing habitat</td>
<td>Tributaries and main stem</td>
</tr>
<tr>
<td>Estuarine use</td>
<td>A few days to weeks</td>
</tr>
<tr>
<td>Ocean migration</td>
<td>As far north as Alaska</td>
</tr>
<tr>
<td>Age at return</td>
<td>4-5 years</td>
</tr>
<tr>
<td>Recent natural spawners</td>
<td>800</td>
</tr>
</tbody>
</table>

All LCR Chinook salmon runs have been designated as part of a LCR Chinook Salmon ESU that includes natural populations in Oregon and Washington from the ocean upstream to and including the White Salmon River in Washington and Hood River in Oregon. Fall Chinook salmon (tules and brights) historically were found throughout the entire range, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries) (LCFRB 2010). Bright Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, bright Chinook salmon mature at an older average age than either LCR spring or tule Chinook salmon, and have a more northerly oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (NWFSC 2015).

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Chinook Salmon ESU, is at high risk and remains at threatened status. Each LCR Chinook salmon natural population baseline and target persistence probability level is summarized in Table 11, 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 11 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 (2013c) 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 11 represents
one of multiple possible scenarios that would meet biological criteria for delisting. The
similarities between the Gorge and Cascade MPG, coupled with compensation in the other strata
for not meeting TRT criteria in the Gorge stratum would provide an ESU no longer likely to
become endangered.

2.2.1.5. Upper Willamette River Spring Chinook Salmon ESU

On March 24, 1999, NMFS listed the UWR Chinook Salmon ESU as a threatened species (64
FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April
14, 2014 (79 FR 20802) (Table 7). Critical habitat was designated on June 28, 2005 (70 FR
37160) (Table 7).

The ESU includes all naturally spawned populations of spring-run Chinook salmon in the
Clackamas River and in the Willamette River, and its tributaries, above Willamette Falls,
Oregon, as well as several artificial propagation programs (Figure 4). The ESU contains seven
historical populations, within a single MPG (western Cascade Range, Table 13).

Table 13. UWR Chinook salmon ESU description and major population group (MPG) (Jones Jr.
2015; NMFS 2016b).

<p>| ESU Description | Threatened | Listed under ESA in 1999; updated in 2014 (see Table 7) |</p>
<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Cascade Range</td>
<td>Clackamas River, Molalla River, North Santiam River, South Santiam River, Calapooia River, McKenzie River, Middle Fork Willamette River</td>
</tr>
</tbody>
</table>

**Artificial production**

| Hatchery programs included in ESU (6) | McKenzie River spring, North Santiam spring, Mollala spring, South Santiam spring, MF Willamette spring, Clackamas spring |
| Hatchery programs not included in ESU (0) | n/a |

UWR Chinook salmon’s genetics have been shown to be strongly differentiated from nearby populations, and are considered one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin (Beacham et al. 2006; Waples et al. 2004). 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 a zoogeographic isolating mechanism for a considerable period of time (Waples et al. 2004), and has led to, among other attributes, the unique early run timing of these populations relative to other LCR spring-run populations. Historically, the peak migration of adult salmon over the falls occurred in late May. Low flows during the summer and autumn months prevented fall-run salmon and coho from reaching the UWR basin (NMFS and ODFW 2011).

The generalized life history traits of UWR Chinook are summarized in Table 14. Today, adult UWR Chinook salmon begin appearing in the lower Willamette River in January, with fish entering the Clackamas Rivers as early as March. The majority of the run ascends Willamette Falls from late April through May, with the run extending into mid-August (Myers et al. 2006).
Figure 4. Map of the UWR Chinook Salmon ESU’s spawning and rearing areas, illustrating populations and major population groups (From NWFSC 2015).

Chinook migration past the falls generally coincides with a rise in river temperatures above 50°F (Howell et al. 1985; Mattson 1948; 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 14. A summary of the general life history characteristics and timing of UWR Chinook salmon.

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

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

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

According to the most recent status review (NWFSC 2015), abundance levels for five of the seven individual populations in this ESU remain well below their recovery goals. Of these, the Calapooia River population may be functionally extinct, and the Molalla River population remains critically low (although perhaps only marginally better than the 0 VSP score estimated in the Recovery Plan). Abundances in the North and South Santiam Rivers have risen since the last review (Ford 2011), but still range only in the high hundreds of fish. Improvements in the status of the Middle Fork Willamette River population relates solely to the return of natural adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the Middle Fork Willamette River individual population. The status review incorporates valuable information from the Fall Creek program that is relevant to the use of reservoir draw downs as a method of juvenile downstream passage. The proportion of natural-origin spawners improved in the North and South Santiam Basins, but was still below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production in the Molalla River. Additionally, the Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but both individual populations experienced declines in abundance7 (NWFSC 2015).

7 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.
All seven historical populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the Western Cascade Range (Table 15).

Table 15. 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.

<table>
<thead>
<tr>
<th>Population (Watershed)</th>
<th>A/P</th>
<th>Diversity</th>
<th>Spatial Structure</th>
<th>Overall Extinction Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clackamas River</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Molalla River</td>
<td>VH</td>
<td>H</td>
<td>H</td>
<td>VH</td>
</tr>
<tr>
<td>North Santiam River</td>
<td>VH</td>
<td>H</td>
<td>H</td>
<td>VH</td>
</tr>
<tr>
<td>South Santiam River</td>
<td>VH</td>
<td>M</td>
<td>M</td>
<td>VH</td>
</tr>
<tr>
<td>Calapooia River</td>
<td>VH</td>
<td>H</td>
<td>VH</td>
<td>VH</td>
</tr>
<tr>
<td>McKenzie River</td>
<td>VL</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Middle Fork Willamette River</td>
<td>VH</td>
<td>H</td>
<td>H</td>
<td>VH</td>
</tr>
</tbody>
</table>

1 All populations are in the Western Cascade Range ecological subregion. Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH). All populations originate in the action area (From NMFS 2016b).

The Clackamas and McKenzie River populations had the best overall risk ratings for A/P, spatial structure, and diversity, as of 2016. Data collected since the BRT status update in 2005 highlighted the substantial risks associated with pre-spawning mortality. A recovery plan was finalized for this species on August 5, 2011 (NMFS and ODFW 2011). Although recovery plans are targeting key limiting factors for future actions, there have been no significant on-the-ground-actions since the 2011 status review to resolve the lack of access to historical habitat above dams nor substantial actions removing hatchery fish from the spawning grounds (NMFS 2016b). Furthermore, no data is available for natural-origin spawner abundance for UWR Chinook salmon populations.

Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. The overview above for UWR Chinook salmon populations suggests that there has been relatively little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk (Table 16) (NWFSC 2015).

Table 16. Summary of VSP scores and recovery goals for UWR Chinook salmon populations (NWFSC 2015).

<table>
<thead>
<tr>
<th>MPG</th>
<th>State</th>
<th>Population</th>
<th>Total VSP Score</th>
<th>Recovery Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Cascade Range</td>
<td>OR</td>
<td>Clackamas River</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>Molalla River</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>North Santiam River</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>South Santiam River</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>Calapooia River</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Steelhead (*O. mykiss*) occur as two basic anadromous run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type (inland), or summer steelhead, enters freshwater in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type (coastal), or winter steelhead, enters freshwater with well-developed gonads and spawns shortly after river entry (Barnhart 1986).

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

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

The UCR Steelhead DPS consisted of three MPGs before the construction of Grand Coulee Dam, but it is currently limited to one MPG with four extant populations: Wenatchee, Methow, Okanogan, and Entiat. A fifth population in the Crab Creek drainage is believed to be functionally extinct. What remains of the DPS includes all naturally spawned populations in all tributaries accessible to steelhead upstream from the Yakima River in Washington State, to the U.S. – Canada border (Figure 5).
Figure 5. Upper Columbia River Steelhead DPS (ICTRT 2008).

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the UCR Steelhead DPS is at high risk and remains at threatened status. The ESA Recovery Plan (UCSRB 2007) requires each of the four extant steelhead populations to be viable. For the 2005-2014 period, abundance has increased for natural-origin spawners in each of the four extant populations (Table 17). However, natural-origin returns remain well below target levels for three of the four populations. Productivity remained the same for three of the four populations and decreased for the Entiat population relative to the last review (Ford 2011). For spatial structure and diversity, hatchery origin returns continue to constitute a high fraction (Table 17) of total spawners in natural spawning areas for the DPS as a whole (NWFSC 2015). The predominance of hatchery fish on the spawning grounds is an increasing risk, and populations that rely solely on hatchery spawners are not viable over the long-term (McElhany et al. 2000). Based on the combined ratings for abundance/productivity and spatial structure/diversity, three of the four extant populations and the DPS remain at high risk of extinction.
Table 17. Risk levels and viability ratings for natural-origin UCR steelhead populations (NWFSC 2015).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wenatchee River</td>
<td>1000</td>
<td>1025 (386-2235)</td>
<td>1.207</td>
<td>58</td>
<td>Maintained</td>
</tr>
<tr>
<td>Entiat River</td>
<td>500</td>
<td>146 (59-310)</td>
<td>0.434</td>
<td>31</td>
<td>High</td>
</tr>
<tr>
<td>Methow River</td>
<td>1000</td>
<td>651 (365-1105)</td>
<td>0.371</td>
<td>24</td>
<td>High</td>
</tr>
<tr>
<td>Okanogan River</td>
<td>750</td>
<td>189 (107-310)</td>
<td>0.154</td>
<td>13</td>
<td>High</td>
</tr>
</tbody>
</table>

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

- past management practices such as the Grand Coulee Fish Maintenance Project
- survival through the FCRPS
- degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters
- spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high quality spawning gravels
- predation by native and non-native species
- harvest
- interbreeding and competition with hatchery fish that far outnumber fish from natural populations

### 2.2.1.7. Snake River Steelhead DPS

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

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for southeast Washington (SRSRB 2011) requires that the Tucannon River population be at moderate risk and for the Asotin Creek population to be
at low risk of extinction. The most recent status review (NWFSC 2015) found that the Tucannon River population remains at high risk, and the Asotin Creek population is maintained (Table 18). However, both populations have insufficient data on abundance and productivity to assess accurately these metrics.

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

There is one independent population of steelhead within the Imnaha MPG, the Imnaha River population. The Draft ESA Recovery Plan for northeast Oregon (NMFS 2012a) requires that the Imnaha River population achieve low risk. NMFS’ status review (NWFSC 2015) found that information for this population is insufficient to be able to assess risk reliably, but estimates the population is most likely at moderate risk of extinction (Table 18).


<table>
<thead>
<tr>
<th>Population</th>
<th>ICTRT minimum threshold</th>
<th>Natural spawning abundance</th>
<th>Productivity</th>
<th>Abundance and productivity risk</th>
<th>Spatial structure and diversity risk</th>
<th>Overall risk viability rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tucannon River</td>
<td>1000</td>
<td>ID</td>
<td>ID</td>
<td>High¹</td>
<td>Moderate</td>
<td>High¹</td>
</tr>
<tr>
<td>Asotin Creek</td>
<td>500</td>
<td>ID²</td>
<td>ID</td>
<td>Moderate¹</td>
<td>Moderate</td>
<td>Moderate¹</td>
</tr>
<tr>
<td>Lo. Grande Ronde</td>
<td>1000</td>
<td>ID</td>
<td>ID</td>
<td>High¹</td>
<td>Moderate</td>
<td>High¹</td>
</tr>
<tr>
<td>Joseph Creek</td>
<td>500</td>
<td>1839</td>
<td>1.86</td>
<td>Very low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Up. Grande Ronde</td>
<td>1500</td>
<td>1649 (0.21)</td>
<td>3.15 (0.4)</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Wallowa River</td>
<td>1000</td>
<td>ID</td>
<td>ID</td>
<td>High¹</td>
<td>Moderate</td>
<td>High¹</td>
</tr>
<tr>
<td>Imnaha River</td>
<td>1000</td>
<td>ID</td>
<td>ID</td>
<td>Moderate¹</td>
<td>Moderate</td>
<td>Moderate¹</td>
</tr>
</tbody>
</table>

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

2.2.1.8. Mid-Columbia River Steelhead DPS

On March 25, 1999, NMFS listed the Mid-Columbia River Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the Mid-Columbia River steelhead was designated on September 2, 2005 (70 FR 52808) (Table 7).
The Mid-Columbia River Steelhead DPS includes naturally spawned anadromous *O. mykiss* originating from below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind River (Washington) and Hood River (Oregon) to and including the Yakima River, excluding the Upper Columbia River tributaries (upstream of Priest Rapids Dam) and the Snake River (Figure 6). Four MPGs, composed of 19 historical populations (2 extirpated), compose the Mid Columbia River Steelhead DPS (Figure 6). Inside the geographic range of the DPS, 11 hatchery steelhead programs are currently operational. Seven of these artificial programs are included in the DPS (Table 19).

Table 19. MCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

<table>
<thead>
<tr>
<th>DPS Description</th>
<th>Threatened</th>
<th>Listed under ESA as threatened in 1999; updated in 2014 (see Table 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 major population groups</td>
<td>19 historical populations (2 extirpated)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascades Eastern Slope Tributaries</td>
<td>Deschutes River Eastside, Deschutes River Westside, Fifteenmile Creek*, Klickitat River*, Rock Creek*</td>
</tr>
<tr>
<td>Yakima River</td>
<td>Naches River, Satus Creek, Toppenish Creek, Yakima River Upstream Mainstem</td>
</tr>
<tr>
<td>Umatilla/Walla Walla rivers</td>
<td>Touchet River, Umatilla River, Walla Walla River</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Artificial production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hatchery programs included in DPS (7)</td>
</tr>
<tr>
<td>Hatchery programs not included in DPS (4)</td>
</tr>
</tbody>
</table>

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

Best available information indicates that the MCR Steelhead DPS is at moderate risk and remains at threatened status. The most recent status update (NWFSC 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis on this DPS. However, this DPS has been noted as difficult to evaluate in several of the reviews for reasons such as: the wide variation in abundance for individual natural populations across the DPS, chronically high levels of hatchery strays into the Deschutes River, and a lack of consistent information on annual spawning escapements in some tributaries (NWFSC 2015).
1 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 20) (NMFS 2009).

Table 20. 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 DPS1.

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

1 Risk ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH), and extirpated (E). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS. Extirpated populations were not evaluated as indicated by the blank cells.

* Re-introduction efforts underway (NMFS 2009).

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

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

Limited population abundance data are available for the populations in the MCR Steelhead DPS. Of the 17 populations in this DPS, data on natural-origin spawner abundances for 14 populations are provided below; such information for the remaining three populations is not available. In the 2010 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 20). 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 20). There is significant tribal and sport harvest associated with the Klickitat steelhead run, with the sport harvest being targeted on hatchery fish (NWFSC 2015). Overall, natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. Natural-origin returns to the Umatilla, Walla Walla, John Day, and Klickitat rivers have increased over the last several years (http://odfwrecoverytracker.org/explorer/).

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

### 2.2.1.9. Lower Columbia River Steelhead DPS

On March 19, 1998, NMFS listed the LCR Steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834) and most recently on April 14, 2014 (79 FR 20802) (Table 7). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833) (Table 7).

The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive), and the Willamette and Hood Rivers, Oregon (inclusive), as well as multiple artificial propagation programs (NWFSC 2015). Inside the geographic range of the DPS, 29 hatchery programs are currently operational, of which only 7 are considered part of the ESA-listed DPS description (Table 21). Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, Oregon, and from the Little White Salmon and White Salmon Rivers, Washington. The LCR Steelhead DPS is composed of 23 historical populations, distributed through two ecological zones, split by summer or winter life history resulting in four MPGs (Table 22). There are six summer populations and seventeen winter populations (Figure 7).

<p>| Table 21. LCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015). |
|---------------------------------|----------------------------------------|
| <strong>DPS Description</strong>            | <strong>Listed under ESA in 1998; updated in 2014 (see Table 7)</strong> |
| 4 major population groups      | 23 historical populations              |
| <strong>Major Population Group</strong>     | <strong>Populations</strong>                        |
| Cascade summer                  | Kalama (C), North Fork Lewis, East Fork Lewis (G), Washougal (C) |
| Gorge summer                    | Wind (C), Hood                         |</p>
<table>
<thead>
<tr>
<th>Winter</th>
<th>Hatchery Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cascade</strong></td>
<td>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)</td>
</tr>
<tr>
<td><strong>Gorge</strong></td>
<td>Lower Gorge, Upper Gorge, Hood (C, G)</td>
</tr>
</tbody>
</table>

**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 2013c).

Figure 7. Map of populations in the LCR Steelhead DPS (NWFSC 2015).
LCR basin populations include summer and winter steelhead (Table 22). The two life history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013c). 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 (Busby et al. 1996; Hulett et al. 1996; Leider et al. 1986).

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

<table>
<thead>
<tr>
<th>MPG</th>
<th>Population (State)</th>
<th>Status Assessment</th>
<th>Recovery Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Persistence Probability</td>
<td>Contribution²</td>
</tr>
<tr>
<td>Cascade summer</td>
<td>Kalama (WA)</td>
<td>M Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>North Fork Lewis (WA)</td>
<td>VL Stabilizing</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td>EF Lewis (WA)</td>
<td>VL Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Washougal (WA)</td>
<td>M Primary</td>
<td>H</td>
</tr>
<tr>
<td>Gorge summer</td>
<td>Wind (WA)</td>
<td>H Primary</td>
<td>VH</td>
</tr>
<tr>
<td></td>
<td>Hood (OR)</td>
<td>VL Primary</td>
<td>H*</td>
</tr>
<tr>
<td>Cascade winter</td>
<td>Lower Cowlitz (WA)</td>
<td>L Contributing</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Upper Cowlitz (WA)</td>
<td>VL Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Cispus (WA)</td>
<td>VL Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Tilton (WA)</td>
<td>VL Contributing</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>South Fork Toutle (WA)</td>
<td>M Primary</td>
<td>H+</td>
</tr>
<tr>
<td></td>
<td>North Fork Toutle (WA)</td>
<td>VL Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Coweeman (WA)</td>
<td>L Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Kalama (WA)</td>
<td>L Primary</td>
<td>H+</td>
</tr>
<tr>
<td></td>
<td>North Fork Lewis (WA)</td>
<td>VL Contributing</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>East Fork Lewis (WA)</td>
<td>M Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Salmon Creek (WA)</td>
<td>VL Stabilizing</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td>Washougal (WA)</td>
<td>L Contributing</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Clackamas (OR)</td>
<td>M Primary</td>
<td>H*</td>
</tr>
<tr>
<td></td>
<td>Sandy (OR)</td>
<td>L Primary</td>
<td>VH</td>
</tr>
<tr>
<td>Gorge winter</td>
<td>Lower Gorge (WA/OR)</td>
<td>L Primary</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge (WA/OR)</td>
<td>L Stabilizing</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Hood (OR)</td>
<td>M Primary</td>
<td>H</td>
</tr>
</tbody>
</table>
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 (2013c).
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 2013c).

* 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 22 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 2013c).

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

2.2.1.10. Upper Willamette River Steelhead DPS

On March 25, 1999, NMFS listed the Upper Willamette River (UWR) Steelhead DPS as a
threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most
recently on April 14, 2014 (79 FR 20802) (Table 7). Critical habitat for the DPS was designated
on September 2, 2005 (70 FR 52848) (Table 7).

The UWR steelhead DPS includes all naturally spawned anadromous winter-run steelhead
originating below natural and manmade impassable barriers in the Willamette River, Oregon,
and its tributaries upstream from Willamette Falls to the Calapooia River (NWFSC 2015). One
MPG, composed of 4 historical populations, 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 23, Figure 8) (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).
The DPS/ESU Boundaries Review Group considered new genetic information relating to the relationship between the Clackamas River winter steelhead and steelhead native to the LCR and UWR DPSs. The Review Group concluded that there was sufficient information available for considering reassigning the Clackamas River winter steelhead population to the UWR River Steelhead DPS. The most recent status review concluded that further review is necessary before there can be any consideration of redefining the DPS; therefore, the most recent status review evaluation was conducted based on existing DPS boundaries (Figure 8) (NWFSC 2015).

Table 23. UWR Steelhead DPS description and MPGs.¹

<table>
<thead>
<tr>
<th>DPS Description</th>
<th>Threatened</th>
<th>Major Population Group</th>
<th>Artificial production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Listed under ESA as threatened in 1999; updated in 2014 (see Table 7)</td>
<td>1 major population group, 4 historical populations</td>
<td>South Santiam River (C,G), North Santiam River (C,G), Molalla River, Calapooia River</td>
</tr>
</tbody>
</table>

¹ The designations “(C)” and “(G)” identify core and genetic legacy populations, respectively (Jones Jr. 2015; McElhany et al. 2003; NWFSC 2015).
Before the construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. Presently, the majority of the UWR winter steelhead run return to freshwater from January through April, pass Willamette Falls from mid-February to mid-May, and spawn from March through June (with peak spawning in late April and early May). Table 24 summarizes the general life history traits for UWR steelhead. This species may spawn more than once; however, the frequency of repeat spawning is relatively low. The repeat spawners are typically females that spend more than one year post spawning in the ocean and spawn again the following spring (ODFW 2010b).

UWR steelhead currently exhibit a stream-type life history with individuals exhibiting yearling life history strategy. Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins from one to four years (average of two years), then as smoltification occurs in April through May, migration downstream through the mainstem Willamette and Columbia River estuaries and into the ocean occurs. The downstream migration speed depends on factors including river flow, temperature, turbidity, and others, but with the quickest migration occurring with high river flows. UWR steelhead can forage in the ocean for one to two years (average of two years) and during this time period, are thought to migrate north to Canada and Alaska and into the North Pacific including the Alaska Gyre (Table 24) (Myers et al. 2006; ODFW 2010b).
Table 24. A summary of the general life history characteristics and timing of UWR steelhead. Data are from (From ODFW 2010b).

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

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 Chinook salmon and steelhead in the LCR. Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

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

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

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

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

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

Currently, the best measure of steelhead abundance is the count of returning winter-run adults to the Upper and Lower Bennett Dams for the North Santiam River population. Recent passage improvements at the dams and an upgraded video counting system have contributed to a higher level of certainty in adult estimates. The Bennett Dam counts may also approximate spawner counts, given that post-dam prespawning mortality is thought to be low for winter steelhead. Unfortunately, steelhead were not counted at Bennett Dam from 2006 to 2010, due to budget constraints. The most recent average count for unmarked (presumed native) winter steelhead (2010-2014) is only 1195 ± 194. Longer term trends 1999-2014 are negative, -5 ±3 % (NWFSC 2015).

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

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

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

Table 25. 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 Tracker1)*.

<table>
<thead>
<tr>
<th>Year</th>
<th>Molalla River</th>
<th>North Santiam River</th>
<th>South Santiam River</th>
<th>Calapooia River</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>525</td>
<td>1,919</td>
<td>979</td>
<td>253</td>
</tr>
<tr>
<td>1998</td>
<td>1,256</td>
<td>1,970</td>
<td>1,043</td>
<td>358</td>
</tr>
<tr>
<td>1999</td>
<td>1,079</td>
<td>2,211</td>
<td>1,748</td>
<td>264</td>
</tr>
<tr>
<td>2000</td>
<td>1,898</td>
<td>2,437</td>
<td>1,608</td>
<td>225</td>
</tr>
<tr>
<td>2001</td>
<td>1,654</td>
<td>3,375</td>
<td>3,268</td>
<td>446</td>
</tr>
<tr>
<td>2002</td>
<td>2,476</td>
<td>3,227</td>
<td>2,282</td>
<td>351</td>
</tr>
<tr>
<td>2003</td>
<td>1,707</td>
<td>4,013</td>
<td>2,033</td>
<td>458</td>
</tr>
<tr>
<td>2004</td>
<td>1,987</td>
<td>3,863</td>
<td>3,546</td>
<td>684</td>
</tr>
<tr>
<td>2005</td>
<td>1,388</td>
<td>1,650</td>
<td>1,519</td>
<td>140</td>
</tr>
<tr>
<td>2006</td>
<td>1,433</td>
<td>2,965</td>
<td>1,805</td>
<td>257</td>
</tr>
<tr>
<td>2007</td>
<td>1,341</td>
<td>2,863</td>
<td>1,535</td>
<td>245</td>
</tr>
<tr>
<td>2008</td>
<td>1,273</td>
<td>2,789</td>
<td>1,534</td>
<td>236</td>
</tr>
</tbody>
</table>

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

Table 26. Scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall viability risk for UWR steelhead populations (NMFS 2011a).¹

<table>
<thead>
<tr>
<th>Population (Watershed)</th>
<th>A/P</th>
<th>Diversity</th>
<th>Spatial Structure</th>
<th>Overall Extinction Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molalla River</td>
<td>VL</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>North Santiam River</td>
<td>VL</td>
<td>M</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>South Santiam River</td>
<td>VL</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Calapooia River</td>
<td>M</td>
<td>M</td>
<td>VH</td>
<td>M</td>
</tr>
</tbody>
</table>

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

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

Table 27. Summary of VSP scores and recovery goals for UWR Steelhead populations (NWFSC 2015).

<table>
<thead>
<tr>
<th>MPG</th>
<th>Population</th>
<th>Total VSP Score</th>
<th>Recovery Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willamette</td>
<td>Molalla River</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>North Santiam River</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>South Santiam River</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Calapooia River</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

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

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

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015). At this stage of the recovery efforts, there is only one extant population, and the ESU remains endangered with a high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015). At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural program (NMFS 2015b).

Factors that limit the ESU have been, and continue to be impaired mainstem 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. 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). However, some limiting factors have improved since the listing. 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).

2.2.1.12. Columbia River Chum Salmon ESU

On March 25, 1999, NMFS listed the Columbia River (CR) Chum Salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014 (Table 7). 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 28 lists these hatchery programs, with three included in the ESU and one excluded from the ESU.
Table 28. 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 2013c).

<table>
<thead>
<tr>
<th>ESU Description</th>
<th>Threatened</th>
<th>3 major population groups</th>
<th>17 historical populations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Population Group</strong></td>
<td><strong>Populations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coast</td>
<td>Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamakowa (C), Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cascade</td>
<td>Cowlitz-fall (C), Cowlitz-summer (C), Kalama, Lewis (C), Salmon Creek, Clackamas (C), Sandy, Washougal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gorge</td>
<td>Lower Gorge (C,G), Upper Gorge¹</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Includes 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 28. This ESU is comprised of three MPGs that has 17 populations (Table 29). Chum salmon are primarily limited to the tributaries downstream of Bonneville Dam and the majority of the fish spawn in Washington tributaries of the Columbia River (Figure 9).

Table 29. Current status for CR chum salmon populations and recommended status under the recovery scenario (NMFS 2013c).

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population (State)</th>
<th>Status Assessment</th>
<th>Recovery Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Persistence Probability</td>
<td>Contributio n</td>
</tr>
<tr>
<td>Coast</td>
<td>Youngs Bay (OR)</td>
<td>VL</td>
<td>Stabilizing</td>
</tr>
<tr>
<td></td>
<td>Grays/Chinook (WA)</td>
<td>M</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Big Creek (OR)</td>
<td>VL</td>
<td>Stabilizing</td>
</tr>
<tr>
<td></td>
<td>Elochoman/Skamakowa (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Clatskanie (OR)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Mill/Abernathy/Germany (WA)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Scappoose (OR)</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td>Cascade</td>
<td>Cowlitz – fall (WA)</td>
<td>VL</td>
<td>Contributing</td>
</tr>
</tbody>
</table>
Cowlitz – summer (WA)   VL   Contributing   M   900
Kalama (WA)   VL   Contributing   M   900
Lewis (WA)   VL   Primary   H   1,300
Salmon Creek (WA)   VL   Stabilizing   VL   --
Clackamas (OR)   VL   Contributing   M   500
Sandy (OR)   VL   Primary   H   1,000
Washougal (WA)   VL   Primary   H+   1,300

Gorge
Lower Gorge (WA/OR)   H   Primary   VH   2,000
Upper Gorge (WA/OR)   VL   Contributing   M   900

1 VL=very low, L=low, M=moderate, H=high, VH = very high. These are adopted in the recovery plan.
2 Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.
3 Abundance objectives account for related goals for productivity.

Figure 9. Map of the CR Chum Salmon ESU’s spawning and rearing areas, illustrating populations and major population groups (From NWFSC 2015).
Columbia River chum salmon are classified as fall-run fish, entering fresh water from mid-
October through November and spawning from early November to late December in the lower
main stems of the tributaries and side channels. There is evidence that a summer-run chum
salmon population returned historically to the Cowlitz River, and fish displaying this life history
are occasionally observed there. The recovery scenario currently includes this as an identified
population in the Cascade MPG (Table 29). Historically, chum salmon had the widest
distribution of all Pacific salmon species, comprising up to 50% of annual biomass of the seven
species, and may have spawned as far up the Columbia River drainage as the Walla Walla River
(Nehlsen et al. 1991). Chum salmon fry emerge from March through May (LCFRB 2010),
typically at night (ODFW 2010a), and are believed to migrate promptly downstream to the
estuary for rearing. Chum salmon fry are capable of adapting to seawater soon after emergence
from gravel (LCFRB 2010). Their small size at emigration is thought to make chum salmon
susceptible to predation mortality during this life stage (LCFRB 2010).

Given the minimal time juvenile chum salmon spend in their natural streams, the period of
estuarine residency appears to be a critical phase in their life history and may play a major role in
determining the size of returning adults (NMFS 2013d). 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 2013d). Shallow, protected habitats, such as salt marshes,
tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon
during estuarine residency (LCFRB 2010).

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

Status of the species is determined based on the abundance, productivity, spatial structure, and
diversity of its constituent natural populations. Best available information indicates that the
species, in this case the Columbia River Chum Salmon ESU, is at high risk and remains at
threatened status. Each Columbia River chum salmon population baseline and target persistence
probability is summarized in Table 29 along with target abundance for each population that
would be consistent with delisting criteria. Persistence probability is measured over a 100 year
time period and ranges from very low (probability of less than 40%) to very high (probability of
greater than 99%).

Over the last century, Columbia River chum salmon returns have collapsed from hundreds of
thousands to just a few thousand per year (NMFS 2013c). Of the 17 populations that historically
made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either
their baseline probability of persistence is very low, extirpated, or nearly so (Ford 2011; NMFS
2013c; 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 29 for
Oregon populations are minimum abundance thresholds (MATs) because Oregon lacked
sufficient data to quantify abundance targets. MATs are a relationship between abundance,
productivity, and extinction risk based on specific assumptions about productivity; more
information about MATs can be found in McElhany et al. (2006).

Currently almost all natural production occurs in just two populations: the Grays/Chinook and
the Lower Gorge. The most recent total abundance information for Columbia River chum
salmon in Washington is provided in Table 30, including chum salmon counted passing
Bonneville Dam. For the other Washington populations not listed in Table 30 and all Oregon
populations there are only occasional reports of only a few chum salmon (NWFSC 2015).

Table 30. Peak spawning ground counts for fall chum salmon in index reaches in the LCR, and
Bonneville Dam counts 2001-2014 (from WDFW SCORE¹).

<table>
<thead>
<tr>
<th>Return Year</th>
<th>Grays River</th>
<th></th>
<th>Mainstem</th>
<th>West Fork Grays</th>
<th>Grays River Total</th>
<th>Hamilton Creek Total</th>
<th>Hardy Creek</th>
<th>Mainstem Columbia (area near I-205)</th>
<th>Bonneville Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1,234</td>
<td>811</td>
<td>2,201</td>
<td>4,246</td>
<td>617</td>
<td>835</td>
<td>na</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>2,792</td>
<td>2,952</td>
<td>4,749</td>
<td>10,493</td>
<td>1,794</td>
<td>343</td>
<td>3,145</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>4,876</td>
<td>5,026</td>
<td>5,657</td>
<td>15,559</td>
<td>821</td>
<td>413</td>
<td>2,932</td>
<td>411</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>1,051</td>
<td>5,344</td>
<td>6,757</td>
<td>13,152</td>
<td>717</td>
<td>52</td>
<td>2,324</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>1,337</td>
<td>1,292</td>
<td>1,166</td>
<td>3,795</td>
<td>257</td>
<td>71</td>
<td>902</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>3,672</td>
<td>1,444</td>
<td>1,129</td>
<td>6,245</td>
<td>478</td>
<td>109</td>
<td>869</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>837</td>
<td>1,176</td>
<td>1,803</td>
<td>3,816</td>
<td>180</td>
<td>12</td>
<td>576</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>992</td>
<td>684</td>
<td>725</td>
<td>2,401</td>
<td>221</td>
<td>3</td>
<td>644</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>968</td>
<td>724</td>
<td>1,084</td>
<td>2,776</td>
<td>216</td>
<td>46</td>
<td>1,118</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>843</td>
<td>3,536</td>
<td>1,704</td>
<td>6,083</td>
<td>594</td>
<td>175</td>
<td>2,148</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>2,133</td>
<td>2,317</td>
<td>5,603</td>
<td>10,053</td>
<td>867</td>
<td>157</td>
<td>4,801</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>3,363</td>
<td>1,706</td>
<td>2,713</td>
<td>7,782</td>
<td>489</td>
<td>75</td>
<td>2,498</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>1,786</td>
<td>1,292</td>
<td>1,754</td>
<td>4,832</td>
<td>647</td>
<td>56</td>
<td>1,364</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>1,380</td>
<td>1,801</td>
<td>1,078</td>
<td>4,259</td>
<td>922</td>
<td>108</td>
<td>1,387</td>
<td>122</td>
<td></td>
</tr>
</tbody>
</table>

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

*Date Accessed: April 12, 2016.

The methods and results for categorizing spatial distribution from the LCFRB Plan (2010) for
Columbia River chum salmon populations are reported in the recovery plan, and updated scores
are summarized here in Table 32. 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 (LCFRFB 2010). Population
status is characterized relative to persistence (which combines the abundance and productivity
criteria), spatial structure, diversity, and also habitat characteristics. This overview for chum
salmon populations suggests that risks related to diversity are higher than those for spatial
structure (Table 32). 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 31. Columbia River Chum Salmon ESU populations and scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall net persistence probability of the populations (NMFS 2013a).  

<table>
<thead>
<tr>
<th>MPG</th>
<th>Ecological Subregion</th>
<th>Run Timing</th>
<th>Spawning Population (Watershed)</th>
<th>A/P</th>
<th>Diversity</th>
<th>Spatial Structure</th>
<th>Overall Persistence Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coast Range</td>
<td>Fall</td>
<td>Youngs Bay (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grays/Chinook rivers (WA)</td>
<td>VH</td>
<td>M</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big Creek (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Elochoman/Skamokawa rivers (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Clatskanie River (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mill, Abernathy and Germany creeks (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scappoose Creek (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td>Cascade Range</td>
<td>Summer</td>
<td>Cowlitz River (WA)</td>
<td>VL</td>
<td>L</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fall</td>
<td>Cowlitz River (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kalama River (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lewis River (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salmon Creek (WA)</td>
<td>VL</td>
<td>L</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Clackamas River (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sandy River (OR)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Washougal River (WA)</td>
<td>VL</td>
<td>H</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td></td>
<td>Columbia Gorge</td>
<td>Fall</td>
<td>Lower Gorge (WA &amp; OR)</td>
<td>VH</td>
<td>H</td>
<td>VH</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Upper Gorge (WA &amp; OR)</td>
<td>VL</td>
<td>L</td>
<td>L</td>
<td>VL</td>
</tr>
</tbody>
</table>

1 Ratings range from low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2013c; NWFSC 2015).

* No data are available to make a quantitative assessment.

The most recent status review (NWFSC 2015) concluded that a total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0 (Table 32). The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of individual populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (NWFSC 2015).
Table 32. Summary of VSP scores and recovery goals for CR chum salmon populations (NWFSC 2015).

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

Notes: Summaries taken directly from Figure 82 in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

2.2.1.13. Lower Columbia River Coho Salmon ESU

On June 28, 2005, NMFS listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014. Critical habitat was originally proposed for designation on January 14, 2013, and was finalized on January 24, 2016 (81 FR 9252) (Table 7).

The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia River up to and including the White Salmon and Hood rivers (Figure 10). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160). LCR coho salmon are divided into 3 major population groups, with the majority of the populations and associated hatchery programs located below Bonneville Dam (Table 33). NMFS has determined that any effects from the Proposed Action would be limited to Gorge MPG, primarily the Upper Gorge/White Salmon, and the Upper Gorge/Hood River populations due to the proximity to the LWS NFH. Generally, these populations have low baseline persistence probabilities (Table 34).
Table 33. LCR Coho Salmon ESU description and MPGs (Jones Jr. 2011; NMFS 2013c).  

<table>
<thead>
<tr>
<th>ESU Description</th>
<th>Threatened</th>
<th>Listed under ESA in 2005; updated in 2014 (see Table 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Population Group</td>
<td>3 major population groups</td>
<td>24 historical populations</td>
</tr>
</tbody>
</table>

### Coast
- Youngs Bay, Grays/Chinook, Big Creek, Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose

### Cascade
- Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, South Fork Toutle, North Fork Toutle, Coweeman, Kalama, North Fork Lewis, East Fork Lewis, Salmon Creek, Clackamas, Sandy, Washougal

### Gorge
- Lower Gorge, Upper Gorge/White Salmon, Upper Gorge/Hood

### Artificial production

| Hatchery programs included in ESU (23) | Grays River (Type-S), Sea Resources (Type-S), Peterson Coho Salmon Project (Type-S), Big Creek Hatchery (ODFW stock #13), Astoria High School (STEP) Coho Salmon Program, Warrenton High School (STEP) Coho Salmon Program, Cathlamet High School FFA Type-N Coho Salmon Program, Cowlitz Type-N Coho Salmon Program, Cowlitz Game and Anglers Coho Salmon Program, Friends of the Cowlitz Coho Salmon Program, North Fork Toutle River Hatchery (type-S), Kalama River Type -N Coho Salmon Program, Kalama River Type-S Coho Salmon Program, Lewis River Type-N Coho Salmon Program, Lewis River Type-S Coho Salmon Program, Fish First Wild Coho Salmon Program, Fish First Type-N Coho Salmon Program, Syverson Project Type-N Coho Salmon Program, Washougal River Type-N Coho Salmon Program, Eagle Creek NFH, Sandy Hatchery (ODFW stock #11), Bonneville/Cascade/Oxbow Complex (ODFW stock #14) |
| Hatchery programs not included in ESU (1) | CCF Coho Salmon Program (Klaskanine River origin) |

*The Elochoman Type-S and Type-N coho salmon hatchery programs have been discontinued and NMFS has recommended removed them from the ESU (Jones Jr. 2015)*

---

8 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.

Table 34. Current status for LCR coho salmon Gorge MPG populations and recommended status under the recovery scenario (NMFS 2013c).

<table>
<thead>
<tr>
<th>Major Population Group</th>
<th>Population (State)</th>
<th>Status Assessment</th>
<th>Recovery Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline Persistence Probability&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Contribution&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gorge</td>
<td>Lower Gorge (WA/OR) - Late</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge/White Salmon (WA) - Late</td>
<td>VL</td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge/Hood (OR) - Early</td>
<td>VL</td>
<td>Primary</td>
</tr>
</tbody>
</table>
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.
4. Oregon’s analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

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

Although run-time variation is considered inherent to overall coho salmon life history, LCR coho salmon typically display one of two major life history types, either early- or late-returning freshwater entry. Freshwater entry timing for this ESU is also associated with ocean migration patterns (Table 35) 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 2013c).

Table 35. Life history and population characteristics of LCR coho salmon.

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

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 2013c).

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the LCR Coho Salmon ESU is at high risk and remains at threatened status. Each population’s baseline and target persistence probabilities is summarized in Table 34, along with target abundance for each population that would be consistent with delisting the species. Persistence probability is measured over a 100-year time period and ranges from very low (probability of persistence over 100 years less than 40%) to very high (probability greater than 99%).

Table 36 presents escapement of LCR coho salmon in Oregon Gorge tributaries (2002-2015). Table 37 presents escapement of LCR coho salmon in Washington Gorge tributaries (2002-2015). It is unclear how comprehensive the surveys are or if the estimates are intended to be expanded estimates for the population as a whole. On the Washington side, the estimates are characterized as cumulative fish per mile index counts.
Table 36. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015 (http://www.odfwrecoverytracker.org/)*.

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorge</td>
<td>Lower Gorge</td>
<td>Natural</td>
<td>338</td>
<td>-</td>
<td>-</td>
<td>263</td>
<td>226</td>
<td>126</td>
<td>223</td>
<td>468</td>
<td>920</td>
<td>216</td>
<td>96</td>
<td>151</td>
<td>362</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pHOS</td>
<td>17%</td>
<td>-</td>
<td>-</td>
<td>85%</td>
<td>70%</td>
<td>67%</td>
<td>46%</td>
<td>29%</td>
<td>7%</td>
<td>54%</td>
<td>56%</td>
<td>6%</td>
<td>51%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge/Hood</td>
<td>Natural</td>
<td>147</td>
<td>41</td>
<td>126</td>
<td>1,262</td>
<td>373</td>
<td>170</td>
<td>69</td>
<td>65</td>
<td>223</td>
<td>232</td>
<td>169</td>
<td>561</td>
<td>42</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pHOS</td>
<td>60%</td>
<td>-</td>
<td>-</td>
<td>45%</td>
<td>48%</td>
<td>45%</td>
<td>29%</td>
<td>0%</td>
<td>85%</td>
<td>69%</td>
<td>78%</td>
<td>65%</td>
<td>76%</td>
<td>64%</td>
</tr>
</tbody>
</table>

* Date accessed: April 13, 2016.

Table 37. Natural-origin spawning escapement numbers and the proportion of all natural spawners composed of hatchery-origin fish (pHOS1) on the spawning grounds for LCR coho salmon populations in Washington from 2002 through 2015 (https://fortress.wa.gov/dfw/score/score/species/coho.jsp?species=Coho)*.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gorge</td>
<td>Lower Gorge</td>
<td>Natural</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>28</td>
<td>-</td>
<td>-</td>
<td>385</td>
<td>504</td>
<td>524</td>
<td>-</td>
<td>704</td>
<td>650</td>
<td>-</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pHOS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>29%</td>
<td>13%</td>
<td>20%</td>
<td>-</td>
<td>35%</td>
<td>-</td>
<td>11%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Upper Gorge/Hood</td>
<td>Natural</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>152</td>
<td>86</td>
<td>71</td>
<td>35</td>
<td>111</td>
<td>96</td>
<td>106</td>
<td>24</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pHOS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23%</td>
</tr>
</tbody>
</table>

* Date accessed: April 13, 2016
This information, although limited, indicates there are several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are actually relatively low.

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

2.2.2. Range-wide Status of Critical Habitat

NMFS determines the range-wide status of critical habitat by examining the condition of its PBFs that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species’ life stages. An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 7).

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

The status of critical habitat is based primarily on a watershed-level analysis of conservation value that focused on the presence of ESA-listed species and physical features that are essential to the species’ conservation. NMFS organized information at the 5th field hydrologic unit code
(HUC) watershed scale because it corresponds to the spatial distribution and site fidelity scales of salmon and steelhead populations (McElhany et al. 2000). The analysis for the 2005 designations of salmon and steelhead species was completed by Critical Habitat Analytical Review Teams (CHARTs) that focused on large geographical areas corresponding approximately to recovery domains (NMFS 2005b). Each watershed was ranked using a conservation value attributed to the quantity of stream habitat with physical and biological features (PBFs; also known as primary and constituent elements ((PCEs)), the present condition of those PBFs, the likelihood of achieving PBF potential (either naturally or through active restoration), support for rare or important genetic or life history characteristics, support for abundant populations, and support for spawning and rearing populations. In some cases, our understanding of these interim conservation values has been further refined by the work of technical recovery teams and other recovery planning efforts that have better explained the habitat attributes, ecological interactions, and population characteristics important to each species.

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

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

**Critical Habitat for Upper Columbia River Spring Chinook Salmon**

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

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

**Critical Habitat for Upper Columbia River Steelhead**

The UCR Steelhead DPS’s range includes 42 watersheds. The CHART assigned low, medium, and high conservation value ratings to 3, 8, and 31 watersheds, respectively (NMFS 2005b). The following are the major factors limiting the conservation value of critical habitat for UCR steelhead:
• Forestry practices
• Grazing
• Agriculture
• Channel modifications/diking
• Road building/maintenance
• Urbanization
• Sand and gravel mining
• Mineral mining
• Dams
• Irrigation impoundments and withdrawals
• River, estuary, and ocean traffic
• Wetland loss/removal
• Beaver removal
• Exotic/invasive species introductions
• Forage fish/species harvest

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

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

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

• Agriculture
• Channel modifications/diking
• Dams,
• Forestry
• Fire activity and disturbance
• Grazing
2.2.3. Climate Change

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

2.3. Action Area

The “action area” means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The action area resulting from this analysis includes the mainstem Columbia River from the confluence with the Methow River through the estuary (i.e., mouth of the Columbia River), which is a migration corridor for outmigrating juveniles. The action area also includes the Methow, Chelan, Entiat, and Wenatchee Subbasins and their tributaries, which are areas where fish are captured, reared, and released, as well as areas where they may be monitored, or to which they might stray.

2.4. Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The ‘Environmental Baseline’ includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area and the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation (50 CFR 402.02).

2.4.1. Habitat and Hydropower (NMFS 2012a)

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

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

- Juvenile and adult passage survival (safe passage in the migration corridor);
- Water quantity (i.e., flow) and seasonal timing (water quantity and velocity and safe passage in the migration corridor; cover/shelter, food/prey, riparian vegetation, and space associated with the connectivity of the estuarine floodplain);
- Temperature in the reaches below the large mainstem storage projects (water quality and safe passage in the migration corridor).
• Sediment transport and turbidity (water quality and safe passage in the migration corridor)
• Total dissolved gas (water quality and safe passage in the migration corridor)
• Food webs, including both predators and prey (food/prey and safe passage in the migration corridor)

While harmful land-use practices continue in some areas, many land management activities, including forestry practices, now have fewer impacts on salmonid habitat due to raised awareness and less invasive techniques. For example, timber harvest on public land has declined drastically since the 1980s and current harvest techniques (e.g., the use of mechanical harvesters and forwarders) and silvicultural prescriptions (i.e., thinning and cleaning) require little, if any, road construction and produce much less sediment. In addition, the Federal Conservation Reserve and Enhancement Program (CREP) began in the 1990’s nearly 80 percent of all salmonid bearing streams in the area have been re-vegetated with native species and protected from impacts. Under the CREP, highly erodible and other environmentally sensitive lands that have produced crops are converted to a long-term resource-conserving vegetative cover. Participants in the CREP are required to seed native or introduced perennial grasses or a combination of shrubs and trees with native forbs and grasses.

**Upper Columbia River**

Many factors have contributed to habitat degradation in the Wenatchee, Entiat, Methow, and Okanogan subbasins. The historical land use patterns are similar in each; beaver trapping, which began in the early 1800s, had some effect on riparian conditions. Mining, which began in the 1860s, was probably the first major activity affecting riparian and stream conditions. This was followed by a period of intense livestock grazing with pressure highest from the late 1800s to the 1930s. Grazing pressure then fell as allotment systems replaced the open range. Water diversion began in the mid-1880s, affecting stream flow, which impacted adult salmonid migration and juvenile rearing capacity. Timber harvest began in the 1920s and up until 1955 selective harvest was the primary method. Since then partial cutting and clear-cutting have predominated, with the most intense harvest occurring in the 1980s. Some of these factors have been partially addressed through changes in land-use practices and/or implementation of BMPs (e.g., fish screens at water diversions; UCSRB 2014). In addition, some of the headwater areas are in relatively pristine condition and serve as strongholds for the listed species. However, many of the factor effects remain as a result of remnant infrastructure and previous land conversion/modifications (UCSRB 2007).

Limits to the viability of salmon and steelhead in the Wenatchee Basin include lack of habitat diversity and quantity, excessive sediment load, obstructions, a lack of channel stability, low flows, and high summer temperatures. Habitat diversity is affected by channel confinement, loss of floodplain connectivity and off-channel habitat, reduced quantities of large wood, and a lack of riparian vegetation. The mainstem and many of its tributaries also lack high-quality pools and spawning areas.

Limits to the viability of salmon and steelhead in the Entiat Basin include reduced stream channel configuration and complexity due to logging and flood control measures. These historical and ongoing activities have led to a condition with low instream habitat diversity including few pools, lack of large wood accumulations, and disconnected side channels,
wetlands, and floodplains. The result is a reduction in resting and rearing areas for both adult and juvenile salmon throughout the Entiat River.

Limits to the viability of salmon and steelhead in the Methow basin include housing and agricultural development that have diminished the overall function of the stream channel and floodplain. This has impaired stream complexity, wood and gravel recruitment, floodwater retention, and water quality. Additionally, late summer and winter instream flow conditions often reduce migration, spawning, and rearing habitat for native salmonids. This problem is partly natural (a result of watershed-specific weather and geomorphic conditions) but is exacerbated by irrigation withdrawals.

Limits to the viability of salmon and steelhead in the Okanogan Basin include barriers, poor water quality, and low late-summer instream flows (mainstem and tributary). Summer water temperatures often exceed lethal tolerance levels for salmonids along the Okanogan River mainstem. These high temperatures are partially due to natural phenomena (low gradient, aspect, high ambient air temperatures, and upstream lake effects), but are exacerbated by activities like dam operations, irrigation, and land management. High water temperatures and low flows in summer and fall may limit adult run timing as well as juvenile salmonid rearing in the mainstem and in several tributaries.

Mainstem Columbia River

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

2.4.2. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. As the climate changes, air temperatures in the Pacific Northwest are expected to increase <1°C in the Columbia Basin by the 2020s and 2°C to 8°C by the 2080s (Mantua et al. 2010). Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2015d).
These changes will not be spatially homogenous across the entire Pacific Northwest. There is likely no trend in precipitation (neither strongly increase nor decrease), although summers may become drier and winters wetter due to changes in the same amount of precipitation being subjected to altered seasonal temperatures (Mote and Eric P. Salathé Jr. 2010; PCIC 2016). Warmer winters will result in reduced snowpack throughout the Pacific Northwest, leading to substantial reductions in stream volume and changes in the magnitude and timing of low and high flow patterns (Beechie et al. 2013; Dalton et al. 2013). Many basins that currently have a snowmelt-dominated hydrological regime (maximum flows during spring snow melt) will become either transitional (high flows during both spring snowmelt and fall-winter) or rain-dominated (high flows during fall-winter floods; (Beechie et al. 2013; Schnorbus et al. 2014). Summer low flows are expected to be reduced between 10-70% in areas west of the Cascade Mountains of the next century, while increased precipitation and snowpack is expected for the Canadian Rockies. More precipitation falling as rain and larger future flood events are expected to increase maximum flows by 10-50% across the region (Beechie et al. 2013). Climate change is also predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower elevation streams will have larger fall/winter flood events and lower late summer flows, while higher elevations may have higher minimum flows.

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

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, seasonal hydrology in Pacific Northwest watersheds will shift to more frequent and severe early large storms, changing stream flow timing, which may limit salmon survival (Mantua et al. 2009).
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments. The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology
• Temperature-induced changes to stream flow patterns
• Alterations to freshwater, estuarine, and marine food webs

How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier et al. 2008b). Dittmer (2013) suggests that juveniles may outmigrate earlier if they are faced with less tributary water. Lower and warmer summer flows may be challenging for returning adults. In addition, the warmer water temperatures in the summer months may persist for longer periods and more frequently reach and exceed thermal tolerance thresholds for salmon and steelhead (Mantua et al. 2009). Larger winter streamflows may increase redd scouring for those adults that do reach spawning areas and successfully spawn. Climate change may also have long-term effects that include accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007). The uncertainty associated with these potential outcomes of climate change do provide some justification for hatchery programs as reservoirs for some salmon stocks. For more detail on climate change effects, see NMFS (2017d).

2.4.3. Hatcheries

A broader discussion of hatchery programs in the Action Area can be found in our opinions on:
• Mitchell Act-funded programs (NMFS 2017d).
• Methow/Winthrop spring Chinook salmon programs (NMFS 2016).
• WNFH/Wells Complex steelhead programs (NMFS 2017e).
• Entiat National Fish Hatchery summer Chinook salmon program (NMFS 2013b).
• Wenatchee spring Chinook salmon programs (NMFS 2013a).
• Wenatchee steelhead program (NMFS 2016a).
• Leavenworth spring Chinook salmon program (NMFS 2017b).
• Okanogan Tribal Resource Management Plan (NMFS 2017c).

Included in the Environmental Baseline are the ongoing effects of hatchery programs or facilities which have undergone Federal review under the ESA, as well as the past effects of programs which have not yet undergone such review, including those found in the proposed action. A more comprehensive discussion of hatchery programs in the Columbia Basin can be found in our opinion on Mitchell Act funded programs (NMFS 2017d). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species (NWFSC 2015) and was summarized in Section 2.2.1 of this Opinion. In the past, hatcheries have been used to compensate for factors that limit anadromous salmonid viability (e.g., harvest, human development) by maintaining fishable returns of adult salmon and steelhead. A new role for hatcheries emerged during the 1980s and 1990s as a tool to conserve the genetic resources of depressed natural populations and to reduce short-term extinction risk (e.g., Snake River sockeye salmon). Hatchery programs also can be used to help improve viability by supplementing natural population abundance and expanding spatial distribution. However, the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014). Therefore, fixing the factors limiting viability is essential for long-term viability.
Below, we summarize releases within the Action Area in the UCR Basin (Table 39) because the releases from the proposed action is in the UCR Basin, and the returning adults from the proposed action would return to the UCR Basin.

Table 38. Upper Columbia River hatchery programs with releases in the action area

<table>
<thead>
<tr>
<th>Biological Opinion</th>
<th>Program Name</th>
<th>Maximum Release Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow/Winthrop spring Chinook salmon programs (NMFS 2016)</td>
<td>Methow Hatchery</td>
<td>224,000</td>
</tr>
<tr>
<td></td>
<td>Winthrop National Fish Hatchery</td>
<td>400,000</td>
</tr>
<tr>
<td>Wells Complex steelhead programs (NMFS 2017e)</td>
<td>Wells Complex¹</td>
<td>308,000</td>
</tr>
<tr>
<td></td>
<td>Winthrop National Fish Hatchery</td>
<td>200,000</td>
</tr>
<tr>
<td>Entiat National Fish Hatchery summer Chinook salmon program (NMFS 2013b)</td>
<td>Entiat National Fish Hatchery</td>
<td>400,000</td>
</tr>
<tr>
<td>Wenatchee spring Chinook salmon programs (NMFS 2013a)</td>
<td>Chiwawa</td>
<td>205,000</td>
</tr>
<tr>
<td></td>
<td>Nason Creek</td>
<td>223,760</td>
</tr>
<tr>
<td>Wenatchee steelhead program (NMFS 2016a)</td>
<td>Wenatchee</td>
<td>247,300</td>
</tr>
<tr>
<td>Leavenworth spring Chinook salmon program (NMFS 2017b)</td>
<td>Leavenworth National Fish Hatchery</td>
<td>1,200,000</td>
</tr>
</tbody>
</table>

¹ The Wells Complex steelhead program produces an additional 100,000 smolts, which is transferred for release in the Okanogan Basin (NMFS 2017c), which is outside of the action area.

2.4.4. Harvest

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

*U.S. v. Oregon* Fisheries

The fisheries that take place as a result of the *U.S. v. Oregon* agreement occur between Buoy 10 and Priest Rapids Dam. A detailed discussion of the history of *U.S. v. Oregon* agreement can be found in NMFS (2017a). Within this area, fisheries are divided into six zones below McNary Dam, and fisheries also take place between McNary Dam and Priest Rapids Dam (i.e., Hanford Reach). Commercial and recreational fisheries take place from Zones 1 through 5 (between Buoy 10 and Bonneville Dam), while tribal and recreational fisheries take place in Zone 6 (between Bonneville Dam and McNary Dam) and in the Hanford Reach. The effects of these fisheries on ESA-listed species are analyzed in NMFS (2008d). The expected incidental take and the actual harvest that occurred from these fisheries are summarized in Table 39 and in Table 40, respectively.

Table 39. 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.
<table>
<thead>
<tr>
<th>ESU or DPS</th>
<th>Take Limits (%)</th>
<th>Treaty Indian (%)</th>
<th>Non-Indian (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snake River fall-run Chinook Salmon</td>
<td>21.5 – 45.0 1</td>
<td>20.0 – 30.0</td>
<td>1.5 – 15.0</td>
</tr>
<tr>
<td>Snake River spring/summer-run Chinook Salmon</td>
<td>5.5 – 17.0 2</td>
<td>5.0 – 14.3 2</td>
<td>0.5 – 2.7</td>
</tr>
<tr>
<td>LCR Chinook Salmon</td>
<td>Managed by components listed below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spring-run component</td>
<td>Managed For Hatchery Escapement Goals</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>tule component (early-fall run)</td>
<td>41% Exploitation Rate 4</td>
<td>0</td>
<td>41% exploitation rate 4</td>
</tr>
<tr>
<td>bright component (late-fall run)</td>
<td>Managed For Escapement Goal</td>
<td>0</td>
<td>5,700 escapement goal</td>
</tr>
<tr>
<td>UWR Chinook Salmon</td>
<td>15.0</td>
<td>0</td>
<td>15.0</td>
</tr>
<tr>
<td>Snake River Basin Steelhead</td>
<td>Managed by components listed below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-Run Component</td>
<td>4.0 5</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>B-Run Component</td>
<td>15 – 22 7</td>
<td>13 – 20 7</td>
<td>2.0 7</td>
</tr>
<tr>
<td>LCR Steelhead</td>
<td>Managed by components listed below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter component</td>
<td>2.0</td>
<td>6</td>
<td>2.0</td>
</tr>
<tr>
<td>summer component</td>
<td>4.0 5</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>UWR Steelhead</td>
<td>2.0 5</td>
<td>0</td>
<td>2.0</td>
</tr>
<tr>
<td>MCR Steelhead</td>
<td>Managed by components listed below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter component</td>
<td>2.0</td>
<td>6</td>
<td>2.0</td>
</tr>
<tr>
<td>summer component</td>
<td>4.0 5</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>UCR spring-run Chinook Salmon</td>
<td>5.5 – 17.0 2</td>
<td>5.0 – 14.3 2</td>
<td>0.5 – 2.7</td>
</tr>
<tr>
<td>CR Chum Salmon</td>
<td>5.0</td>
<td>0</td>
<td>5.0</td>
</tr>
<tr>
<td>UCR Steelhead</td>
<td>Managed by components listed below</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural-Origin Component</td>
<td>4.0 5</td>
<td>6</td>
<td>4.0</td>
</tr>
<tr>
<td>Hatchery-Origin Component</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Snake River Sockeye Salmon</td>
<td>6.0 – 8.0 1</td>
<td>5.0 – 7.0</td>
<td>1.0</td>
</tr>
<tr>
<td>LCR Coho Salmon</td>
<td>10 – 30 9</td>
<td>0</td>
<td>10 – 30 9</td>
</tr>
<tr>
<td>Monitoring, Evaluation, and Research</td>
<td>0.1 - 0.5 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Allowable take depends on run size.
2 Impacts in treaty fisheries on listed wild fish can be up to 0.8% higher than the river mouth runsize harvest rates (indicated in table above) due to the potential for changes in the proportion wild between the river mouth and Bonneville Dam.
3 NMFS (2012c) determined fisheries have ranged from exploitation rates of 2% to 28% over the last ten years, and are expected to remain within this range through managing for hatchery escapement until other actions concerning terminal fish passage in the LCR are addressed.
4 Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2012c) evaluated the PFMC’s harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.
5 Applies to non-Indian fisheries only; 2% in winter/spring/summer seasons and 2% in fall season.
6 There is no specific harvest rate limit proposed for treaty fisheries on winter steelhead above Bonneville Dam or on A-run summer steelhead.
7 For fall fisheries only.
8 There is no take prohibition on ad-clipped hatchery fish even if they are part of a threatened ESA-listed group.
Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2017d) evaluated the PFMC’s harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.

Total exploitation rate limits include ocean and inriver fisheries.
Table 40. Annual post season performance of fisheries managed under the 2008 U.S. v. Oregon Agreement.

<table>
<thead>
<tr>
<th>ESU or DPS</th>
<th>Total impact annually achieved based on postseason reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snake River spring/summer-run Chinook</td>
<td>9.1%</td>
</tr>
<tr>
<td>UCR spring-run Chinook</td>
<td>9.1%</td>
</tr>
<tr>
<td>UWR spring-run Chinook</td>
<td>5.9%</td>
</tr>
<tr>
<td>LCR Chinook</td>
<td>yes</td>
</tr>
<tr>
<td>Fall tule component</td>
<td>33.0%</td>
</tr>
<tr>
<td>Fall bright component</td>
<td>5,485</td>
</tr>
<tr>
<td>Snake River fall Chinook</td>
<td>27.4%</td>
</tr>
<tr>
<td>LCR Coho</td>
<td>7.3%</td>
</tr>
<tr>
<td>CR Chum</td>
<td>1.6%</td>
</tr>
<tr>
<td>Snake River Sockeye</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

**Separate Rates**

<table>
<thead>
<tr>
<th>Tribal only</th>
<th>Steelhead B-Run (in fall fisheries)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15.2%</td>
</tr>
</tbody>
</table>

**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 (winter fisheries) | 0.3%  | 0.3%  | 0.7%  | 0.7%  | 0.8%  | 0.6%  | 0.6%  | 0.6% |
| UWR Steelhead | Winter Component (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.
Rate set annually in coordination with PFMC for combined exploitation rate for ocean and Columbia River mainstem fisheries up to Bonneville Dam.

Managed for hatchery escapement goals to the Cowlitz, Lewis and Sandy Rivers. If annual box is yes, then H.E. goal was met 100%.

Managed for an escapement goal of 5,700 fish in the North Lewis River.
Fisheries above Priest Rapids Dam

Fisheries above Priest Rapids Dam occur both on the Columbia River and on its tributaries. Within this area, there are a mark-selective spring Chinook salmon and steelhead fisheries and various fisheries targeting non-ESA-listed fish.

ESA-listed UCR spring Chinook salmon are not harvested in the action area above Priest Rapids Dam.

Mark-selective steelhead fisheries operate in the action area under permit 1395 (NMFS 2003). Allowable incidental take is based on natural-origin returns, with the idea being that as the number of natural-origin returns increases, a higher percentage of natural-origin fish is allowed to be encountered in the fishery. There are no encounters with spring Chinook salmon because these fisheries occur from September through March (before and after spring Chinook salmon return to this area), although seasons are often shorter because of in-season management of steelhead returns. Table 41 summarizes the incidental take associated with the mark-selective steelhead fisheries from 2010 through 2016.

Table 41. Summary of natural-origin UCR steelhead encounters associated with mark-selective steelhead fisheries above Priest Rapids Dam (2010-2016).

<table>
<thead>
<tr>
<th>Season</th>
<th>Area</th>
<th>Natural-origin escapement</th>
<th>Allowable incidental take</th>
<th>Realized incidental take¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2011</td>
<td>Methow River</td>
<td>1773</td>
<td>71</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Columbia River¹</td>
<td>4050</td>
<td>81</td>
<td>34</td>
</tr>
<tr>
<td>2011-2012</td>
<td>Methow River</td>
<td>1187</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Columbia River²</td>
<td>1185</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>2012-2013</td>
<td>Methow River</td>
<td>905</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Columbia River²</td>
<td>545</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>2013-2014</td>
<td>Methow River</td>
<td>1481</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Columbia River³</td>
<td>359</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>2014-2015</td>
<td>Methow River</td>
<td>2168</td>
<td>43</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Columbia River³</td>
<td>283</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>2015-2016</td>
<td>Methow River</td>
<td>1248</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Columbia River³</td>
<td>98</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Sources: WDFW (2011); WDFW (2012); WDFW (2014a); WDFW (2015a); WDFW (2016a)

¹ Based on 5 percent assumed catch and release mortality.
² This includes the reach from Priest to Wells Dam and the Entiat River.
The Wenatchee River also has a conservation fishery that may impact ESA-listed steelhead, which was analyzed in NMFS (2013a), and which found that up to 10 natural-origin adult UCR steelhead may be caught and released, with no more than 1 percent incidental mortality.

In this area, there are four other fisheries that incidentally impact ESA-listed spring Chinook salmon and steelhead. The Methow River resident trout fishery, which occurs from June through September, has incidentally killed up to 650 juveniles and encountered up to 12 adult steelhead annually over the last five years, and remains within their allowed take through NMFS permit 1554 (Table 42). The summer Chinook and sockeye salmon fishery has incidentally killed up to 10 adult steelhead annually (Table 42), which is within their allotted take under permit 1554 (NMFS 2008g). This fishery is unlikely to encounter spring Chinook salmon because it operates from July to October after spring Chinook salmon have already entered or spawned in the tributary habitats, and does not take place in the Methow River. Another fishery operating under permit 1554 is a recreational fishery targeting non-ESA listed spring Chinook salmon (Carson stock) in Icicle Creek, which has encountered spring Chinook salmon and steelhead in the past (The non-game fishery above Priest Rapids has not resulted in take of listed spring Chinook salmon and steelhead despite operating year-round (WDFW 2013; WDFW 2014b; WDFW 2015b; WDFW 2016b; WDFW 2017a).

Table 42. Summary of natural-origin UCR steelhead and UCR spring Chinook salmon encounters associated with fisheries targeting non-listed fish above Priest Rapids Dam (2012-2016).

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishery</th>
<th>Allowable steelhead</th>
<th>Realized steelhead</th>
<th>Allowable spring Chinook salmon</th>
<th>Realized spring Chinook salmon</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>429 juveniles 12 adults</td>
<td>8 juveniles</td>
<td>0 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>9 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Icicle Creek spring Chinook salmon</td>
<td>10 adults</td>
<td>0</td>
<td>3 adults</td>
<td>1 adult</td>
</tr>
<tr>
<td>2013</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>650 juveniles 12 adults</td>
<td>8 juveniles</td>
<td>8 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>4 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Icicle Creek spring Chinook salmon</td>
<td>10 adults</td>
<td>14 adults</td>
<td>3 adults</td>
<td>No information</td>
</tr>
<tr>
<td>2014</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>302 juveniles 4 adults</td>
<td>8 juveniles</td>
<td>8 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>10 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Icicle Creek spring Chinook salmon</td>
<td>10 adults</td>
<td>0</td>
<td>3 adults</td>
<td>No information</td>
</tr>
</tbody>
</table>
2015

<table>
<thead>
<tr>
<th></th>
<th>Methow River</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>resident trout</td>
<td>1250 juveniles</td>
<td>396 juveniles</td>
<td>8 juveniles</td>
<td>2 juveniles</td>
</tr>
<tr>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>9 adults</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Icicle Creek spring Chinook salmon</td>
<td>10 adults</td>
<td>0</td>
<td>3 adults</td>
<td>No information</td>
<td></td>
</tr>
</tbody>
</table>

2016

<table>
<thead>
<tr>
<th></th>
<th>Methow River</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>resident trout</td>
<td>1250 juveniles</td>
<td>495 juveniles</td>
<td>8 juveniles</td>
<td>4 juveniles</td>
</tr>
<tr>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>3 adults</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Icicle Creek spring Chinook salmon</td>
<td>10 adults</td>
<td>2 adults</td>
<td>3 adults</td>
<td>No information</td>
<td></td>
</tr>
</tbody>
</table>

Sources: WDFW (2013); WDFW (2014b); WDFW (2015b); WDFW (2016b); WDFW (2017a)

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

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Appendix A and application of the methodology and analysis of the Proposed Action is in Section 2.4.2. The “effects of the action” means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, 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. Effects of the Proposed Action that are expected to occur later in time (i.e., after the 10-year timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

#### 2.5.1. Factors That Are Considered When Analyzing Hatchery Effects

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

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

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

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species
must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before
formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or Proposed
Action for its effects on ESA-listed species and on designated critical habitat depends on six
factors. These factors are:

(1) the hatchery program does or does not remove fish from the natural population and
use them for hatchery broodstock
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning
grounds and encounters with natural-origin and hatchery fish at adult collection
facilities
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing
areas, migratory corridor, estuary, and ocean
(4) RM&E that exists because of the hatchery program
(5) the operation, maintenance, and construction of hatchery facilities that exist because
of the hatchery program
(6) fisheries that exist because of the hatchery program, including terminal fisheries
intended to reduce the escapement of hatchery-origin fish to spawning grounds

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

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

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

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

2.5.2.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

The proposed hatchery programs pose ecological risks and risks from handling related to adult collection to UCR spring Chinook salmon and UCR steelhead, while posing no genetic risks because the species propagated does not interbreed with any ESA-listed individuals. The overall effect of this factor on these Upper Columbia River species is negligible. There is no effect of this factor on other ESA-listed species because those species are not present on the spawning grounds or in adult collection facilities of these hatchery fish.

Genetic Effects

Because the fish from the proposed action return to the UCR Basin as an adult to potentially spawn, only listed species which are present in UCR (i.e., UCR spring Chinook salmon and UCR steelhead) have the potential to be affected genetically by the proposed action. Within the UCR Basin, there is a possibility that late returning spring Chinook salmon could interbreed with summer/fall Chinook salmon from the early part of the run (Table 43) in some areas where spawning distribution overlaps. However, based on spring Chinook salmon spawning timing in subbasins where hatchery summer/fall Chinook salmon are released (e.g., Snow et al. (2016), Hillman et al. (2016)), there is little to no temporal overlap with summer/fall Chinook salmon spawning, so interbreeding between hatchery-origin summer/fall Chinook salmon and UCR spring Chinook salmon is unlikely.

9 Thus, Snake River spring summer Chinook salmon, Snake River fall Chinook salmon, Lower Columbia River Chinook salmon, Upper Willamette River spring Chinook salmon, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Snake River sockeye salmon, Columbia River chum salmon, and Lower Columbia coho salmon will not experience population-level genetic effects due to the proposed action.
Spring Chinook salmon are not likely to interbreed with hatchery-origin fall Chinook salmon because spring Chinook salmon would finish spawning before fall Chinook salmon would start spawning (Table 43) and their spawning spatial distributions do not overlap.

Also, steelhead do not interbreed with Chinook salmon, so there are no genetic effects on UCR steelhead from hatchery-origin summer/fall or fall Chinook salmon.

Table 43. Timing of adult return and spawning for UCR salmonids.

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

Sources: (WDFW 2002)

Ecological Effects

Ecological effects from returning adult hatchery-origin fish include redd superimposition, competition for spawning grounds, and contribution of marine derived nutrients. Because these effects could occur once the hatchery-origin fish return to the tributaries, the analysis here is limited to effects on UCR spring Chinook salmon and UCR steelhead, which are the only ESA-listed species present in the tributaries to which these hatchery-origin adults return.\(^{10}\) Predation by the returning adult hatchery-origin is not likely to be an ecological effect because these adult fish cease to eat upon freshwater entry.

In Table 44 below, the average number of fish for each program that have strayed to other basins is summarized. These numbers are the number of hatchery-origin fish that could interact with ESA-listed fish in the recipient basins, as discussed below.

\(^{10}\) Thus, Snake River spring summer Chinook salmon, Snake River fall Chinook salmon, Lower Columbia River Chinook salmon, Upper Willamette River spring Chinook salmon, Snake River steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, Upper Willamette River steelhead, Snake River sockeye salmon, Columbia River chum salmon, and Lower Columbia coho salmon will not experience population-level ecological effects as a result of the proposed action.
Table 44. Average number of hatchery-origin summer/fall and fall Chinook salmon straying into other basins.

<table>
<thead>
<tr>
<th>Program</th>
<th>Chelan</th>
<th>Entiat</th>
<th>Hanford Reach</th>
<th>Methow</th>
<th>Okanogan</th>
<th>Wenatchee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls&lt;sup&gt;4&lt;/sup&gt;</td>
<td>71</td>
<td>34</td>
<td>3</td>
<td>122</td>
<td>72</td>
<td>21</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>24</td>
<td>30</td>
<td>3</td>
<td>102</td>
<td>24</td>
<td>N/A&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Methow</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>N/A&lt;sup&gt;5&lt;/sup&gt;</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Wells</td>
<td>63</td>
<td>8</td>
<td>(not reported)</td>
<td>108</td>
<td>69</td>
<td>4</td>
</tr>
<tr>
<td>Priest Rapids/Ringold Springs</td>
<td>0&lt;sup&gt;6&lt;/sup&gt;</td>
<td>(not reported)</td>
<td>N/A&lt;sup&gt;5&lt;/sup&gt;</td>
<td>0&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0&lt;sup&gt;6&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

1 Source: (Hillman et al. 2017b)
2 Source: (Richards and Pearsons 2015)
3 Source: (Snow et al. 2016)
4 Chelan Falls numbers include data from when the program released fish from Turtle Rock facility (located on the Columbia River). Strays into the Chelan River were from releases from the Turtle Rock facility and not the Chelan Falls Acclimation Facility.
5 These are target areas for the programs, and hatchery-origin fish from the respective programs are intended to spawn naturally. Thus, any hatchery-origin fish from the respective programs would not be considered a stray in these target areas.
6 While no Priest Rapids or Ringold Springs fall Chinook salmon have been detected in these basins, the actual number of Priest Rapids or Ringold Springs hatchery fish straying into these basins may be higher than noted because the number of these strays into these tributaries is undeterminable unless one of the few PIT-tagged or CTW-tagged adults enters and is encountered or detected in the tributaries.

Spawning site competition and redd superimposition are possible ecological effects between spring Chinook salmon and hatchery-origin summer/fall Chinook salmon. The potential effects of spawning site competition could occur in September when spawning timing of UCR spring and summer/fall Chinook salmon runs could briefly overlap (Table 43). However, the likelihood of spatial overlap is minimal because spring Chinook salmon tend to spawn farther upstream than summer/fall Chinook salmon (e.g., Snow et al. (2016), Hillman et al. (2016)).

Even though summer/fall and spring Chinook salmon may overlap spatially in some tributary mainstems, the likelihood of redd superimposition appears to be low even in target areas, based
on patterns observed in the Wenatchee River, which is a target area for the Wenatchee summer/fall Chinook salmon program. In the Wenatchee River, redd superimposition of spring Chinook salmon reds by summer/fall Chinook salmon were observed to be very limited, typically 2 or 3 per year (Willard 2017), compared to the average of 48 spring Chinook salmon reds observed in the mainstem Wenatchee River (Hillman et al. 2016). Because this tributary is a spawning ground for both natural-origin and hatchery-origin summer/fall Chinook salmon, only a subset of the observed redd superimposition is a result of redd superimposition by the hatchery-origin fish from the Wenatchee summer/fall Chinook salmon program. We expect to see similar level of redd superimposition in the Methow River. We, therefore, conclude that the likelihood of redd superimposition on UCR spring Chinook salmon by hatchery-origin summer/fall Chinook salmon is low, and the adverse effects, therefore, minimal.

Spawning site competition and redd superimposition by the hatchery-origin fish could occur when there is a spatial overlap between two species. Spawning site competition and redd superimposition are not likely to occur between spring Chinook salmon and fall Chinook salmon because the distributions do not overlap. Fall Chinook salmon spawn primarily in the mainstem Columbia River and the extreme downstream reaches of the tributary mainstems, while spring Chinook salmon spawn primarily in the upper tributaries and upper reaches of the mainstem of the Wenatchee, Entiat, and Methow Rivers, so there is virtually no overlap between fall and spring Chinook salmon in space. Thus, spawning site competition and redd superimposition are not likely to occur between spring Chinook salmon and fall Chinook salmon.

Spawning site competition and redd superimposition by summer/fall and fall Chinook salmon as a result of the proposed action are not likely to affect steelhead because steelhead spawning and emergence occur before summer/fall and fall Chinook salmon spawn.

Because the average numbers of strays into other basins are small and because the likelihood of competition or redd superimposition is minimal to none, the strays from these hatchery programs are unlikely to have any detectable ecological effects on any of the naturally spawning ESA-listed species.

Hatchery fish contributes marine-derived nutrients to the ecosystem in the Upper Columbia River. Two of the six programs do not intend for returning adults to spawn naturally. The four programs that do intend for hatchery-origin adults to spawn naturally contribute about 428 kg of phosphorous to the UCR Basin annually (Table 45), which is approximately 22% of the phosphorus input in the Action Area (Table 10).

Table 45. Total phosphorous imported by adult returns from the proposed hatchery programs based on the equation, mean adult mass and phosphorous concentration in Scheuerell et al.

<table>
<thead>
<tr>
<th>Program</th>
<th>Subbasin Location</th>
<th>Total Escapement</th>
<th>pHOS</th>
<th>Number of Hatchery-origin Adults</th>
<th>Average adult mass (kg)</th>
<th>Concentration of phosphorous (kg/adult)</th>
<th>Phosphorous imported (kg/year) From hatchery-origin adults (only)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wenatchee</td>
<td>Wenatchee</td>
<td>9,100</td>
<td>0.14</td>
<td>1,274</td>
<td>6.75</td>
<td>0.0038</td>
<td>32.68</td>
<td>233.42</td>
</tr>
<tr>
<td>Methow</td>
<td>Methow</td>
<td>1,913</td>
<td>0.33</td>
<td>631</td>
<td>6.75</td>
<td>0.0038</td>
<td>16.19</td>
<td>49.07</td>
</tr>
<tr>
<td>Chelan Falls</td>
<td>Chelan</td>
<td>821</td>
<td>0.59</td>
<td>484</td>
<td>6.75</td>
<td>0.0038</td>
<td>12.42</td>
<td>21.06</td>
</tr>
<tr>
<td>Wells</td>
<td>Multiple</td>
<td>No information</td>
<td>No information</td>
<td>4,388</td>
<td>6.75</td>
<td>0.0038</td>
<td>112.55</td>
<td></td>
</tr>
<tr>
<td>Priest Rapids/Ringold Springs</td>
<td>Hanford Reach (Columbia River mainstem)</td>
<td>65,518</td>
<td>0.151</td>
<td>9,893</td>
<td>6.75</td>
<td>0.0038</td>
<td>253.76</td>
<td>1,680.54</td>
</tr>
</tbody>
</table>

| Total | 427.60 | 1,984.08 |

1 The number of hatchery-origin adults are determined by multiplying total escapement numbers by pHOS.
2 Source: Cederholm et al. (2000).
3 Source: Scheuerell et al. (2005).
4 These numbers are determined by multiplying together the number of hatchery-origin adults, average adult mass, and concentration of phosphorus.
5 These numbers are determined by multiplying together the number of total escapement, average adult mass, and concentration of phosphorus.
6 The number of hatchery fish is based on average number of returns per release life history (sub-yearling or yearling) added together from (Snow et al. 2016).
7 Analysis for Priest Rapids and Ringold Springs hatchery programs are combined for this table because the escapement numbers are from the Hanford Reach, which includes both programs.

**Adult Collection Facilities**

**Negligible:** While broodstock collection for these programs target summer/fall or fall Chinook salmon, ESA-listed spring Chinook salmon or steelhead could be encountered incidentally to the broodstock collection; these encountered spring Chinook salmon or steelhead are handled, but do not lead to mortality. Most of the encounters of UCR spring Chinook salmon during broodstock collection for summer/fall Chinook salmon occur concurrently with RM&E associated with the spring Chinook salmon. Collection of fall Chinook salmon, occurring later than the summer/fall collection, does not result in the incidental encounter of UCR spring Chinook salmon because of
the difference in the run-timing. Similarly, broodstock collection for these programs occur concurrently with many steelhead hatchery broodstock collection or sampling programs. Thus, only a small number of spring Chinook salmon and steelhead are expected to be encountered in addition to encounters analyzed in other opinions. Table 46 summarizes where the effects have already been considered in other opinions.

Table 46. Broodstock collection for summer/fall and fall Chinook salmon and associated biological opinions where effects on listed species have been already analyzed.

<table>
<thead>
<tr>
<th>Program</th>
<th>Collection Location</th>
<th>Collection Duration</th>
<th>Spring Chinook Salmon Analysis</th>
<th>Summer Steelhead Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls</td>
<td>Entiat Hatchery</td>
<td>July 1-September 15</td>
<td>NMFS (2013b); NMFS (2017c)</td>
<td>NMFS (2017c)</td>
</tr>
<tr>
<td></td>
<td>Chief Joseph Hatchery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wenatchee</td>
<td>Dryden Dam</td>
<td>July 1-September 15</td>
<td>NMFS (2013a)</td>
<td>NMFS (2016a)</td>
</tr>
<tr>
<td></td>
<td>Tumwater Dam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow</td>
<td>Wells dam</td>
<td>July 1-September 15</td>
<td>NMFS (2016)</td>
<td>NMFS (2017e)</td>
</tr>
<tr>
<td>Wells Hatchery</td>
<td>Wells Hatchery/Dam</td>
<td>July 1-August 28</td>
<td>NMFS (2016)</td>
<td></td>
</tr>
<tr>
<td>Priest Rapids;</td>
<td>Priest Rapids</td>
<td>Mid-September-early December</td>
<td>NA</td>
<td>NMFS (2016a); NMFS (2008c)</td>
</tr>
<tr>
<td>Ringold Springs</td>
<td>Hatchery/Dam; Hanford Reach</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chelan Falls Canal Trap will be used to primarily trap summer/fall Chinook salmon for the Chelan Falls program, with the Entiat Hatchery and Chief Joseph Hatchery being the back-up facilities to provide additional broodstock if needed. The trap will be operated above 21°C, which is a temperature threshold that could start migration blockage (Richter and Kolmes 2005), but the operation of the Chelan Falls Trap above 21°C is likely to be a minimal risk to ESA-listed species because, while UCR spring Chinook salmon and UCR steelhead are potentially present in the area, these species are not likely to be encountered during broodstock trapping operations based on observations from past trap operations. In addition, trapping will cease if an ESA-listed species are encountered in waters above 21°C, pending further consultation with NMFS or the USFWS to determine if continued trap operation poses substantial risk to listed species. Since the start of the Chelan Falls Trap operation in 2016, no steelhead have been encountered at the trap. Some unidentified Chinook salmon have been encountered at the trap (none in 2016 and 10 in 2017) (Willard 2017), but most, if not all, of these fish are likely to be summer/fall Chinook salmon for several reasons. First, the trap has been and will be operated after the spring Chinook salmon run is complete (August 4 in 2016, July 21 in 2017, and after July 15 in future years), so the likelihood of encountering spring Chinook salmon is very low. Second, WDFW errs on the conservative side, and assumes a Chinook salmon to be spring Chinook salmon if it cannot visually be identified as a summer Chinook salmon\(^{11}\); however,

\(^{11}\) WDFW typically relies on morphology and/or coloration to distinguish between spring Chinook salmon and summer/fall Chinook salmon. For example, spring Chinook salmon tend to have stream-lined body, be heavily spotted with greenish yellow hue, while summer/fall Chinook salmon tend to be more robust bodied.
these unidentifiable Chinook salmon are likely to be summer/fall Chinook salmon based on an
evaluation at the Eastbank Hatchery Outfall (for 2015 and 2016), which found that 60 to 86
percent (with 75% probability of positive assignment) of unidentified Chinook salmon at the
Eastbank Hatchery Outfall (collected as part of broodstock collection for their summer/fall
Chinook salmon program) were summer/fall Chinook salmon (Small and Bell 2015; Small and
Bowman 2017). To verify that these Chinook salmon are, in fact, not spring Chinook salmon,
 genetic samples will be collected and analyzed for these unidentified Chinook salmon.

To the extent that the unidentified Chinook salmon are spring Chinook salmon, a wide range of
effects could occur. Because these fish will only be handled for sampling and released, direct
mortality is not likely to occur. Being trapped in a trap, depending on the timing, could delay fish
from getting to the spawning grounds; spring Chinook salmon spawning occurs from early
August to mid-September. Spawning location has been shown to be an important factor in
reproductive success for some spring Chinook salmon populations (Hughes and Murdoch 2017),
but because it appears that most, if not all, spring Chinook salmon have migrated past the Chelan
River at this time (Faulkner et al. 2015), it is not anticipated that trapping could cause spring
Chinook salmon to spawn in sub-optimal habitat. However, fish that die from indirect effects of
trapping will be very low based on the number of encounters (e.g., 10 in 2017). Mortality could
occur if the water temperature is too high, but it is not likely because the summer/fall Chinook
salmon (which have physiological characteristics similar to spring Chinook salmon) that are also
in the trap have not had any health issues (CPUD and WDFW 2017).

For the Priest Rapids and Ringold Springs programs, the broodstock collection can occur at the
volunteer trap at the Priest Rapids Hatchery, at the OLAFT, or through hook-and-line angling in
Hanford Reach. Spring Chinook salmon are not likely to be encountered during these activities.
The steelhead encounters at the OLAFT were analyzed in NMFS (2016a), which found that up to
15% of adult steelhead would be handled with no more than 2% incidental mortality through
RM&E performed by WDFW, of which the operation of OLAFT for broodstock collection for
Priest Rapids Hatchery is a subset. The steelhead encounters during hook-and-line angling were
analyzed in NMFS (2008c), which found that up to 162 adult UCR steelhead may be
encountered with 16 mortalities during the Hanford Reach summer Chinook salmon fishery, of
which the broodstock collection for Priest Rapids Hatchery occurs as a subset.

At the Priest Rapids volunteer trap, three categories of steelhead are encountered: no external
marking, ad-clip only, and ad-clip and right ventricle clip. Of these, fish with no external
marking and fish with ad-clip only could be ESA-listed UCR steelhead. Thus, we focus our
analysis here on them. The volunteer trap encountered 5, 10, and 3 potentially listed steelhead
(based on marking) in 2014, 2015, and 2016, respectively, with no mortality in any year
(Richards 2017). Thus, we expect that the operation of Priest Rapids volunteer trap can
encounter up to 15 adult UCR steelhead with up to 3 mortality, accounting for a year with a good
return and representing a worst-case-scenario level of mortality.

At the Ringold Springs Rearing Facility, steelhead are occasionally handled during broodstock
collection. When they are collected, they are immediately released upstream of the hatchery
discharge channel in the Columbia River, through a new pipe that was recently installed to
replace hauling in a truck, which used to occur (USACE and WDFW 2017). Encounter rates at
the Ringold Facility have been very low; five natural-origin steelhead (visually identified as ad-
present) were encountered in 2010 and three in 2011 (USACE and WDFW 2017), none of which
counters resulted in mortality during handling.

2.5.2.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in
juvenile rearing areas, the migratory corridor, estuary, and ocean

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

Hatchery release competition and predation effects

In reviewing competition and predation effects in the mainstem Columbia River, NMFS used the
PCD Risk model of Pearsons and Busack (2012) PCD Risk, to quantify the potential number of
natural-origin salmon and steelhead juveniles lost to competition and predation from the release
of hatchery-origin juveniles. The original version of the model suffered from operating system
conflicts that prevented completion of model runs and was suspected of also having coding
errors. As a result, the program was modified by Busack in 2017 into a considerably simpler
version to increase supportability and reliability. At present, the program does not include
disease effects and probabilistic output. 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, or growth that likely occurs post-release. Also, the model was designed to
address interference competition associated with territorial interactions; as such, it likely
overestimates the effects of competitive interactions when territories are not formed. Parameter
values used in the model runs are shown in Table 47 - Table 50.

For our model runs, we assumed a 100 percent population overlap between hatchery fish and all
natural-origin species present. Hatchery summer/fall Chinook salmon are released from April-
May whereas hatchery fall Chinook salmon are released anywhere between May-July, with a
large proportion being released in June (all 7,299,504 fall Chinook salmon from Priest Rapids).
These releases may overlap with natural-origin chum, coho, sockeye, spring, and fall Chinook
salmon, and steelhead in the Action Area. However, our analysis is limited to assessing effects
on listed species, and this limits overlap of those species to certain areas. To address this, we
modified residence times for hatchery summer/fall and fall Chinook salmon if they did not
overlap completely with certain natural-origin species, by adjusting the total distance traveled.
For example, Snake River fall Chinook salmon do not inhabit the upper Columbia River (UCR)
above McNary Dam and thus effects on Snake River fall Chinook salmon from hatchery
summer/fall and fall Chinook salmon releases as part of the Proposed Action would not occur
until they comingled in the mainstem Snake River (or below McNary Dam; more detailed calculations can be found in Kondo (2017d)). We believed it was better to address overlap by adjusting residence time than by adjusting population overlap, because the population overlap parameter represents microhabitat overlap not basinwide-scale overlap. We acknowledge that a 100-percent population overlap in microhabitats is likely an overestimation.

The model was run in two segments: from release to McNary Dam, and as an aggregate run from McNary Dam through the estuary. The model run from release to McNary Dam was further broken into three individual runs: (1) release to confluence of UCR (only necessary for two release sites: Wenatchee River at RM 16 and Methow River at RM 37.5, discussed below), (2) mouth of tributaries to McNary Dam, and (3) confluence of Columbia River and Snake River to McNary Dam. The model runs from release to McNary Dam were split into three individual segments based on the different age/species of natural-origin salmon and steelhead likely to be encountered during different stretches of the river. The following explains the caveats regarding each step of this 3-part model run from release to McNary Dam:

1. Release to confluence of tributary and UCR: Three release sites are on tributaries of the mainstem UCR; however, Chelan Falls release site is located at RM 0.25 on the Chelan River. Because the travel time of the Chelan Falls summer/fall Chinook salmon to the mouth of Chelan River would be less than a day, we do not expect the released fish to have meaningful interactions with natural-origin fish during this short stretch. Therefore, this release site was treated as if the fish were direct release on the mainstem UCR. The two release sites that were considered for this part of the model run are for the Wenatchee and Methow summer/fall Chinook salmon yearling programs at RM 16 and 37.5 on the Wenatchee and Methow Rivers, respectively. The following assumptions were made for these model runs:
   • Travel (residence) time was proportional to what the fish’s travel time was from release to McNary Dam (e.g., if the fish took 100 days to travel from release to McNary at a rate of 5 miles/day, that same rate was applied to the distance these fish had to swim from release to the mouth of UCR; see Kondo (2017d) for more details).
   • Survival rate of hatchery fish was assumed to be 100% during these short stretches in the tributary.
   • Temperatures at the release sites were used in model runs.
   • Model runs account for hatchery fish predation and competition effects on natural-origin Chinook salmon ages 0 and 1, and steelhead ages 1 and 2.

2. Mouth of tributaries to McNary Dam: Releases from all programs were analyzed for this stretch because all fish migrate through this area. Chelan Falls (located at RM 0.25 on the Chelan River) included that 0.25 RM in the travel (residence) time calculation. The following assumptions were made for these model runs:
   • Travel (residence) time was proportional to what the fish’s travel time was from release to McNary Dam.
   • Survival rate of hatchery fish was assumed to be the same as the survival from release to McNary Dam, as we are assuming the losses of hatchery fish will take place in the main UCR stretch.
• Temperatures at the release sites were used in model runs.
• Model runs account for hatchery fish predation and competition effects on natural-origin age 1 Chinook salmon and age 2 steelhead because rearing fish (age 0 Chinook salmon and age 1 steelhead) would not be present in the mainstem Columbia River.

3. Confluence of Columbia River and Snake River to McNary Dam: Releases from all programs were analyzed for this stretch because all fish migrate through this area. The segment between the Snake River and McNary Dam is being replicated during this model run (as it was also analyzed in the model run above, see step 2) because different natural-origin species are now present beginning where the Snake River meets the UCR, and from there downstream. This is the most accurate way of accounting for hatchery-origin effects on natural-origin fish that are only present in that specific stretch of the river, rather than assuming certain natural-origin fish are throughout the entire river. The following assumptions were made for these model runs:
  • Travel (residence) time was proportional to what the fish’s travel time was from release to McNary Dam.
  • Hatchery-origin fish numbers for each release site is reduced from the original release number at the release site because we assume that only a percentage of these fish have survived to the mouth of the Snake River (e.g., if a release of 100,000 fish has a 55% survival rate from release to McNary Dam, this model segment would be run with 55% of 100,000 or 55,000 hatchery-origin fish; see Kondo (2017d) for more details).
  • Survival rate of hatchery fish was assumed to be 100% from the confluence of Columbia River and Snake River to McNary Dam, as they were assumed to be reduced in the mainstem of the UCR, before they reach the confluence of the Snake River.
  • Temperatures at McNary Dam forebay were used in model runs.
  • Model runs account for hatchery fish predation and competition effects on natural-origin Chinook salmon age 0 and sockeye salmon age 1 and 2 because these fish commingle with the hatchery-origin fish at the confluence of Columbia River and Snake River; age 2 Snake River steelhead would also join the hatchery-origin fish from confluence of the two rivers, but the effect of these age 2 steelhead were analyzed in the run from the mouth of the tributary to McNary Dam (#2, above).

The aggregate model run from McNary Dam through the estuary further grouped the individual release sites into three groups: summer/fall Chinook salmon yearlings, summer/fall Chinook salmon subyearlings, and fall Chinook salmon subyearlings. Within each group, some hatchery fish parameters were averaged to obtain one value to use for that group. The following assumptions were made for these model runs:
  • Travel (residence) time was proportional to what the fish’s travel time was from release to McNary Dam and averaged by grouping to obtain one travel time per group.
• Survival rate of hatchery fish from McNary Dam to Bonneville Dam was used as proxy by assuming that the survival rate of hatchery fish below Bonneville Dam to the mouth of the Columbia River is 100 percent.

• Hatchery-origin fish numbers for each aggregate group are reduced from the original release number by using the survival rate to McNary Dam.

• Temperatures at McNary Dam forebay were used in model runs.

• Model runs account for hatchery fish predation and competition effects on natural-origin Chinook salmon age 0 and 1, steelhead age 2, chum salmon age 0, sockeye salmon age 1 and 2, and coho salmon age 2.

Table 47. Parameters from the PCD Risk model that are the same across all programs.

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

1 All values from HETT (2014) unless otherwise noted.
2 Daly et al. (2014)
Table 48. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

<table>
<thead>
<tr>
<th>Species</th>
<th>Age Class</th>
<th>Size in mm (SD)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook salmon</td>
<td>0</td>
<td>38 (4)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>98 (4)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td>Steelhead</td>
<td>1</td>
<td>126 (24)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>170 (24)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td>Sockeye salmon</td>
<td>1</td>
<td>86 (7)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>128 (8)</td>
<td>HETT (2014)</td>
</tr>
<tr>
<td>Coho salmon</td>
<td>2</td>
<td>90 (20)</td>
<td>Simpson (2017)</td>
</tr>
<tr>
<td>Chum salmon</td>
<td>0</td>
<td>40 (3)</td>
<td>Hillson et al. (2017)</td>
</tr>
</tbody>
</table>

Table 49. Hatchery fish parameter values for the PCD Risk model run from release of fish to McNary Dam.

<table>
<thead>
<tr>
<th>Program</th>
<th>Release Site</th>
<th>Release Number</th>
<th>Size in mm (SD) at release</th>
<th>Survival Rates to McNary (mean)</th>
<th>Release to UCR mouth (if applicable)</th>
<th>Mouth of trib. to mouth of Snake River</th>
<th>Snake confluence to McNary</th>
<th>Release to McNary</th>
<th>Temp. at release (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls summer/fall Chinook salmon</td>
<td>Chelan River (RM 0.25)</td>
<td>576,000</td>
<td>161 (20)</td>
<td>0.615</td>
<td>n/a*</td>
<td>18.8</td>
<td>3.2</td>
<td>22</td>
<td>9.7</td>
</tr>
<tr>
<td>Methow summer/fall Chinook salmon (yearlings)</td>
<td>Methow River (RM 37.5)</td>
<td>220,000</td>
<td>154 (20)</td>
<td>0.55</td>
<td>3.5</td>
<td>18.7</td>
<td>2.9</td>
<td>25</td>
<td>12.7</td>
</tr>
<tr>
<td>Wells summer/fall Chinook salmon (subyearlings)</td>
<td>Columbia River (RM 515)</td>
<td>484,000</td>
<td>103 (20)</td>
<td>0.35</td>
<td>n/a*</td>
<td>35.3</td>
<td>5.7</td>
<td>41</td>
<td>9.7</td>
</tr>
</tbody>
</table>
Table 50. Hatchery fish parameter values for aggregate runs for the PCD Risk model, starting at McNary Dam and through the estuary.

<table>
<thead>
<tr>
<th>Aggregate Run Group</th>
<th>Program</th>
<th>Number of Hatchery Fish Survived to McNary Dam</th>
<th>Mean sizes in mm (SD)</th>
<th>Survival Rates (mean for McNary to Bonneville&lt;sup&gt;1&lt;/sup&gt;)</th>
<th>Travel (residence) Time (median days)</th>
<th>Temperature (°C) at McNary (mean)&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer/fall Chinook salmon (yearlings)</td>
<td>Chelan Falls summer/fall Chinook salmon (yearlings)</td>
<td>354,240</td>
<td>0.91</td>
<td>30.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wenatchee summer/fall Chinook salmon (yearlings)</td>
<td>423,500</td>
<td>N/A</td>
<td>0.92</td>
<td>24.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methow summer/fall Chinook salmon (yearlings)</td>
<td>121,000</td>
<td>0.87</td>
<td>27.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wells summer/fall Chinook salmon (yearlings)</td>
<td>236,800</td>
<td>0.66</td>
<td>35.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Parameters</td>
<td></td>
<td>1,135,540</td>
<td>163.14 (20)</td>
<td>0.84</td>
<td>29</td>
<td>13.2</td>
</tr>
</tbody>
</table>

<sup>1</sup> Because this release on the Chelan River is a short distance to the Columbia River and we do not expect the released fish to have meaningful interactions with natural-origin fish during this short stretch, we did not analyze the effect from release to the mouth of the Chelan River.

<sup>2</sup> Data from HETT (2014) unless otherwise noted.

<sup>3</sup> Data from [http://www.cbr.washington.edu/dart/query/river_graph_text](http://www.cbr.washington.edu/dart/query/river_graph_text); access date August 16, 2017. 10 year average (2007-2016) of temperature (WQM).
We conducted model runs with natural-origin fish numbers at the point where all possible hatchery-origin fish interactions are exhausted at the end of each day. It is possible that in doing this, we ran the models with natural-origin juvenile abundances that exceed actual numbers available. Using natural-origin juvenile numbers at the point where all possible hatchery-origin fish interactions are exhausted at the end of each day allows us to estimate worst-case impacts on listed natural-origin fish. The exception to this is for sockeye salmon because we have data for natural-origin abundance for the one population that composes the entire ESU that demonstrates that, from 2006-2016, the maximum number of natural-origin sockeye salmon produced was ~61,000. Thus, we used this value in the model along with the actual proportions of each age-class (87 percent age-1, and 13 percent age-2) available (Kozfkay 2017). To ensure the effects due to competition and predation are within our model estimates, we will continue to monitor median travel times from release to McNary Dam on an annual basis (using a 5-year rolling median) compared to the values used in our analyses (see Table 49).

The resulting juveniles lost from release to McNary Dam for all natural-origin species are summarized in Table 51. The resulting juveniles lost from McNary Dam through the estuary are summarized in Table 52. Using the smolt-to-adult survival rate (SAR) representative of each species, these lost juveniles equate to 2,488 Chinook salmon, 517 steelhead, 15 sockeye salmon, 96 chum salmon, and 468 coho salmon adult equivalents (Table 51, Table 52) from release to the mouth of the Columbia River.
Table 51. Maximum numbers of juvenile natural-origin salmon and steelhead lost to predation (P) and competition (C) from hatchery-origin summer/fall and fall Chinook salmon from the Proposed Action for model runs from release to McNary Dam.

<table>
<thead>
<tr>
<th>Program</th>
<th>Release Site</th>
<th>Chinook Salmon</th>
<th>Steelhead</th>
<th>Sockeye Salmon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P4</td>
<td>C5</td>
<td>C5</td>
</tr>
<tr>
<td>Chelan Falls summer/fall Chinook salmon (yearlings)</td>
<td>Chelan River (RM 0.25)</td>
<td>3,216</td>
<td>15,487</td>
<td>2,711</td>
</tr>
<tr>
<td>Wenatchee summer/fall Chinook salmon (yearlings)</td>
<td>Wenatchee River (RM 16)</td>
<td>1,322</td>
<td>6,428</td>
<td>1,363</td>
</tr>
<tr>
<td>Methow summer/fall Chinook salmon (yearlings)</td>
<td>Methow River (RM 37.5)</td>
<td>1,684</td>
<td>9,388</td>
<td>1,444</td>
</tr>
<tr>
<td>Wells summer/fall Chinook salmon (subyearlings)</td>
<td>Columbia River (RM 515)</td>
<td>0</td>
<td>7,486</td>
<td>378</td>
</tr>
<tr>
<td>Wells summer/fall Chinook salmon (yearlings)</td>
<td></td>
<td>2,834</td>
<td>8,105</td>
<td>1,261</td>
</tr>
<tr>
<td>Priest Rapids fall Chinook salmon (subyearlings)</td>
<td>Columbia River (RM 413)</td>
<td>0</td>
<td>169,721</td>
<td>4,279</td>
</tr>
<tr>
<td>Ringold Springs fall Chinook salmon (subyearlings)</td>
<td>Columbia River (RM 352)</td>
<td>0</td>
<td>79,627</td>
<td>1,866</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>305,298</strong></td>
<td><strong>13,302</strong></td>
<td><strong>691</strong></td>
</tr>
<tr>
<td><strong>SAR</strong></td>
<td></td>
<td>0.0037</td>
<td>0.011</td>
<td>0.005</td>
</tr>
<tr>
<td>Adult Equivalents</td>
<td></td>
<td>1,130</td>
<td>146</td>
<td>4</td>
</tr>
</tbody>
</table>

1 The Chinook salmon lost here includes age 0 and age 1 fish from release to the mouth of the respective tributaries, age 1 fish from mouth of the respective tributaries to McNary Dam, and age 0 Snake River Chinook salmon from the confluence of the Columbia River and Snake River to McNary Dam.

2 The steelhead lost here includes age 1 and 2 fish from release to the mouth of the respective tributaries and age 2 fish from mouth of the respective tributaries to McNary Dam.

3 The sockeye salmon lost here includes age 1 and 2 fish from the confluence of the Columbia River and Snake River to McNary Dam because there are no listed species of sockeye salmon in UCR.

4 Predation values only shown for Chinook salmon interactions because no predation occurs on steelhead or sockeye salmon from Chinook salmon (HETT 2014).

5 Competition, as used here, is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values.

6 SAR for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016), steelhead (NMFS 2017e), and sockeye (IDFG 2012).
Recent travel time information from the applicants (GPUD 2017) suggests that our assumption of 100% population overlap between hatchery-origin fish and natural-origin Chinook yearlings above McNary Dam may be a substantial overestimate; it is possible that overlap may be as low as 5% for fish released from the Priest Rapids fall Chinook program above McNary Dam (GPUD, DPUD, CPUD, personal communication, December 20, 2017). Using 5% as the population overlap parameter in the model would yield in having 33,328 juvenile ESA-listed and non-listed Chinook salmon lost to competition above McNary Dam, compared to the 169,721 juveniles lost under the 100% population overlap scenario. While the information provided by the operators is still under review, it is likely that it is much closer to reality than our earlier assumption. NMFS plans to continue refining model parameters to better assess ecological effects in the future.
Table 52. Maximum numbers of juvenile natural-origin salmon and steelhead lost to predation (P) and competition (C) with hatchery-origin summer/fall and fall Chinook salmon from the Proposed Action for aggregate model runs from McNary Dam through the estuary.

<table>
<thead>
<tr>
<th>Aggregate Group</th>
<th>Program(s) in Group</th>
<th>Chinook salmon$^1$</th>
<th>Steelhead$^2$</th>
<th>Sockeye salmon$^3$</th>
<th>Chum salmon$^4$</th>
<th>Coho salmon$^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P$^6$</td>
<td>C$^7$</td>
<td>C$^7$</td>
<td>C$^7$</td>
<td>P$^6$</td>
</tr>
<tr>
<td>Summer/fall Chinook yearling salmon</td>
<td>Chelan Falls, Wenatchee, Methow, Wells</td>
<td>31,591</td>
<td>34,535</td>
<td>11,965</td>
<td>767</td>
<td>10,247</td>
</tr>
<tr>
<td>Summer/fall Chinook subyearling salmon</td>
<td>Wells</td>
<td>0</td>
<td>6,531</td>
<td>240</td>
<td>627</td>
<td>N/A$^8$</td>
</tr>
<tr>
<td>Fall Chinook subyearling salmon</td>
<td>Priest Rapids, Ringold Springs</td>
<td>0</td>
<td>258,472</td>
<td>9,590</td>
<td>781</td>
<td>N/A$^8$</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>331,129</td>
<td>21,795</td>
<td>2,175</td>
<td>27,678</td>
<td>24,744</td>
</tr>
<tr>
<td>SAR$^9$</td>
<td></td>
<td>0.0041</td>
<td>0.017</td>
<td>0.005</td>
<td>0.0039</td>
<td>0.0189</td>
</tr>
<tr>
<td>Adult Equivalents</td>
<td></td>
<td>1,358</td>
<td>371</td>
<td>11</td>
<td>96</td>
<td>468</td>
</tr>
</tbody>
</table>

$^1$ The Chinook salmon lost here includes age 0 and age 1 fish.
$^2$ The steelhead lost here are only age 2 fish.
$^3$ Chum salmon lost here are only age 0 fish.
$^4$ The sockeye salmon lost here includes age 1 and age 2 fish.
$^5$ The coho salmon lost here are age 2 fish.
$^6$ Predation values only shown for Chinook salmon and chum salmon interactions with Chinook salmon because no predation occurs on steelhead and sockeye salmon from Chinook salmon (HETT 2014).
$^7$ Competition, as used here, is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values.
$^8$ Summer/fall and fall Chinook subyearlings are not likely to interact with chum and coho salmon because the chum and coho salmon would already be emigrated out of the freshwater system before the subyearlings reach White Salmon River (where chum and coho salmon would spatially overlap with the hatchery releases).
$^9$ Smolt-to-adult survival rate for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016; NMFS 2017f; NMFS 2017g), steelhead (average of: NMFS 2017e; NMFS 2017f; NMFS 2017g), sockeye (IDFG 2012), chum (Hillson 2015), and coho salmon (ODFW 2011).
Table 52 summarizes the likely number of adults that would be lost from each ESU between McNary Dam through the estuary. While these numbers represent the maximum potential effect from the proposed action, these ecological interactions also occur between natural-origin species; thus, the effects attributable to the proposed action is only that portion that exceeds the natural level of ecological interactions. Because the Chinook salmon lost to ecological effects between release and the estuary includes both listed and non-listed fish, only a portion of the lost adult Chinook salmon equivalents are likely to be listed. However, our analysis assumes that all Chinook salmon lost are listed in order to represent an absolute maximum total (and in the absence of more precise data). In addition, the SAR for subyearlings tend to be lower than for yearlings, so adult equivalents for subyearlings may also be lower than what is noted in Table 52. We also assume that the effects on each population within each ESU is proportional to their ESU composition. For example if a single population represents 5 percent of the natural-origin adults, then the loss our model predicts would be some percentage of the 5 percent contribution of that population to the ESU.

While we assume in our analysis that the fish would continue to travel at the same rate below McNary Dam as the rate from release to McNary Dam, this assumption likely overestimates the effect these fish would have on natural-origin fish below McNary Dam because these hatchery-origin fish are likely to be traveling quicker as they get closer to the mouth of the Columbia River. For illustrative purposes, we also ran the model for effects on natural-origin Chinook salmon between McNary Dam through the estuary using the travel rate of yearling (7 days) and subyearling Chinook salmon (8 days) from McMichael et al. (2010) and from G.A. et al. (2011). For this model run, we assume that the summer/fall and fall Chinook subyearlings have the same travel rate below McNary Dam. The results are compared below in Table 53, which summarizes the effect on listed and non-listed Chinook salmon juveniles.

Table 53. Comparison of results based on different travel times.

<table>
<thead>
<tr>
<th>Aggregate Group</th>
<th>Program(s) in Group</th>
<th>Chinook salmon from Table 53</th>
<th>Chinook salmon from quicker travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Summer/fall Chinook yearling salmon</td>
<td>Chelan Falls, Wenatchee, Methow, Wells</td>
<td>31,591</td>
<td>34,535</td>
</tr>
<tr>
<td>Summer/fall Chinook subyearling salmon</td>
<td>Wells</td>
<td>0</td>
<td>6,531</td>
</tr>
<tr>
<td>Fall Chinook subyearling salmon</td>
<td>Priest Rapids, Ringold Springs</td>
<td>0</td>
<td>258,472</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>331,129</td>
<td>63,311</td>
</tr>
<tr>
<td>SAR(^1)</td>
<td></td>
<td>0.0041</td>
<td>0.0041</td>
</tr>
<tr>
<td>Adult Equivalents</td>
<td></td>
<td>1,358</td>
<td>260</td>
</tr>
</tbody>
</table>

\(^1\) Smolt-to-adult survival rate for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016; NMFS 2017f; NMFS 2017g).

To understand the potential effect on each Chinook ESU, we calculated the likely number of adults that would be lost from each ESU between release to McNary Dam (Table 54) using the
percent of listed wild yearlings (96) and subyearlings (4), and proportion of each attributable to each listed ESU at McNary Dam (taking the average of values from 2012 through 2016; Table 7a of: Zabel 2013; Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2017). We then applied a similar methodology at Tongue Point (i.e., mouth of the Columbia River) for the reach from McNary Dam to the Columbia River mouth, where 27 percent of listed Chinook salmon are likely to be yearlings, while 73 percent of listed Chinook salmon are likely to be subyearlings, to be able to estimate ESU level loss (taking the average of values from 2012 through 2016; Table 7a of: Zabel 2013; Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2017). In addition, we applied the ratio of UCR spring Chinook salmon returns compared to the UCR summer/fall Chinook salmon returns (0.24) in order to calculate the UCR spring Chinook salmon adult equivalent for each segment of the run (781 and 18, respectively) to better estimate the effect on UCR Spring Chinook Salmon ESU. Effects on all ESUs are less than 4 percent, a relatively small amount of loss. The ESU with the largest proportional effect was the UCR Spring Chinook Salmon ESU (3.8 percent loss). However, it is important to remember that this also includes some unlisted subyearling Chinook salmon from the UCR, and our ESU proportion estimates do not account for some unlisted fish. Thus, we believe effects on Chinook salmon abundance and productivity due to ecological interactions with outmigrating hatchery juveniles are negative, and would be divided proportionally among the extant populations within each ESU.

All 517 adult steelhead lost to ecological effects from release through the estuary are listed fish. Our analysis shows that loss of steelhead adult equivalents due to ecological effects with outmigrating juvenile hatchery fish is less than 1.5 percent for each listed DPS. Thus, we believe this to be a small negative effect on DPS abundance and productivity, which would be divided proportionally among the extant populations within each DPS.

The 15 adult sockeye salmon lost to these ecological effects are from the Snake River sockeye ESU. This loss equates to a one percent loss from the ESU; a small negative effect on ESU abundance and productivity.

For both chum and coho salmon, there is only a single ESU in the Columbia River Basin (i.e., Columbia River Chum Salmon ESU and Lower Columbia River Coho Salmon ESU). The percentages of chum and coho salmon adult equivalents lost to ecological interactions ae less than one percent, and we assume would be divided proportionally among the 17 chum and 24 coho salmon populations within the ESUs.
Table 54. Maximum total ESA-listed natural-origin adult equivalents lost through competition and predation with juvenile hatchery fish by ESU/DPS compared to returning adults of respective ESU/DPS.

<table>
<thead>
<tr>
<th>Listed Species (ESU/DPS)</th>
<th>Percent Yearlings at McNary Dam</th>
<th>Yearling AE from Release to McNary Dam</th>
<th>Percent Subyearlings at McNary Dam</th>
<th>Subyearling AE from Release to McNary Dam</th>
<th>Percent Yearlings at Tongue Point</th>
<th>Yearling AE from McNary Dam to Tongue Point</th>
<th>Percent Subyearlings at Tongue Point</th>
<th>Subyearling AE from McNary Dam to Tongue Point</th>
<th>Total Lost EAs</th>
<th>Total Adults at Mouth of Columbia River</th>
<th>Percentage of Lost Adults to Total Adults at Mouth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snake River Spring/Summer Chinook Salmon ESU</td>
<td>28</td>
<td>651</td>
<td>0</td>
<td>0</td>
<td>26</td>
<td>95</td>
<td>0</td>
<td>0</td>
<td>746</td>
<td>32,8233</td>
<td>2.3</td>
</tr>
<tr>
<td>Snake River Fall Chinook Salmon ESU</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>45</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>40</td>
<td>85</td>
<td>23,1984</td>
<td>0.4</td>
</tr>
<tr>
<td>UCR Spring Chinook Salmon ESU</td>
<td>72</td>
<td>1871</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>42</td>
<td>0</td>
<td>0</td>
<td>191</td>
<td>5,0645</td>
<td>3.8</td>
</tr>
<tr>
<td>Lower Columbia River Chinook Salmon ESU</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>121</td>
<td>96</td>
<td>951</td>
<td>1,072</td>
<td>38,4646</td>
<td>2.8</td>
</tr>
<tr>
<td>Upper Willamette River Spring Chinook Salmon ESU</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>36</td>
<td>132</td>
<td>0</td>
<td>0</td>
<td>132</td>
<td>9,3567</td>
<td>1.4</td>
</tr>
<tr>
<td>Total Chinook Salmon</td>
<td>100</td>
<td>1085</td>
<td>100</td>
<td>45</td>
<td>100</td>
<td>367</td>
<td>100</td>
<td>991</td>
<td>2488</td>
<td>141,728</td>
<td>1.8</td>
</tr>
<tr>
<td>Steelhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snake River Steelhead DPS</td>
<td>11</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>47</td>
<td>174</td>
<td>0</td>
<td>0</td>
<td>189</td>
<td>54,4148</td>
<td>0.3</td>
</tr>
<tr>
<td>UCR Steelhead DPS</td>
<td>45</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>88</td>
<td>6,9298</td>
<td>1.3</td>
</tr>
<tr>
<td>Middle Columbia Steelhead DPS</td>
<td>42</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>132</td>
<td>22,3008</td>
<td>0.6</td>
</tr>
<tr>
<td>Lower Columbia River Steelhead DPS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>70</td>
<td>0</td>
<td>0</td>
<td>70</td>
<td>22,0318</td>
<td>0.3</td>
</tr>
</tbody>
</table>

101
<table>
<thead>
<tr>
<th></th>
<th>Upper Willamette River Steelhead DPS</th>
<th>Snake River Sockeye Salmon ESU</th>
<th>Columbia River Chum Salmon ESU</th>
<th>Lower Columbia River Coho Salmon ESU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 0 0 0 9 33 0 0 10,159 0.3</td>
<td>100 4 0 0 100 11 0 0 15 1,623 0.9</td>
<td>0 0 0 0 0 0 100 96 96 18,498 0.5</td>
<td>0 0 0 0 100 468 0 0 468 267,060 0.2</td>
</tr>
</tbody>
</table>

1 We accounted for effects on the listed UCR Spring Chinook Salmon ESU from our model by applying the total Chinook adult equivalents to McNary from the UCR by the ratio of UCR spring Chinook salmon to UCR River summer Chinook salmon. This was calculated by summing the average total return (hatchery and natural) of UCR spring Chinook salmon (Table 8 of ODFW and WDFW 2016) and the total return of summer Chinook salmon (Table 10 of ODFW and WDFW 2016) from 2011-2015, and then dividing the total UCR spring Chinook return into this sum. We then applied this average proportion (0.24) of UCR spring Chinook to the total number of UCR Chinook salmon adult equivalents estimated to be lost from our model analysis (781).

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

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

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

5 This number was obtained by taking the average number of wild adult returns to the Columbia River from 2011 to 2015 from Table 8 of ODFW and WDFW (2016). This number was obtained by taking the average of the sum of the estimated number of Lower Columbia River fall bright Chinook salmon, fall tule Chinook salmon, and spring/summer Chinook salmon for 2011 to 2015. The fall bright Chinook salmon numbers were obtained by summing the total natural spawner abundance estimates of each population from Tables 2.1.12 through 2.1.14 of TAC (2017) from 2011 to 2015. Then, we accounted for harvest impacts using LRH impact numbers of sport and commercial fisheries from the respective (Table 9 of TAC 2012; Table 12 of TAC 2013; Table 16 of TAC 2014; Table 17 of TAC 2015; Table 18 of TAC 2016). The fall tule Chinook salmon numbers were obtained from Table 4 of WDFW and ODFW (2017) by using the 2011 to 2015 actual return numbers for the Lower River Wild stock. The spring/summer Chinook salmon numbers were obtained by summing the total natural spawner abundance estimates of each population from Tables 2.1.10 and 2.1.11 of TAC (2017) from 2011 to 2015. Then, we accounted for harvest impacts using the total impact of the Upper Willamette River spring-run Chinook salmon fishery from the respective years (Table 88 of NMFS 2017d) as a surrogate.

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

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

8 To obtain these numbers, we summed the total wild summer steelhead returns (Table 6 of WDFW and ODFW 2017) and total wild winter steelhead returns (Table 11 of ODFW and WDFW 2016) for 2011 to 2015, then applied the proportions of DPS obtained from Zabel (2013); Zabel (2014a); Zabel (2014b); Zabel (2015); Zabel (2017), described above.
Another effect on natural-origin fish can result from released fish that residualize in a tributary. Residual hatchery fish are those fish that do not emigrate following release from the hatchery. These fish have the potential to compete with and prey on natural-origin juvenile fish for a longer period of time relative to migrants. Residuals are not explicitly accounted for in our model at this time. The ecological impacts of hatchery fish residualizing are likely to occur in the tributaries, where natural-origin fish are rearing because residual fish would compete with or prey on rearing fish. Conversely, residuals from programs that release into mainstem Columbia River (i.e., Wells Hatchery summer/fall Chinook salmon, Priest Rapids fall Chinook salmon, and Ringold Springs fall Chinook salmon programs) would not be expected to have any effect if they stay in mainstem Columbia River; however, if they migrate to a tributary, they could also have ecological effects on natural-origin fish. Because natural-origin summer/fall Chinook salmon migrate as subyearlings migrate out as subyearlings, the risk that subyearlings released through these hatchery programs remain to residualize and affect ESA-listed species is negligible.

For the proposed yearling programs, residual hatchery fish are likely to occur in proportions larger than found in natural populations when the hatchery fish mature early (i.e., precocial maturation). Harstad et al. (2017) examined the precocial maturation rate of the Chelan Falls, Wenatchee (Dryden) and Methow (Carlton) yearling summer/fall Chinook salmon programs. This study showed that the Chelan Falls program had an average of 19.1% minijack rates (early male maturation rate) between 2007 and 2008, the Wenatchee program had an average of 17.3% minijack rates between 2006 and 2009, and the Methow program had an average of 33.5% minijack rates between 2006 and 2009. Another assessment was made in 2016 for these programs that showed that the Chelan Falls summer/fall Chinook salmon, Wenatchee summer/fall Chinook salmon, and Methow summer/fall Chinook salmon programs had 6.2 percent, 3.1 percent, and 10.1 percent male maturation rates, respectively (USFWS 2016).

Because hatchery practices have changed to minimize early maturation, it is likely that the precocial maturation rate of current practices are within the range of 6.2-19.1% for the Chelan Falls program, 3.1-17.3% for the Wenatchee program, and 10.1-33.5% for the Methow program. There is no information available for the Wells program.

Because residuals are likely to occur as a subset of early mature fish, only a subset, if any, of these hatchery fish would have residualized, though the extent is unknown. In addition, residuals that linger around the release site may not encounter listed juvenile fish if the natural-origin juvenile rearing occurs higher in the tributary than the release site. While females were not sampled during this assessment, IDFG (2003) found that only a few females, if any, were found to be precocially mature. NMFS recommends expanding this metric to include female samples in the calculation; thus, the maximum average observed male maturation rate of 33%, combined with only a few to no females maturation rates would equate to about a 15 percent potential residualism rate.

Applicants have proposed actions, which are expected to minimize their ecological impacts, and continue to improve their hatchery rearing practice to minimize early maturation. For example, cold water is used, when available, to minimize rapid fish growth that tends to contribute to early maturation. Some facilities also use circular tanks that allows more control over fish growth than straight raceways because the vessels have higher flows than traditional raceways that allows the fish to “exercise”, resulting in lower fat content of fish which results in lower rates of precocious maturation.
Naturally-produced progeny competition

Naturally spawning hatchery-origin summer/fall and fall Chinook salmon are likely to be less efficient at reproduction than their natural-origin counterparts (Christie et al. 2014), but the progeny of such hatchery-origin spawners are likely to make up a sizable portion of the juvenile fish population. This is actually a desired result of the integrated recovery programs. Therefore, added production could result in a density-dependent response of decreasing growth/mortality, earlier migration due to high densities, and potential exceedance of habitat capacity. However, ecological impacts on listed species may increase in the future if the summer/fall or fall Chinook salmon populations grow.

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

Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these hatchery programs. This is because no detections of exotic pathogens have occurred in the last three years and epidemics have all been caused by endemic pathogens with available treatments (Table 55). Diseases that could be caused by pathogens outlined in Table 55 were treated accordingly (e.g., medicated feed, formalin) (WDFW 2017b).

Table 55. Pathogens detections in summer/fall or fall Chinook salmon reared for the proposed programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Pathogen Detected</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priest Rapids Fall Chinook</td>
<td><em>Not Available</em></td>
<td></td>
<td><em>Flavobacterium columnare</em></td>
<td>None</td>
</tr>
<tr>
<td>Ringold Fall Chinook</td>
<td><em>Not Available</em></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Wenatchee Summer Chinook</td>
<td><em>Fungus</em>; <em>Flavobacterium psychrophilum</em></td>
<td></td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Wells Summer Chinook</td>
<td><em>Ichthyophthirius multifilis</em></td>
<td><em>Flavobacterium psychrophilum</em></td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
Furthermore, to prevent outbreaks and reduce the amplification of IHNV in natural environments, hatchery staff drain the coelomic fluid from females during spawning and treat eggs with an iodophor solution, controlling, to some extent, the transmission of IHNV (IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989). Because of these preventative measures, no epidemics of IHNV associated with these programs have occurred in recent years. Thus, NMFS believes the risk of pathogen transmission to wild fish from hatchery fish and amplification of pathogens in the natural environment is low.

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

NMFS has already evaluated the effects of a large portion of the research, monitoring and evaluation (RM&E) for the summer/fall and fall Chinook salmon programs during consultations for upper Columbia River spring Chinook salmon and steelhead programs (NMFS 2015a; NMFS 2016a; NMFS 2016). This is because RM&E for the summer/fall and fall Chinook salmon programs is conducted opportunistically with hatchery programs that rear listed species. Thus, our analysis here focuses only on those programs that specifically conduct RM&E on summer/fall Chinook salmon as outlined in Table 56 and concludes that ESA-listed species are not likely to be affected, as discussed below.

Table 56. RM&E associated with the hatchery programs in the Proposed Action.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Species</th>
<th>Program</th>
<th>Collection Site</th>
<th>Timing</th>
<th>Previously Evaluated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt Traps</td>
<td>Summer/fall Chinook salmon</td>
<td>Wenatchee; Methow</td>
<td>Methow trap; Twisp trap; Low Wen trap; Chiwawa trap</td>
<td>Feb-Dec (Methow); Mar-Nov (Twisp); Feb-Oct (Low Wen); Mar-Nov (Chiwawa)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wells; Chelan Falls</td>
<td>No sampling</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Fall Chinook salmon</td>
<td>Priest Rapids</td>
<td>No sampling</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ringold Springs</td>
<td>No sampling</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Spawning/Carcass Surveys</td>
<td>Summer/fall Chinook salmon</td>
<td>Wenatchee; Methow; Chelan Falls</td>
<td>Wenatchee; Methow and Chelan Rivers</td>
<td>Sep-Nov</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wells</td>
<td>No sampling</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Many RM&E activities do not affect any ESA-listed species. Any tagging or clipping for these programs occur on summer/fall and fall Chinook salmon, which are not listed species in the UCR Basin. Also, no adult listed spring Chinook salmon are likely to be present when the spawning and carcass surveys occur for these programs. Even if some listed species are present during these activities (e.g., steelhead, rearing juveniles), the typical response of fish to spawning and carcass survey is within the range of normal behaviors (i.e., startling response to a predator) and would not adversely affect listed species.

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

Best available information indicates that the most hatchery facility operations have no effect on ESA-listed species, while the intake pipe at the Priest Rapids Hatchery may have negligible effects on Upper Columbia River spring Chinook salmon and steelhead. As described below, we assume that a maximum of 0.5 percent of outmigrating juvenile Upper Columbia River spring Chinook salmon and steelhead are entrained into the Priest Rapids Hatchery. The analysis here focuses on the effects on Upper Columbia River spring Chinook salmon and steelhead because other ESA-listed species are not present in areas where hatchery facility operations could cause an effect.

Table 57. Program facility and water use

<table>
<thead>
<tr>
<th>Program</th>
<th>Facility</th>
<th>Surface Water (cfs)</th>
<th>Ground Water (cfs)</th>
<th>Water Source</th>
<th>Water Diversion Distance</th>
<th>Discharge Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Summer/Fall Chinook Program</td>
<td>Eastbank Hatchery¹</td>
<td>0</td>
<td>55</td>
<td>Eastbank Aquifer</td>
<td>NA</td>
<td>Columbia River</td>
</tr>
<tr>
<td></td>
<td>Chelan Falls Acclimation Facility</td>
<td>24</td>
<td>0</td>
<td>Chelan River</td>
<td>290 ft.</td>
<td>Chelan River</td>
</tr>
<tr>
<td>Wenatchee Summer/Fall Chinook Salmon²</td>
<td>Dryden Pond</td>
<td>32.2</td>
<td>0</td>
<td>Wenatchee River</td>
<td>135 ft.</td>
<td>Wenatchee River</td>
</tr>
<tr>
<td>Methow Summer/Fall Chinook Salmon²</td>
<td>Carlton Acclimation Pond</td>
<td>7.5 total</td>
<td></td>
<td>Methow River</td>
<td>200 ft.</td>
<td>Methow River</td>
</tr>
<tr>
<td>Wells Hatchery Summer/Fall Chinook Salmon³</td>
<td>Wells Hatchery³</td>
<td>150</td>
<td>38</td>
<td>Columbia River</td>
<td>~650 ft.</td>
<td>Columbia River</td>
</tr>
<tr>
<td>Priest Rapids Fall Chinook Program</td>
<td>Priest Rapids Hatchery</td>
<td>102</td>
<td>14</td>
<td>Columbia River</td>
<td>2.2 RM</td>
<td>Columbia River</td>
</tr>
<tr>
<td>Ringold Springs Hatchery Fall Chinook Salmon⁴</td>
<td>Ringold Springs Rearing Facility</td>
<td>70</td>
<td>0</td>
<td>Ringold Springs</td>
<td>NA (out of anadromy)</td>
<td>Columbia River</td>
</tr>
</tbody>
</table>

¹ The operation of Eastbank Hatchery was analyzed in NMFS (2016a).
² These programs also use Eastbank Hatchery for early rearing, which was analyzed in NMFS (2016a).
³ The operation of Wells Hatchery was analyzed in NMFS (2017e).
This program also uses Bonneville Hatchery for early rearing. The operation of Bonneville Hatchery was analyzed in NMFS (2017d).

As described in Table 57, the operation of some facilities have been analyzed in previous consultations (NMFS 2016a; NMFS 2017d; NMFS 2017e). In addition, because Ringold Springs fall Chinook salmon program does not withdraw water from anadromous water (i.e., ditches designed to collect rain water, which do not allow natural-origin salmonid passage, are the source of the hatchery water), there is no effect on ESA-listed salmonids as a result of withdrawing water into the Ringold Springs Rearing Facility. Thus, we focus our analysis here on the operation of Chelan Falls Acclimation Facility, Dryden Pond, Carlton Acclimation Pond, and the Priest Rapids Hatchery, as well as the discharge from the Ringold Springs Rearing Facility.

All of these facilities are appropriately screened and in compliance with NMFS criteria for their intake pipes (Table 5) and are not likely to adversely affect ESA-listed salmonids through impingement or entrainment, with the exception of the Priest Rapids Hatchery. The Priest Rapids Hatchery has an intake screen that is not compliant with the NMFS screening criteria, though Grant PUD (as the owner of the facility) has a plan to replace it to meet the NMFS screening criteria (PUD 2009).

Currently, there are no good estimates of how many ESA-listed fish get entrained (if at all) into the intake pipe at the Priest Rapids Hatchery. Thus, we will use the proportion of water intake compared to the stream flow to estimate the proportion of fish that may get entrained as the fish migrate downstream past the intake. While this estimate relies on many assumptions that are not likely to reflect the reality, it is the best available information we have. Because Upper Columbia River spring Chinook salmon and steelhead outmigrate from March through June, we focus our analysis on flows between March and June. The lowest flow and the average flow between March 1 and June 30 of 2013-2017 was 20.6 kilo-cubic-feet-per-second (kcf) on April 2, 2013, and 2014 and 202 kcf, respectively (Kondo 2017a; Kondo 2017b), while the hatchery would, at most, withdraw 102 cfs during this time. Using the average instream flow, the proportion of the hatchery intake compared to the instream flow is 0.05 percent (102 divided by 202,000). The proportion of the hatchery intake compared to the minimum instream flow is 0.5 percent (102 divided by 20,600). Therefore, we expect that 0.5 percent of outmigrating juvenile spring Chinook salmon and steelhead are entrained into the Priest Rapids Hatchery as the maximum proportion.

These hatchery facilities also withdraw water from the river, which could affect Upper Columbia River spring Chinook salmon or steelhead by reducing the flow. However, the proportion of withdrawal compared to the amount of available instream flow are not at levels that adversely affect any ESA-listed species for the programs described here (Table 58). Chelan Falls Acclimation Facility draws its water from the Chelan Dam tailrace, located on the Chelan River, 12 For example, fish are typically not evenly distributed in the river. The intake pipe is located far from the main flow of the river where migrating juveniles are more likely to be encountered. In addition, Grant PUD has conducted numerous studies examining survival of steelhead, yearling Chinook salmon, and sockeye smolts in this area, including route specific assessments. None of the studies have indicated that smolts pass through, or even near-to, the siphon intake. Further, as there is no documented spawning of listed species in the Priest Rapids Pool, it is unlikely that fry would be present to be pulled into the siphon intake.
so it does not reduce instream flow of Chelan River. In addition, the Chelan Dam tailrace has water exchange or inflow from the Columbia River (the amount fluctuates), water from the powerhouse (amount fluctuates), and from the Chelan River (80 cfs minimum), allowing the tailrace pool to be maintained at approximately 3,857,300 cubic feet; the Chelan Falls Acclimation Facility withdraws water at 24 cfs, which equates to about 2 percent of the tailrace water being withdrawn per hour (24*60*60/3,857,300). Dryden Pond\textsuperscript{13} is likely to reduce at most 3.9 percent of instream flow during March and April for 135 feet (i.e., the facility’s water diversion distance). Similarly, Carlton Acclimation Pond is likely to reduce at most 3 percent of instream flow from October through May for 200 feet. Priest Rapids Hatchery diverts water for a longer distance (2.2 RM), but its water diversion would only withdraw at most 2.9 percent of the flow, with over 3300 cfs of flow remaining in the river (Table 58).

Table 58. Facility water use compared to instream flow

<table>
<thead>
<tr>
<th>Facility</th>
<th>Surface Water Use (cfs)</th>
<th>Period of Use</th>
<th>Water Source</th>
<th>Divergence Distance</th>
<th>Minimum Instream Flow during Water Use (cfs)</th>
<th>Proportion of Withdrawal compared to Instream Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelan Falls Acclimation Facility</td>
<td>24</td>
<td>Nov - April</td>
<td>Chelan River</td>
<td>290 ft.</td>
<td>NA\textsuperscript{1}</td>
<td>NA</td>
</tr>
<tr>
<td>Dryden Pond</td>
<td>32.2</td>
<td>March - April</td>
<td>Wenatchee River</td>
<td>135 ft.</td>
<td>821\textsuperscript{2}</td>
<td>3.9%</td>
</tr>
<tr>
<td>Carlton Acclimation Pond</td>
<td>7.5</td>
<td>Oct - May</td>
<td>Methow River</td>
<td>200 ft.</td>
<td>253\textsuperscript{3}</td>
<td>3.0%</td>
</tr>
<tr>
<td>Priest Rapids Hatchery</td>
<td>102</td>
<td>Sept - June</td>
<td>Columbia River</td>
<td>2.2 RM</td>
<td>3500\textsuperscript{4}</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

\textsuperscript{1} The Chelan Dam tailrace is a pool of water that does not have an instream flow.

\textsuperscript{2} This number was obtained from (USGS 2012), USGS Gage #12459000, by querying the flow between March 1 and April 30 of 2012-2015. This number (821 cfs) is from March 3, 2014.

\textsuperscript{3} This number was obtained from (USGS 2012), USGS Gage #12449500, by querying the flow between March 1 and April 30 of 2012-2015. This number (253 cfs) is from March 2, 2012.

\textsuperscript{4} Kondo (2017c).  

All of the hatchery facilities listed above and the Ringold Springs Rearing Facility are either operated under NPDES permits, or do not need a NPDES permit because rearing levels in the acclimation pond are below permit minimums (Table 5). Facility effluent is monitored to ensure compliance with permit requirements. Though compliance with NPDES permit conditions is not an assurance that effects on ESA-listed salmonids will not occur, the facilities use the water specifically for the purposes of rearing ESA-listed Chinook salmon and steelhead, which have a low mortality during hatchery residence compared to survival in the natural-environment (~70 percent compared to 7 percent (Bradford 1995)). This suggests that the effects of effluent, which is further diluted once discharged, will have a minimal impact on ESA-listed salmonids in the area, as discussed below.

\textsuperscript{13} Dryden Pond withdraws its water from a canal that diverts water from the Wenatchee River, upstream of the Pond. However, this canal is shared with other water users (e.g., irrigators), so the amount of water that enters the canal is not reflective of how much water is used by the operation of Dryden Pond. Therefore, we use the maximum water right that Chelan PUD has for Dryden Pond (i.e., 32.2 cfs) as the amount of water that is taken out of the Wenatchee River as a result of the proposed action.
The total facility discharges proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary, very low or undetectable levels of contaminants. General effects of various biological waste in hatchery effluent are summarized in NMFS (2004a), though the biological waste is not likely to have a detectable effect on listed species because of an abatement pond at Chelan Falls Acclimation Facility and Priest Rapids Hatchery and other features at Dryden Pond, Carlton Acclimation Pond, and Ringold Springs Rearing Facility that reduces the biological waste, as well as the small volume of effluent compared to the stream flow.

Therapeutic chemicals used to control or eliminate pathogens (i.e., formaldehyde, sodium chloride, iodine, potassium permanganate, hydrogen peroxide, antibiotics), can also be present in hatchery effluent. However, these chemicals are not likely to be problematic for ESA-listed species because they are quickly diluted beyond manufacturer’s instructions when added to the total effluent and again after discharge into the recipient water body. Therapeutants are also used periodically, and not constantly during hatchery rearing. In addition, many of them break down quickly in the water and/or are not likely to bioaccumulate in the environment. For example, formaldehyde readily biodegrades within 30 to 40 hours in stagnant waters. Similarly, potassium permanganate would be reduced to compounds of low toxicity within several minutes. Aquatic organisms are also capable of transforming formaldehyde through various metabolic pathways into non-toxic substances, preventing bioaccumulation in organisms (EPA 2015).

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

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

2.6. Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). For the purpose of this analysis, the action area is that part of the Columbia River Basin described in Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline (whether they are Federal, state, tribal or private). This includes the impacts of other hatchery programs in the action area that were included in the environmental baseline (Section 2.4). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future until an opinion for the take permit has been issued.

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

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

The cumulative impacts from these programs contribute to the total impacts from hatcheries in
the entire Columbia River Basin, which is noted in the Mitchell Act Biological Opinion (NMFS
2017a). Between those programs which have already undergone consultation and those for which
consultation is underway, it is likely (though uncertain for ongoing consultations) that the type
and extent of salmon and steelhead hatchery programs and the numbers of fish released in the
Columbia River Basin will change over time. Although adverse effects will continue, these
changes are likely to reduce effects such as competition and predation on natural-origin salmon
and steelhead compared to current levels, especially for those species that are listed under the
ESA. This is because all salmon and steelhead hatchery programs funded and operated by non-
federal agencies and tribes in the Columbia River Basin have 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
- Incorporation of new research results and improved best management practices for
  hatchery operations
- More accurate estimates of natural-origin salmon and steelhead abundance for
  abundance-based fishery management approaches

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 versus cumulative effects. Therefore, all relevant past, present
and future climate-related environmental effects in the action area are described together in the
environmental baseline section.
These potential changes to hatchery operations across the region combined with the proposed action result in a net improvement over current conditions. While the hatchery programs around the basin, and those under review here as well, lead to negative impacts to listed salmonid species as described above, when the beneficial changes to hatchery practices are also combined with the potential negative impacts from these hatchery programs and the rest of the operations in the Columbia River basin, a net beneficial result is expected as hatchery practices continue to improve and to reduce their negative impacts.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 2.4.2) to the environmental baseline (2.3) and to cumulative effects (2.5) to formulate the agency’s opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (Sections 2.2.1, 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 positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the listed species and their designated critical habitat.

2.7.1. UCR Spring Chinook Salmon ESU

Best available information indicates that the UCR Spring Chinook Salmon ESU is at high risk and remains Endangered (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 will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

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

The effects of our proposed action on this ESU beyond those included in the baseline are limited to ecological effects, broodstock collection at Chelan Falls Trap, and facilities effect of the Priest
Rapids Hatchery’s intake. Adverse ecological effects on adults are small because of the
differences in spatial and temporal overlap between UCR spring Chinook salmon and the
hatchery-origin adults. However, natural-origin juveniles may potentially undergo larger effects
because of the overlap in outmigration timing with the hatchery-origin juveniles. Our analysis
showed that the impacts of these programs could equate up to a loss of 799 salmon adult
equivalents from the ESU, which constitutes 2.1 percent of returning adults from this ESU at the
mouth of the Columbia River. Because the model differentiates fish by size and not by run
timing, these 799 adult equivalents could also include the unlisted summer/fall Chinook salmon
as well.

The effect of broodstock collection from the summer/fall Chinook salmon programs are also
small. The Chelan Falls Trap could encounter up to 10 unidentified Chinook salmon that may
potentially be spring Chinook salmon, but many of these encounters are likely to be summer/fall
Chinook salmon rather than spring Chinook salmon; none of these encounters would result in
mortality. Thus, there is very little incidental effect on the UCR Spring Chinook Salmon ESU.

The negative effect of operating the Priest Rapids Hatchery is limited to the entrainment that
may be occurring because of an intake screen that is not compliant with the NMFS screening
criteria. Because there are no good estimates of how many ESA-listed fish get entrained (if at
all), we extrapolate from the diversion of flow that 0.5 percent of outmigrating juvenile UCR
spring Chinook salmon are entrained into the Priest Rapids Hatchery.

The total impacts on the UCR Spring Chinook ESU as a result of the Proposed Action would be
the loss of an estimated 3.8% of adult equivalents from ecological interactions during juvenile
outmigration, and a loss of approximately 0.5% of outmigrating juveniles at the Priest Rapids
hatchery water intake. The effect of these losses would be to reduce the abundance and
productivity of the ESU. While up to 10 spring Chinook salmon are expected to be encountered
at the Chelan Falls Trap, none of these encounters would result in mortality from handling. As
described in Section 2.2.1.6, above, all three remaining populations in this ESU are at High risk,
while the Okanogan population is extirpated. For each of the High-risk populations, current
abundances are well below minimum abundance thresholds, and productivities are well below
replacement (1.0) with the exception of the Entiat River population (Table 8). NMFS expects
that, because the impacts of the Proposed Action on this ESU would accrue during downstream
migration, the effects of the Proposed Action would apply proportionally to the three
populations. Therefore, each population would be expected to lose approximately 4.3% of the
outmigrating juvenile abundance as a result of the Proposed Action. This 4.3% loss would not be
large enough to have a marked effect on the abundance or productivity of any of the populations.
In addition, as described in Section 2.5.2.3, the actual predation and competition effects may be
smaller to an unknown extent than those modeled, though even the conservative assessment of
effects utilized in this Opinion does not suggest an extensive risk to the species. Taken together,
NMFS has determined that the level of impact on abundance and, therefore, productivity, of the
Proposed Action would not appreciably reduce the likelihood of survival and recovery of this
ESU.

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 the ESU describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESU. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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

2.7.2. UCR Steelhead DPS

Best available information indicates that the Snake River Steelhead DPS is at high risk and remains at threatened status (Ford 2011). Ford (2011) determined that all populations remain below minimum natural-origin abundance thresholds. In addition, the biological review team identified the lack of direct data on spawning escapements and pHOS in the individual population tributaries as a key uncertainty, rendering quantitative assessment of viability for the DPS difficult (Ford 2011). Still, after taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of the ESA-listed DPS in the wild.

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

The effects of our proposed action on this DPS beyond those included in the baseline are limited to ecological effects, broodstock collection at Priest Rapids volunteer trap and at Ringold Springs Rearing Facility, and facilities effect of the Priest Rapids Hatchery’s intake. No adverse ecological effects on adults are expected because of the differences in spatial and temporal overlap between UCR steelhead and the hatchery-origin adults. However, natural-origin juveniles may potentially experience a negative effect because of the overlap in outmigration timing with the hatchery-origin juveniles. Our analysis showed that the impacts of these programs equates to a loss of 88 steelhead adult equivalents from the DPS, which constitutes 1.3 percent of returning adults from this DPS at the mouth of the Columbia River.

The effect of broodstock collection from the fall Chinook salmon programs are also small. The Priest Rapids volunteer trap could encounter up to 15 steelhead (as identified by no external marking or ad-clip only), none of which would likely result in mortality. The Ringold Springs Rearing Facility could encounter up to five steelhead, none of which would result in mortality. Thus, there is little to no effect on the UCR Steelhead DPS as a result of broodstock collection.
The negative effect of operating the Priest Rapids Hatchery is limited to the entrainment that may be occurring because of an intake screen that is not compliant with the NMFS screening criteria. Because there are no good estimates of how many ESA-listed fish get entrained (if at all), we assume that 0.5 percent of outmigrating juvenile UCR steelhead are entrained into the Priest Rapids Hatchery.

The total impacts on the UCR Steelhead DPS as a result of the Proposed Action would be the loss an estimated 1.3% of adult equivalents from ecological interactions during juvenile outmigration and a loss of approximately 0.5% of outmigrating juveniles at the Priest Rapids hatchery water intake. The effect of these losses would be to reduce the abundance and productivity of the DPS. As described in Section 2.2.1.6, above, three of the four populations in this DPS are at High risk, while the Wenatchee population is rated Maintained. For each of the High-risk populations, current abundances are well below minimum abundance thresholds, and productivities are well below replacement (1.0) (Table 17). NMFS expects that, because the impacts of the Proposed Action on this DPS would accrue during downstream migration, the effects of the Proposed Action would apply proportionally to the four populations. Therefore, each population would be expected to lose approximately 1.8% of the outmigrating juvenile abundance as a result of the Proposed Action. This 1.8% loss would not be large enough to have a marked effect on the abundance or productivity of any of the populations. In addition, as described in Section 2.5.2.3, the actual predation and competition effects may be smaller to an unknown extent than those modeled, though even the conservative assessment of effects utilized in this Opinion does not suggest an extensive risk to the species. Taken together, NMFS has determined that the level of impact on abundance and, therefore, productivity, of the Proposed Action would not appreciably reduce the likelihood of survival and recovery of this 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 plans for each DPS describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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

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

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

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

The effects of our proposed action on these ESUs and DPSs are limited to ecological effects
from hatchery-origin juvenile fish because of the overlap in outmigration timing. The results of
our analysis are summarized in Table 59. Impacts of these programs equates to a loss ranging
from 15 sockeye salmon adult equivalents from the Snake River Sockeye Salmon ESU to 1,072
Chinook salmon adult equivalents from the Lower Columbia River Chinook Salmon ESU. These
impacts are also characterized as a proportion of lost adults compared to the total returning adults
from each ESU/DPS at the mouth of the Columbia River, ranging from 0.2 percent for the Lower
Columbia River Coho Salmon ESU to 2.7 percent for the Lower Columbia River Chinook
Salmon ESU. The small percentage loss within these ESU and DPS is unlikely to substantially
affect the abundance and productivity of these natural-origin fish in the Columbia River Basin.

<table>
<thead>
<tr>
<th>Species (ESU/DPS)</th>
<th>Total Lost Adult Equivalents</th>
<th>Proportion of Lost Adults to Total Returning Adults from ESU/DPS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook Salmon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snake River Spring/Summer Chinook Salmon ESU</td>
<td>746</td>
<td>2.3</td>
</tr>
<tr>
<td>Snake River Fall Chinook Salmon ESU</td>
<td>85</td>
<td>0.4</td>
</tr>
<tr>
<td>Lower Columbia River Chinook Salmon ESU</td>
<td>1,072</td>
<td>2.8</td>
</tr>
<tr>
<td>Upper Willamette River Spring Chinook Salmon ESU</td>
<td>132</td>
<td>1.4</td>
</tr>
<tr>
<td>Steelhead</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snake River Steelhead DPS</td>
<td>189</td>
<td>0.3</td>
</tr>
<tr>
<td>Middle Columbia Steelhead DPS</td>
<td>132</td>
<td>0.6</td>
</tr>
<tr>
<td>Lower Columbia River Steelhead DPS</td>
<td>70</td>
<td>0.3</td>
</tr>
<tr>
<td>Upper Willamette River Steelhead DPS</td>
<td>33</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 59. Lost natural-origin adult equivalents compared to returning adults from each ESU/DPS
at the mouth of the Columbia River.
<table>
<thead>
<tr>
<th>Species</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snake River Sockeye Salmon ESU</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Columbia River Chum Salmon ESU</td>
<td>96</td>
<td>0.5</td>
</tr>
<tr>
<td>Lower Columbia River Coho Salmon ESU</td>
<td>468</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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 and DPS describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs and steelhead DPSs. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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

**2.7.4. Critical Habitat**

Only the PBFs for UCR spring Chinook salmon and UCR steelhead are likely to be affected from the proposed action. The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat for UCR spring Chinook salmon and UCR steelhead in the action area (Section 2.5.2.5). 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. The operation of the traps and other hatchery facilities may impact only the migration PBFs for UCR spring Chinook salmon and UCR steelhead due to delay at these structures and possible rejection. However, the number of natural-origin adults delayed is expected to be small and the delay would be for only a short period. Thus, the impact on the spawning, rearing, and migration PBFs of UCR spring Chinook salmon and UCR steelhead will be small in scale, and will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

Climate change may have some effects on critical habitat as discussed in Section 2.4.2. With continued losses in snowpack and increasing water temperatures, it is possible that increases in the density and residence time of fish using cold-water refugia could result in increases in ecological interactions between hatchery and natural-origin fish of all life stages, with unknown, but likely small effects. The continued restoration of habitat may also provide additional refugia for fish. After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not alter PBFs essential to the conservation of a species or preclude or significantly delay development of such features.

**2.8. Conclusion**

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the Proposed Action, including effects of the Proposed Action that are likely to persist following expiration of the Proposed Action, and cumulative effects, it is NMFS’
biological opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of any of the ESUs and DPSs listed in the Columbia River Basin (Table 7), or destroy or adversely modify designated critical habitat.

Table 60. Summary of NMFS determination of effects.

<table>
<thead>
<tr>
<th>ESA-Listed Species</th>
<th>Is the Action Likely to Adversely Affect Species?</th>
<th>Is the Action Likely to Adversely Affect Critical Habitat?</th>
<th>Is the Action Likely To Jeopardize the Species?</th>
<th>Is the Action Likely To Destroy or Adversely Modify Critical Habitat?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Columbia River Spring Chinook salmon</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Snake River Spring/Summer Chinook salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Snake River Fall Chinook salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lower Columbia River Chinook salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Upper Willamette River Spring Chinook salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Upper Columbia River steelhead</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Snake River steelhead</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Middle Columbia River steelhead</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lower Columbia River steelhead</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Upper Willamette River steelhead</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Snake River sockeye salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Columbia River chum salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lower Columbia River coho salmon</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

2.9, Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass\textsuperscript{14}, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to

\textsuperscript{14} NMFS recognizes the benefit of providing guidance on the interpretation of the term "harass". As a first step, for use on an interim basis, NMFS will interpret harass in a manner similar to the USFWS regulatory definition for non-captive wildlife: “Create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” NMFS interprets the phrase “significantly disrupt normal behavioral patterns” to mean a change in the animal’s behavior (breeding, feeding, sheltering, resting, migrating, etc.) that could reasonably be expected, alone or in concert with other factors, to create or increase the risk of injury to an [ESA-listed] animal when added to the condition of the
engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not prohibited under the ESA, if that action is performed in compliance with the terms and conditions of the ITS.

2.9.1. Amount or Extent of Take

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

Factor 2: Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

At the Chelan Falls Trap, up to 10 unidentified Chinook salmon are expected to be handled each year, all of which could be ESA-listed Upper Columbia River spring Chinook salmon, and none of which would die as a result of handling.

At the Priest Rapids volunteer trap, up to 15 ESA-listed Upper Columbia River steelhead could be taken by handling (as identified by no external marking or with ad-clip only) annually, of which up to 3 could die as a result of handling.

At the Ringold Springs Rearing Facility, up to 5 ESA-listed Upper Columbia River steelhead could be encountered annually, none of which would die as a result of handling.

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

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

For residualism, the take surrogate is the percentage of summer/fall and fall Chinook salmon from the yearling release group that are observed to be either parr, precociously maturing, or precociously mature prior to release. This surrogate has a causal link to the amount of take expected from residualism because precocious summer/fall and fall Chinook salmon and parr exposed animal before the disruption occurred. See Weiting (2016) for more information on the interim definition of “harass.”
may residualize after release from the hatchery. This take surrogate covers the take pathway whereby the residual hatchery fish potentially compete with or prey on juvenile natural-origin fish for an extended period of time. NMFS considers, for the purpose of this take surrogate, that no more than 15 percent of program fish from each release group should be observed as having the potential to residualize. The take surrogate can be monitored using a running five-year average beginning with the 2018 release by either of the following methods: 1) lethal visual assessment that would look for precocial mature fish; or 2) non-lethal visual assessment that would look for precocial mature male and parr (as defined by the unlikelihood of it smolting; i.e., if there is any indication that it would smolt, it would not be considered a parr). For the second method, the nonlethal visual assessments are likely to detect a lower rate of potentially residualizing fish, adding parr to the sampling would lead to a higher detection rate than visually assessing for precocially mature males alone. The take surrogate can be reliably measured and monitored through either methods of visual assessment of the hatchery population and/or migrant fish prior to release, both of which NMFS considers to be an effect method of monitoring.

For ecological effects of competition and predation caused by emigrating hatchery summer/fall and fall Chinook salmon, NMFS applies a take surrogate that relates to the median travel time for hatchery fish to reach McNary Dam after release. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids through the estuary are measured as follows: the travel time for emigrating juvenile hatchery steelhead is five days longer than the median value (which equates to 50% of the fish) identified in Table 49 for each program for 3 of the previous 5 years of 5-year running medians. For example, if the 5-year running median of the median value in Table 49 is 20, and then the median for the next three years for a particular release group is 23, this would exceed the take threshold. This surrogate has a causal link to the extent of incidental take because, if travel time increases in more years than not, it is a sign that fish are not exiting the action area as quickly as expected, and that the recurring increase in time indicates that the issue is not related to a single external factor but to a more fundamental change in migration timing. This threshold can be reliably monitored using emigration estimates from PIT tags though NMFS expects the operators to develop additional juvenile monitoring techniques during the proposed action.

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

Use of the intake pipe at the Priest Rapids Hatchery could cause incidental take of listed juvenile ESA-listed Upper Columbia River spring Chinook salmon and steelhead through entrainment. However, it is not practical to quantify and track the number of these ESA-listed juvenile fish entrained by the intake pipe because no methods are available to observe or record fish encountering the intake. However, it is possible to estimate the number of individuals encountering the intake and, therefore, being killed through entrainment by estimating the proportion of river flow that is withdrawn at the intake and assuming the proportion of the run of the given species is similar. Therefore, NMFS will designate, as a surrogate take indicator, the proportion of the flow at any given time that is withdrawn by the hatchery. This surrogate has a rational connection to the take of the listed species because the proportion of fish affected correlates to the proportion of flow diverted (and, as discussed above, likely yields an

15 However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 5 percent after five years, operators will contact NMFS in the year the likely exceedance is discovered.
overestimate of take). Take will be considered exceeded for entrainment at the intake pipe if more than 0.5 percent of the river’s flow as measured downstream of the Wanapaum Dam (upriver from the intake pipe) is withdrawn at the intake pipe during juvenile migration periods. The instream flow can be reliably monitored by a gauge downstream of the Wanapaum Dam.

2.9.2. Effect of the Take

In Section 2.8, NMFS determined that the level of anticipated take, coupled with other effects of the Proposed Action, is not likely to jeopardize the continued existence of the Upper Columbia River Spring Chinook Salmon ESU, and Upper Columbia River Steelhead DPS or result in the destruction or adverse modification of their designated critical habitat.

2.9.3. Reasonable and Prudent Measures

“Reasonable and prudent measures” are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. NMFS and the USACE shall ensure that:

1. The applicants implement the hatchery programs and operate the hatchery facilities as described in the Proposed Action (Section 1.3) and in the submitted HGMPs.

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

2.9.4. Terms and Conditions

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

The USACE shall ensure for the Ringold Springs fall Chinook salmon program and their portion of the Priest Rapids fall Chinook salmon program that:

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

   i. Providing advance notice to NMFS of any change in hatchery program operation (including early releases) that potentially increases the amount or extent of take, or results in an effect of take not previously considered.

   ii. Providing notice if monitoring reveals an increase in the amount or extent of take, or discovers an effect of the Proposed Action not considered in this opinion.
iii. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.

1.b. The applicants implement application of at least the minimum number of PIT-tags for the Ringold Springs fall Chinook salmon program that would adequately track the program’s hatchery-origin fish emigration time. The USACE shall secure funding for this monitoring starting with the next available fiscal year budget submittal (2020), and the applicants shall implement this monitoring thereafter. If USACE cannot secure the funding, the USACE shall notify NMFS.

2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
   i. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Emi Kondo (503) 736-4739, emi.kondo@noaa.gov.
   ii. Applicants will notify NMFS SFD within 48 hours after knowledge of exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded within two weeks of the event.
   iii. Applicants will include the reporting information detailed in the WDFW’s section 10 permits in their reports.

NMFS shall include in the section 10 permits conditions that:

1a. The applicants implement the Chelan Falls, the Wenatchee, the Methow, and the Wells summer/fall Chinook salmon programs and the Priest Rapids fall Chinook salmon program as described in the Proposed Action (Section 1.3) and the submitted HGMPs, including:
   i. Providing advance notice to NMFS of any change in hatchery program operation that potentially increases the amount or extent of take, or results in an effect of take not previously considered.
   ii. Providing notice if monitoring reveals an increase in the amount or extent of take, or discovers an effect of the Proposed Action not considered in this opinion.
   iii. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.

1.b. Douglas PUD shall fund and the applicants shall implement monitoring with a minimum of 5,000 PIT-tags per life-stage for the Wells Hatchery summer/fall Chinook salmon program.

1.c. Grant PUD shall coordinate with NMFS environmental service branch to conduct a review of The Priest Rapids Hatchery Siphon Intake Screen Upgrade Concept Study to ensure compliance with the screening criteria. Grant PUD shall notify NMFS SFD if the project becomes designated as lower priority than 2-2 or if it is not funded by the end of calendar year 2024.
1.d. Grant PUD shall monitor and report annually the percentage of water withdrawal compared to the instream flow at the Priest Rapids Hatchery until the NMFS screening criteria compliant intake screen is installed at the Priest Rapids Hatchery.

2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
   a. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Emi Kondo (503) 736-4739, emi.kondo@noaa.gov.
   b. Applicants will notify NMFS SFD within 48 hours after exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded within two weeks of the event.
   c. Applicants will include the reporting information detailed in their section 10 Permit in their reports.

2.10. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat (50 CFR 402.02). NMFS has identified one conservation recommendation appropriate to the Proposed Action:

1. Implement pHOS goals as described in submitted HGMPs.

2.11. Re-initiation of Consultation

This concludes formal consultation on the approval and implementation of four hatchery programs rearing and releasing summer/fall Chinook salmon and two hatchery programs rearing and releasing fall Chinook salmon in the UCR Basin.

As 50 CFR 402.16 states, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.12. “Not Likely to Adversely Affect” Determinations

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

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

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

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

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

Critical habitat for Southern Green Sturgeon DPS was designated on October 9, 2009 (74 FR
52300). Coastal waters included as critical habitat stretch from Monterey Bay, California, to
Cape Flattery, Washington, and include the Strait of Juan de Fuca to the U.S. border with
Canada. Bays in California, Oregon, and Washington are included as well as the Columbia
River estuary, the Sacramento-San Joaquin Delta, and the Sacramento, lower Feather, and lower
Yuba Rivers in California (NMFS and NOAA 2009).

The release of hatchery summer/fall and fall Chinook salmon has not been identified as a threat
to the survival or persistence of Southern Green Sturgeon DPS. An in-depth literature search has
revealed no identified interactions between green sturgeon and hatchery released fish even
though both Northern and Southern Green Sturgeon DPS occur in the Columbia estuary and
River up to Bonneville Dam. One potential effect is increased competition for resources
between hatchery salmonids and green sturgeon. This may be a concern for large releases of
hatchery salmonids in natal rivers; however, the Columbia River is not a natal river for green
sturgeon. The green sturgeon found in the Columbia River estuary are subadults and adults
(Moser and Lindley 2007) and do not occupy the same foraging habitats as URB fall Chinook
salmon juveniles, making the potential increase in competition unlikely and, therefore,
Based on this analysis, NMFS concludes that the Proposed Action is not likely to adversely affect the Southern Green Sturgeon DPS or their designated critical habitat.

2.12.2. Southern Resident Killer Whale DPS

The Southern Resident Killer Whales (SRKW; Southern Residents) DPS consist of three pods (J, K, and L) and was listed as endangered on February 16, 2006 (70 FR 69903), 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 we designate coastal critical habitat, which identified how we 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). Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, it is likely that multiple threats are acting together to impact the whales (NMFS 2008f).

Southern Residents inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as northern British Columbia (Hanson et al. 2013; NMFS 2008f). During the spring, summer, and fall, Southern Residents 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; Hanson and Emmons 2010; 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). Detection rates of K and L pods on passive acoustic recorders indicate the whales occur with greater frequency off Columbia River and Westport and are most common in March (Hanson et al. 2013). Satellite-linked tag deployments on K and L pod individuals have also provided more data on the whales’ movements in the winter (NWFSC unpubl. data). These data indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months, whereas J pod occurs more frequently in inland waters, particularly in the northern Georgia Strait.

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

Southern Residents consume a variety of fish species but salmon are identified as their primary prey (i.e., a high percentage of prey consumed during spring, summer and fall, from long-term studies of resident killer whale diet; Ford and Ellis 2006; Ford et al. 2016; Hanson et al. 2010). Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling in inland waters from May to September indicate that Southern Residents’ diet consists of a high percentage of
Chinook, with an overall average of 88% Chinook across the timeframe and monthly proportions as high as >90% Chinook (Ford et al. 2016; Hanson et al. 2010). Prey and fecal samples collected in the winter months also indicate the whales’ primary prey is Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut in their diet (NWFSC unpubl. data). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kcal/kg) (O’Neill et al. 2014).

The Proposed Action may affect SRKWs indirectly by affecting the availability of their primary prey, Chinook salmon. Hatchery-produced Chinook salmon may benefit SRKW by enhancing prey availability, as scarcity of prey has been identified as a threat to SRKW survival and recovery, and hatchery fish often contribute to the salmon stocks consumed by SRKW (Hanson et al. 2010). The release of 1,596,000 summer/fall Chinook salmon yearlings, 484,000 summer/fall Chinook salmon subyearlings, and 10,799,504 fall Chinook salmon subyearlings under the Proposed Action could potentially increase the number of Chinook salmon available to the SRKW in coastal waters by 152,755 summer/fall and 31,967 fall Chinook salmon adults annually. These adult survival numbers are calculated by applying the Chinook salmon SARs to the release numbers. Because SARs account for mortality occurring after adult salmon re-enter freshwater, these adult numbers are an underestimation of the available prey for SRKW. NMFS (2017d) estimated that the annual average Chinook salmon abundance from all west coast sources, that could potentially provide prey for SRKW, was approximately 2,035,778 fish. The contribution of summer/fall and fall Chinook salmon to this total from the release of hatchery fish under the Proposed Action is less than 9.07% of the total Chinook salmon abundance.

As described in Section 2.5.2.3, the release of hatchery fish in the Upper Columbia River Basin may affect the natural-origin Chinook salmon production in the basin and reduce the number of natural-origin fish available to SRKW as prey by some small amount because of competition or predation between hatchery-origin and natural-origin juveniles as they emigrate. These losses of juveniles equate to a range from 0.2 to 3.7 percent of returning adults at the mouth within each ESU, though, as mentioned above, these numbers are likely an overestimate (see section 2.5.2.3 and Table 54); however, these lost natural-origin fish would be replaced by the hatchery fish, and natural-origin fish numbers may increase over time as the goal of the program is to increase the number of naturally-produced fish spawning in the Upper Columbia River Basin. Based on the current natural-origin abundance in the Upper Columbia River Basin, any increase or decrease in overall natural-origin abundance would not have any discernible effect on the total abundance of Chinook salmon off the west coast. It is unlikely that SRKW would have encountered and

consumed all of these fish lost to competition and predation (Table 54) annually because the 
spatial and temporal distributions of SRKW and Chinook salmon are not entirely overlapping, 
and there is a low probability that all of these lost natural-origin Chinook would be intercepted 
by SRKW across their vast range in the absence of the Proposed Action. Therefore, any adverse 
effect on SRKW as a result of reductions in natural-origin Chinook salmon as prey would be 
insignificant.

Given the Proposed Action is likely to benefit SRKW with production of hatchery summer/fall 
and fall Chinook salmon and providing an increase in prey availability, and the effects of the 
action on the status of listed salmon is small, the release of summer/fall and fall Chinook salmon 
in the Upper Columbia River under the proposed action is not likely to adversely affect the 
SRKW.

2.12.3. Eulachon

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

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

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

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

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

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

Based on the above information, especially information regarding the diet composition of juvenile salmonid fishes in freshwater and estuarine habitats, the release of summer/fall and fall Chinook salmon in the Upper Columbia River under the proposed action is not likely to adversely affect the southern DPS of eulachon or its designated critical habitat.
3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

The consultation requirement of 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 effects include the direct or indirect physical, chemical, or biological alterations 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 EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the implementation of four summer/fall Chinook salmon and two fall Chinook salmon hatchery programs, as described in Section 1.3. The action area of the Proposed Action includes habitat described as EFH for Chinook and coho salmon (PFMC 2003) within the Upper Columbia River Basin. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

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

3.2. Adverse Effects on Essential Fish Habitat

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

The PFMC (2003) recognized concerns regarding the “genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations.” The biological opinion describes in considerable detail the impacts hatchery programs might have on natural salmon and steelhead populations (Section 5). Ecological effects of juvenile and adult hatchery-origin fish on natural-origin Chinook salmon are discussed in Sections 2.5.2.2 and 2.5.2.3. Hatchery summer/fall Chinook salmon returning to the Upper Columbia River are not
expected to compete for space with spring Chinook or coho salmon because of the usage of different habitats based on fish body size and due to differences in run and spawn timing; spring Chinook salmon spawn in the late summer, and coho salmon spawn in the mid-late fall. In contrast, fish produced by the proposed hatchery programs typically spawn from late September to early December (Table 43). Because of this small likelihood of overlap in spawn timing and usage of habitat, the spawning habitat HAPC would not be adversely affected by the proposed action.

EFH for Chinook and coho salmon would likely be affected by the proposed action through ecological interactions. Some summer/fall and fall Chinook salmon from the programs would stray into other rivers (Section 2.5.2.2), but not in numbers that would exceed the carrying capacities of natural production areas, or that would result in increased incidence of disease or predators. Some predation by adult hatchery Chinook salmon on juvenile natural-origin Chinook or coho salmon may occur as summer/fall and fall Chinook salmon hold for a potentially long period of time before spawning. Predation and competition by juvenile hatchery summer/fall and fall Chinook salmon on juvenile natural-origin Chinook or coho salmon is likely small. Our analysis in Section 2.5.2.3 shows that fewer than 2,488 Chinook salmon adult equivalents and 468 coho salmon adult equivalents are likely to be lost to predation and competition with hatchery summer/fall and fall Chinook salmon at the juvenile stage within our action area for this consultation. However, some areas within the action area are not included in the EFH designation (e.g., HUC 17020016 for Priest Rapids does not include EFH for coho salmon), so the level of effect is likely to be less than described here.

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

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS believes that the Proposed Action, as described in the HGMPs and the ITS (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS has no additional conservation recommendations specifically for Chinook and coho salmon EFH besides fully implementing the proposed action and ITS. However, the Reasonable and Prudent Measures and Terms and Conditions included in the ITS, specifically under RPM #1 and its associated Terms and Conditions, sufficiently address potential EFH effects.

3.4. Statutory Response Requirement

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

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

3.5. Supplemental Consultation

The Federal action agencies must reinitiate EFH consultation with NMFS if the Proposed Action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS’ EFH conservation recommendations (50 CFR 600.920(l)).
4. **DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW**

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act") specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, document compliance with the Data Quality Act, and certifies that this opinion has undergone pre-dissemination review.

### 4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA section 7 consultation, that operation of the four summer/fall Chinook salmon and two fall Chinook salmon hatchery programs in the Upper Columbia River as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are: the NMFS (permitting entity); the WDFW (operating entity); the Chelan, and Grant Public Utility Districts (funding entities); the Douglas Public Utility District (funding and operating entity) and the USACE (funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of summer/fall and fall Chinook salmon to the Upper Columbia River basin for conservation and harvest, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmonids. This information will improve scientific understanding of hatchery-origin steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. This opinion will be posted on NMFS’ West Coast Region web site ([http://www.westcoast.fisheries.noaa.gov/](http://www.westcoast.fisheries.noaa.gov/)). The format and naming adheres to conventional standards for style.

### 4.2. Integrity

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

### 4.3. Objectivity

**Information Product Category:** Natural Resource Plan

**Standards:** This consultation and supporting documents are clear, concise, complete, and unbiased, and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 *et seq.*, and the MSA implementing regulations regarding EFH, 50 CFR 600.920(j).

**Best Available Information:** This consultation and supporting documents use the best available information, as described in the references section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.
Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.
5. **APPENDIX A-Factors Considered When Analyzing Hatchery Effects**

NMFS’ analysis of the Proposed Action is in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 61. Generally speaking, effects range from beneficial to negative when programs use local fish\(^\text{17}\) for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock\(^\text{18}\). Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Analysis of a Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. These factors are:

1. the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
2. hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
3. hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,
4. RM&E that exists because of the hatchery program,
5. operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
6. fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The analysis assigns an effect for each factor from the following categories:

1. positive or beneficial effect on population viability,
2. negligible effect on population viability, and
3. negative effect on population viability.

The effects of hatchery fish on ESU/DPS status will depend on which of the four VSP criteria are currently limiting the ESU/DPS and how the hatchery program affects each of the criteria (NMFS 2005c). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population’s current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or

\(^{17}\) 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).

\(^{18}\) Exceptions include restoring extirpated populations and gene banks.
steelhead DPS recovery, the target viability for the affected natural population(s), and the 
environmental baseline including the factors currently limiting population viability.

Table 61. An overview of the range of effects on natural population viability parameters from the 
two categories of hatchery programs.

<table>
<thead>
<tr>
<th>Natural population viability parameter</th>
<th>Hatchery broodstock originate from the local population and are included in the ESU or DPS</th>
<th>Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productivity</strong></td>
<td>Positive to negative effect</td>
<td>Negligible to negative effect</td>
</tr>
<tr>
<td></td>
<td>Hatcheries are unlikely to benefit productivity except in cases where the natural population’s small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004c).</td>
<td>Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).</td>
</tr>
<tr>
<td><strong>Diversity</strong></td>
<td>Positive to negative effect</td>
<td>Negligible to negative effect</td>
</tr>
<tr>
<td></td>
<td>Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity.</td>
<td>Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).</td>
</tr>
<tr>
<td><strong>Abundance</strong></td>
<td>Positive to negative effect</td>
<td>Negligible to negative effect</td>
</tr>
<tr>
<td></td>
<td>Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects.</td>
<td>Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&amp;E, and facility operation, maintenance and construction effects.</td>
</tr>
<tr>
<td><strong>Spatial Structure</strong></td>
<td>Positive to negative effect</td>
<td>Negligible to negative effect</td>
</tr>
<tr>
<td></td>
<td>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).</td>
<td>Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).</td>
</tr>
</tbody>
</table>
**5.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock**

This factor considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The level of effect for this factor ranges from neutral or negligible to negative.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population tapped to provide hatchery broodstock. “Mining” a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program “backfills” with fish from outside the local or immediate area. The physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species is considered under Factor 2.

**5.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities**

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. The level of effect for this factor ranges from positive to negative.

There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations based on the weight of available scientific information at this time. Hatchery fish can thus pose a risk to diversity and to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that beneficial effects exist as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011).

NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery...
practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d).

5.2.1. Genetic effects

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risks.

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population’s effective population size ($N_e$), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande 1987), and diversity loss can be severe if $N_e$ drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase $N_e$. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress $N_e$ by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). Two is when $N_e$ is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of $N_e$ reduction is the Ryman-Laikre effect (Ryman et al. 1995; Ryman and Laikre 1991), when $N_e$ is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase $N_e$ (Busack and Knudsen 2007; Fiumera et al. 2004).

Inbreeding depression, another $N_e$-related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.
Outbreeding effects, the second major area of genetic effects of hatchery programs, are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population’s level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population’s MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish (pHOS) among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These “dip-in” fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). 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

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19 It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.
reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-influenced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). For an individual, the amount of time a fish spend in the hatchery mostly equates to fish culture. For a population, exposure is determined by the proportion of natural-origin fish in the hatchery broodstock, the proportion of natural spawners consisting of hatchery-origin fish (Ford 2002; Lynch and O'Hely 2001), and the number of years the exposure takes place. In assessing risk or determining impact, all three factors must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.
Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 11).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by (Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB). PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

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20 Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish. In other words, all will contribute to the natural-origin gene pool.

21 PNI is computed as $pNOB/(pNOB+pHOS)$. This statistic is really an approximation of the true proportionate natural influence, but operationally the distinction is unimportant.
Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as “the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity.” They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.
Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with “the proportion of the natural spawning population that is made up of hatchery fish” in the Conclusion, Principles and Recommendations section (HSRG 2009), but with “the proportion of effective hatchery-origin spawners” in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (appendix C in HSRG 2009) they introduce a new term, effective pHOS (pHOSeff) 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:

\[
pHOSeff = RRS \times pHOS_{census}
\]

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:

\[
PNI = \frac{pNOB}{(pNOB + pHOSeff)}
\]

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 a rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 12 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases; with no overlap, the proportion of NxN matings is 1 minus pHOS and the proportion of HxH matings equals pHOS. RRS does not affect the mating type proportions directly but changes their effective proportions. Overlap and RRS can be related. For example, in the Wenatchee River, hatchery spring Chinook salmon tend to spawn lower in the system than natural-origin fish, and this accounts for a considerable amount of their lowered reproductive success (Williamson et al. 2010). In that particular situation the hatchery-origin fish were spawning in inferior habitat.

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22 These computations are purely theoretical, based on a simple mathematical binomial expansion $((a+b)^2=a^2 + 2ab + b^2)$. 
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 (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches,
removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences at times. In particular, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species when there is spatial overlap between hatchery and natural spawners. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

5.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally, on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

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

NMFS also analyzes the potential for competition and predation when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. The level of effect for this factor ranges from neutral or negligible to negative.

5.3.1. Competition

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns
and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at “high risk” due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors. However, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration by natural-origin juvenile salmonids. Pearsons et al. (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory fish (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is
generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas in the vicinity of hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (California HSRG 2012; Steward and Bjornn 1990)
- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by naturally produced juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,\(^{23}\) including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

5.3.2. Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from

\(^{23}\) “Action area” means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.
predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

(Rensel et al. 1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas at the time. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearson and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (Rensel et al. 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (HSRG 2004; Pearson and Fritts 1999), but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Beauchamp 1990; Cannamela 1992; CBFWA 1996; Hillman and Mullan 1989; Horner 1978). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Bachman 1984; Olla et al. 1998; Sosiak et al. 1979).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted,
limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

5.3.3. Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou virus* (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Naish et al. 2008; Steward and Bjornn 1990). 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; NWIFC and WDFW 2006; ODFW 2003; USFWS 2004). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular...
monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

53.4. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be
released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or “natal” stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008). (Dittman and Quinn 2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Beckman et al. 2000; Hoar 1976). 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 (Bentzen et al. 2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Quinn 1997; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Clarke et al. 2011; Kenaston et al. 2001).

Having hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. By having the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of homing include:

- The timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

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

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.
Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

- Observation during surveying
- Collecting and handling (purposeful or inadvertent)
- Holding the fish in captivity, sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

5.4.1. Observing/Harassing

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species’ presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fishes’ behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish, which are more sensitive to disturbance. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors. Redds may be visually inspected, but would not be walked on.

5.4.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18°C or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels because stress can be immediately debilitating, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly.

5.4.3. Fin clipping and tagging

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied, but fin clips do not generally alter fish growth (Brynildson and Brynildson 1967; Gjerde and Refstie 1988). Mortality among fin-clipped fish is variable, but can be as high as 80 percent (Nicola and Cordone 1973). In some cases, though, no significant difference in mortality was found between clipped and un-clipped fish (Gjerde and Refstie 1988; Vincent-Lang 1993). The mortality rate typically depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that
have clipped pectoral, dorsal, or anal fins (Nicola and Cordone 1973), probably because the adipose and pelvic fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). However, some work has shown that fish without an adipose fin may have a more difficult time swimming through turbulent water (Buckland-Nicks et al. 2011; Reimchen and Temple 2003).

In addition to fin clipping, PIT tags and CWTs are included in the Proposed Action. PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled, so it is critical that researchers ensure that the operations take place in the safest possible manner. Tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery holding tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice et al. 1987; Prentice and Park 1984; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

Coded-wire tags are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

Mortality from tagging is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release—it can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000b; NMFS 2008a) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by the (Galbreath et al. 2008).
The effects of these actions should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties concerning effects on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agency(s) NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the Proposed Action mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses RM&E and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

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

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. The level of effect for this factor ranges from neutral or negligible to negative.

5.6. Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS’ analysis of the Proposed Action in a section 7 consultation. One is where there are fisheries that exist because of the HGMP that describes the Proposed Action (i.e., the fishery is an interrelated and interdependent action), and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally. The level of effect for this factor ranges from neutral or negligible to negative.

“Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs
listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of
the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and
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