

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

Wells Summer Chinook Hatchery Program for Southern Resident Killer Whales

NMFS Consultation Number: WCR0-2020-00825

Action Agencies: National Marine Fisheries Service (NMFS)

Program Operators: Douglas Public Utility District and Washington Department of Fish and Wildlife

Affected Species and Determinations:

ESA-Listed Species	Status	Is the Action Likely to Adversely Affect Species or Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Upper Columbia River steelhead (<i>Oncorhynchus mykiss</i>)	Threatened	Yes	No	No
Upper Columbia River Spring Chinook salmon (<i>Oncorhynchus tshawytscha</i>)	Endangered	Yes	No	No
Southern Resident Killer Whales	Endangered	No	No	No

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

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

Pursuant to section 4(d) of the Endangered Species Act and associated regulations at 50 CFR 223.203(b)(6), the National Marine Fisheries Service (NMFS) is reviewing a salmonid hatchery program to determine whether the program meets the regulatory requirements, including a finding that they will not appreciably reduce the likelihood of survival and recovery of threatened salmon or steelhead. If NMFS finds that the requirements are met, the prohibitions of ESA §9 will not apply to the take by the hatchery program of threatened salmonids.

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking, and release strategies (NMFS 2008a). 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 underlying activities that drive the Proposed Action are the operation and maintenance of one hatchery program rearing and releasing in the Upper Columbia River. The hatchery program is operated by Douglas PUD under contract to WDFW as described in Table 1. The program is described in detail in the Hatchery and Genetic Management Plan (HGMP) (and accompanying supplementary material), which was submitted to NMFS for review.

Table 1. Hatchery program included in the Proposed Action and ESA coverage pathway requested.

Program	HGMP Receipt	Program Operator	Funding Agencies	Program Type and Purpose	ESA Pathway
Wells Summer Chinook for SRKW ¹	October 9, 2019	Washington Department of Fish and Wildlife and Douglas PUD ²	Washington Department of Fish and Wildlife ³ and/or Pacific Salmon Treaty Funds	Segregated Harvest for SRKW recovery and sustainability	4(d) Limit 5

¹SRKW = Southern Resident Killer Whales

² Public Utility District No. 1 of Douglas County

³This will not include funding for Douglas PUD's normal operating and maintenance costs associated with their existing program obligations. Douglas PUD owns and operates Wells Hatchery.

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.

NMFS also completed an Essential Fish Habitat (EFH) consultation on the Proposed Action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, *et seq.*) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available 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.

1.1. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the Endangered Species Act (ESA). Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994). 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 Upper Columbia River (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 found to be sufficient for ESA consultation.

ESA consultations and an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total number of salmon and steelhead released into the

Columbia River annually. These programs are located in the LCR and MCR and are operated by the USFWS and by the 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 2008f) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008c). The SCA environmental baseline included "the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 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 2008f, 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 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...."

The HGMP was submitted for formal review as described in Table 1. This consultation evaluates the effects of the proposed hatchery program on one salmon ESU and one steelhead DPS in the Upper Columbia River Basin under the ESA, and their designated critical habitat. It also evaluates the effects of the program on Essential Fish Habitat (EFH) under the MSA.

Other summer Chinook programs are reared at Wells Hatchery and have been analyzed in a previous biological opinion (NMFS 2017b) and accompanying section 10(a)(1)(B) permits.

1.2. 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 on-going or Proposed Action authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). Because the actions of the Federal agencies are subsumed within the effects of the hatchery program, and any associated research, monitoring and evaluation, the details of each hatchery program are summarized in this section. 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.

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from operation of the proposed hatchery program in the Upper Columbia River. The applicants propose to wholly carry out all activities described in the Wells Summer Chinook for Southern Resident Killer Whales (SRKW) HGMP (WDFW 2019).

There is one federal Proposed Action we are considering in this opinion:

- The Proposed Action for National Marine Fisheries Service (NMFS) is the approval of the Columbia River summer Chinook salmon hatchery program (Table 1) HGMP under 4(d) of the Endangered Species Act (ESA).

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from this Federal action. The effects of this action, as well as the WDFWs’ funding of the program, is subsumed within the operation of the hatchery program. 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 is unlimited from the date of Opinion completion.

The proposed hatchery program produces subyearling summer Chinook salmon with the primary intent for Southern Resident Orca recovery and sustainability. The approval of this HGMP would authorize take of listed species incidental to the implementation of the proposed summer Chinook salmon artificial propagation program in the UCR region. Below is a description of the proposed activities.

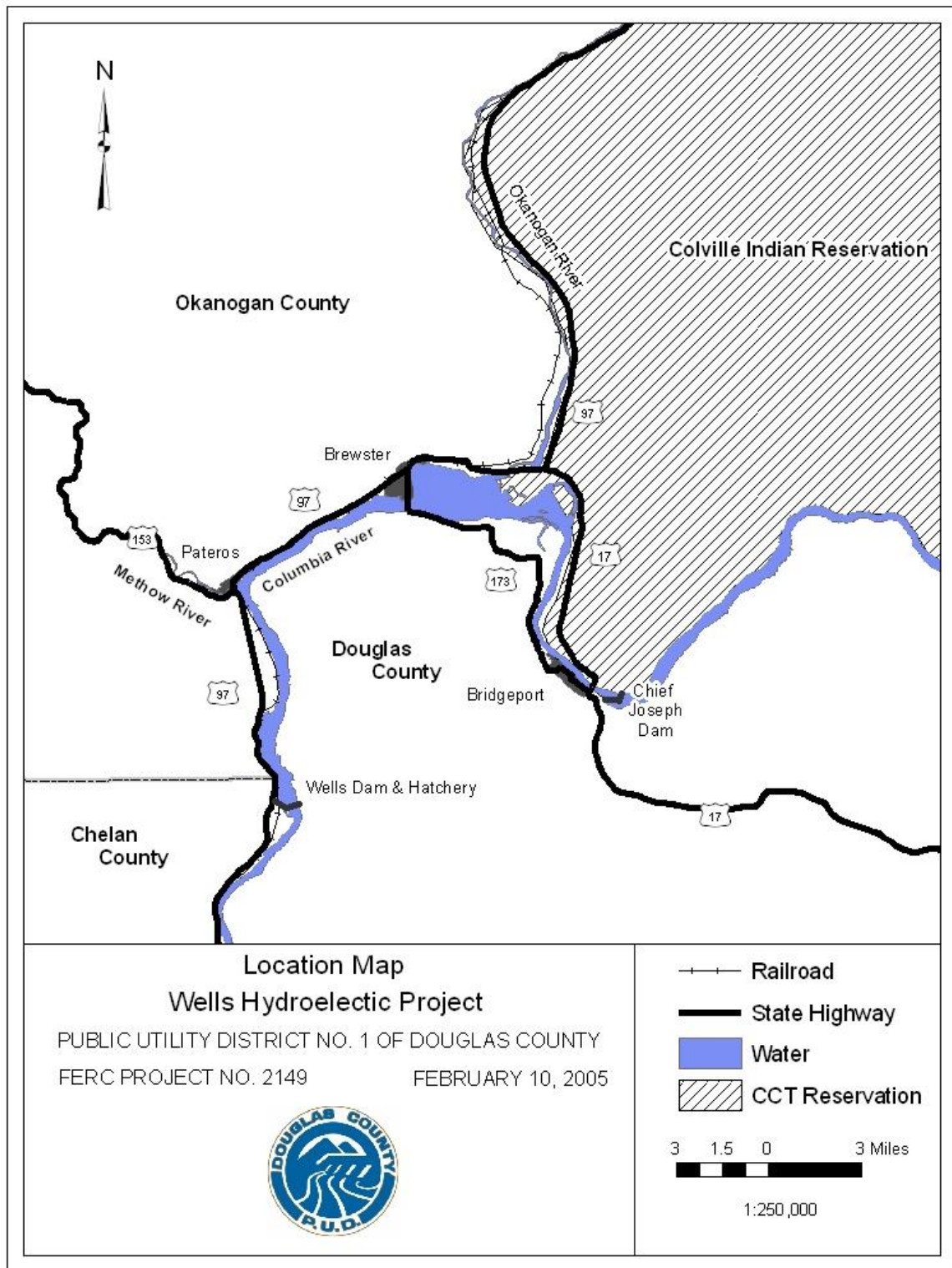


Figure 1. Map of Wells Dam and Hatchery in the Upper Columbia River Basin in the Proposed Action (Courtesy of Shane Bickford, DPUD)

1.2.1. Program Purpose and Type

The purpose of the new segregated Wells Summer Chinook artificial propagation program is to provide increased numbers of summer Chinook for Southern Resident Killer Whales (SRKW) recovery and sustainability.

1.2.2. Proposed Hatchery Broodstock Collection Details

Broodstock collection facilities consist of the Wells Hatchery volunteer channel and the Wells Dam east and west fish ladder traps, if needed. The volunteer channel is the primary source for Wells Hatchery SRKW summer Chinook broodstock.

Douglas PUD and WDFW will annually develop broodstock collection protocols for this program. These objectives and protocols may be adjusted in season to meet changes in the abundance, composition, and location of adult returns, and to minimize impacts on non-target ESA listed Upper Columbia River (UCR) endangered spring Chinook salmon and threatened UCR steelhead..

For the proposed program, broodstock would be collected throughout the run to ensure that the range of traits associated with return timing are represented to reduce the potential for inadvertent genetic selection. Traps would be checked daily when in operation and incidentally captured, endangered UCR spring Chinook salmon and threatened UCR 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.

Please refer to Table 2 for additional information regarding broodstock collection and management for this program.

Table 2. Broodstock collection and spawning details. NOR stands for Natural-Origin Return and HOR stands for Hatchery-Origin Return

Program	Broodstock collection						
	Program Type and Purpose	ESA listed population of fish used in broodstock ¹	Number and origin	Method and location(s)	Approximate timing and frequency ²	NMFS PNI or pHOS targets and pNOB ³	Spawning site and mating protocol
Wells Summer Chinook for SRKW	Segregated harvest	N/A	756 ⁴ adults; hatchery-origin	Wells Hatchery; Wells Dam	July 1-Aug 28; 24 hr/day, up to 7 days/week at hatchery; 16 hr/day, 3 days/week at dam	N/A	On-station; 1:1 sex ratio

¹No ESA listed fish are used in broodstock

²Start date of broodstock collection may be earlier than July 1 to accommodate earlier arrival timing of the run, but operators will contact NMFS if this occurs.

³PNI = Proportionate Natural Influence [pNOB/(pNOB+pHOS)]; pHOS = proportion of hatchery-origin fish on the spawning grounds; pNOB = proportion of natural-origin fish in broodstock

⁴Values based on a current, mean fecundity of 4,171 (H) and 4,662 (W), an egg-to-smolt survival of 0.805, a 1:1 male:female ratio, and 97.9% pre-spawn adult survival. Broodstock numbers reflect a ~ 99% chance of meeting the program production targets.

1.2.3. Proposed Hatchery Egg Incubation and Juvenile Rearing, Acclimation, and Release

Please refer to Table 3 for information regarding annual release groups, marking/tagging, egg incubation location, rearing location, acclimation site and time, and release time and location for the program.

In addition, there is a 10% overage buffer of juvenile releases, whereby in a single year the operator may release up to an additional 10%. This accounts for occasional increases in fecundity and/or hatchery survival, which are balanced against the years in which the total number of smolts released is below the limit. Releases should not be in locations other than those proposed and the number released, by life-stage, should not exceed 110% of the proposed production levels in any individual year. Additionally, the releases should not exceed 105% across a five-year running average. This additional production buffer should be used in the minority of situations and annual operational adjustments, to maintain consistency with the proposed production levels and life stages, should be addressed during the development of the annual operation plan(s). NMFS expects the releases to be at or below 100% in any given year but our conclusions in this opinion include these potential exceedances.

Table 3. Summary of annual release groups (number and life stage), egg incubation location, rearing location, acclimation site and time, and release time and location for the program CWT stands for Coded-Wire Tagged.

Program	Annual release groups (number and life stage)	Marking and Tagging	Egg incubation Location	Rearing Location	Acclimation Site and Time	Release Time and Location
Wells Summer Chinook for SRKW	1.0 million subyearlings ¹	100% adipose-clipped and ≥32% CWT ²	Wells Hatchery		Wells Hatchery; October to May ³	May ⁴ ; Columbia River (RM 515)

¹The 1.0M is an “up-to” value depending on funding. Presently, the first two years of production is funded at the 500K production level annually.

² Approximately 484,000 fish will be marked with CWT of the total Chinook subyearling production at Wells Hatchery including the SRKW Summer Chinook program.

³The acclimation timing for this program also includes timeframes for juvenile rearing because juvenile rearing and acclimation take place in the same facility.

⁴Volitional release occurs in mid-May.

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 before release. Sampling, testing, and treatment/control procedures are outlined in and consistent with IHOT (1995); NWIFC and WDFW (2006); PNFHPC (1989).

1.2.4. Proposed Disposition of Excess Juvenile and Adult Hatchery Fish

Please refer to Table 4 regarding disposition protocols of surplus hatchery-origin fish to spawning needs, post-spawned fish, juveniles, and eggs. In general, hatchery practices are carefully managed to not produce fish in excess (over 10%) of hatchery goals.

Table 4. Summary of disposition by life stage

Program(s)	Life stage	Disposition
Wells Summer Chinook for SRKW	Adults	<p>Surplus fish removed at UCR hatcheries may be:</p> <ul style="list-style-type: none"> • 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 and/or co-managers <p>Nutrient enhancement programs are not within the current Proposed Action and will be consulted on in the future, when such plans are created¹</p>
	Juveniles/eggs	<p>Rearing numbers are carefully managed, and surplus eggs and fish released are not expected to exceed 10%. In the case that excess eggs/fish occur, co-managers will inform regional staff and NOAA and an appropriate response will be discussed and decided upon.</p>

¹Of 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.

1.2.5. Proposed Research, Monitoring, and Evaluation (RM&E)

- The program analyzed in this opinion will, in part, utilize data collected from the existing Wells yearling and subyearling summer Chinook RM&E programs consistent with the PUD M&E plan (Hillman et al. 2017a) and data collected by other RM&E programs operating in the Upper Columbia region. RM&E activities 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 survey data (for carcass recovery and redd survey) collected in upper Columbia tributaries will be used to estimate location, number, stray rates, and timing of naturally-spawning summer Wells Hatchery summer Chinook salmon.
 - 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.
 - Determine hatchery fish effects on population productivity, genetic diversity, spawning distribution, and age and size at maturity.
- Evaluation of data collected by 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 age at maturity, etc.).
- Monitoring of each life-stage survival rates in the hatchery.

1.2.6. **Proposed Operation, Maintenance, and/or Construction of Hatchery Facilities**

This hatchery program returns water to the diverted river (minus leakage or evaporation) along with any groundwater discharge. Water at all facilities is withdrawn in accordance with state-issued water rights. This program operates under an applicable National Pollutant Discharge Elimination System (NPDES) general permit. Minor armoring would be maintained at the fish ladders and effluent outfall. For additional information regarding facility water sources for the program, please refer to Table 5.

Several routine (and semi-routine) maintenance activities occur in or near water that could impact fish in the area including: sediment/gravel removal/relocation from intake and/or outfall structures, pond cleaning, pump maintenance, debris removal from intake and outfall structures, and maintenance and stabilization of existing bank protection. All in-water maintenance activities considered “routine” (occurring on an annual basis) or “semi-routine” (occurring with regularity, but not necessarily on an annual basis) for the purposes of this action will occur within existing structures or the footprint of areas that have already been impacted. In-water work will comply with state HPA and/or Department of Ecology authorizations as well as requirements by the USACE. While in-water maintenance activities are not likely to occur, they would comply with the following guidance if they were to occur:

- In-water work will:
 - Be done during the allowable freshwater work times established for each location, or comply with an approved variance of the allowable freshwater work times with the appropriate state agencies
 - Follow a pollution and erosion control plan that addresses equipment and materials storage sites, fueling operations, staging areas, cement mortars and bonding agents, hazardous materials, spill containment and notification, and debris management
 - Cease if ESA listed fish are observed to be in distress at any time as a result of the activities
 - Include notification of NMFS staff
- Equipment will:
 - Be inspected daily, and be free of leaks before leaving the vehicle staging area
 - Work above ordinary high water or in the dry whenever possible
 - Be sized correctly for the work to be performed and have approved oils / lubricants when working below the ordinary high water mark
 - Be staged and fueled in appropriate areas 150 feet from any water body
 - Be cleaned and free of vegetation before they are brought to the site and prior to removal from the project area

Table 5. Facility water source and use for hatchery program operations (WDFW 2019)

Program	Facility	Surface Water					Ground Water (gpm)			Number and type of instream structures	Meet NMFS screening criteria ¹	NPDES Permit
		Source and water right	Max use (cfs)	Diversion distance	Discharge location	Months utilized	Source and water right	Max use (cfs)	Months utilized			
Wells Summer Chinook for SRKW	Wells Hatchery ²	Columbia River; S3-003620 and S4-26074	150	~650 ft.	Columbia River	6	Well field: G4-22856, G4-24462, G4-22857, G4-28847, G4-28598, G4-29184	38	12	3; intake, outfall, ladder	Yes	Yes

¹Older 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.

²The operation of Wells Hatchery was analyzed in the 2017 Biological Opinion (NMFS 2017b).

1.3. 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.

Fisheries are not part of this Proposed Action. Although fisheries target hatchery-origin returns from this program, harvest frameworks are managed separately from hatchery production, and are not solely tied to production numbers. Additionally, production and fishery implementation are subject to different legal mandates and agreements. Because of the complexities in annual management of the production and fishery plans, fisheries in these areas are considered a separate action.

There are also existing ocean fisheries that may catch fish from this program. However, these mixed fisheries would exist with or without this program, and have previously been evaluated in a separate biological opinion (NMFS 2008b). The impacts of fisheries in the Action Area on this program and, in particular, on ESA-listed salmonids returning to the Action Area for this opinion 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 6¹. 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

¹ESA-listed bull trout (*Salvelinus confluentus*) are administered by the USFWS and the proposed hatchery program is currently covered under a separate USFWS Section 7 consultation

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.

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

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (<i>Oncorhynchus tshawytscha</i>)			
Upper Columbia River Spring	Endangered 70 FR 37160; ¹ June 28, 2005	70 FR 52630; Sept 2, 2005	ESA Section 9
Steelhead (<i>O. mykiss</i>)			
Upper Columbia River	Threatened 74 FR 42605; August 24, 2009	70 FR 52630; Sept 2, 2005	70 FR 37160; June 28, 2005

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

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

2.2.1. Status of Listed Species

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

the natural environment. These parameters or attributes are substantially influenced by habitat and other environmental conditions.

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

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

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

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

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

2.2.1.1. Upper Columbia River Spring Chinook Salmon ESU

Chinook salmon (*Oncorhynchus tshawytscha*) have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). ESA-listed UCR spring Chinook salmon are stream-type. Stream-type Chinook salmon rear for 1 year in freshwater, typically 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..

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., no greater than 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/Chewuch (the previous Chewuch and Methow programs combined). Furthermore, a Nason Creek program began in the Wenatchee Subbasin (Grant County PUD et al. 2009b), while the White River releases were discontinued after 2015 (Grant County PUD et al. 2009a).

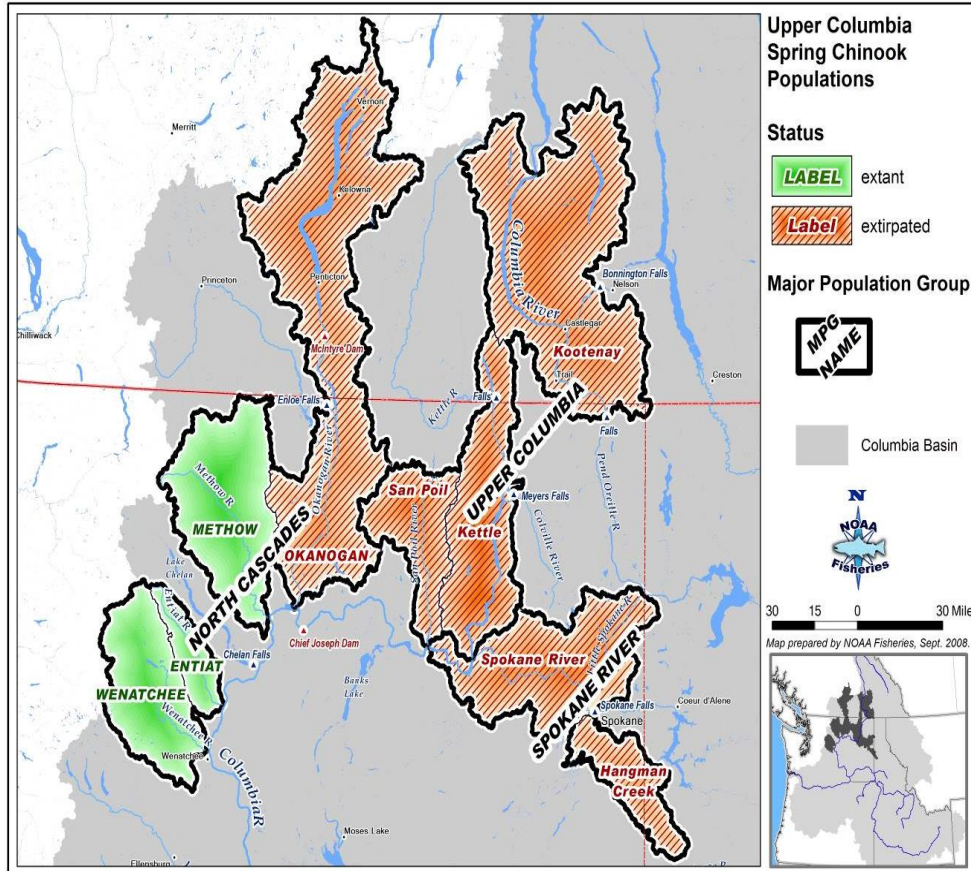


Figure 2. Upper Columbia River Spring Chinook Salmon ESU (ICTRT 2008).

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

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

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

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

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

2.2.1.2. Upper Columbia River Steelhead DPS

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

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

The UCR Steelhead DPS includes all naturally spawned steelhead populations below natural and man-made impassable barriers in streams in the Columbia River Basin upstream of the Yakima River, Washington to the U.S.–Canada border. The UCR Steelhead DPS also includes six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow, Columbia and Okanogan rivers [including Omak Creek]), WNFH, 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 3).

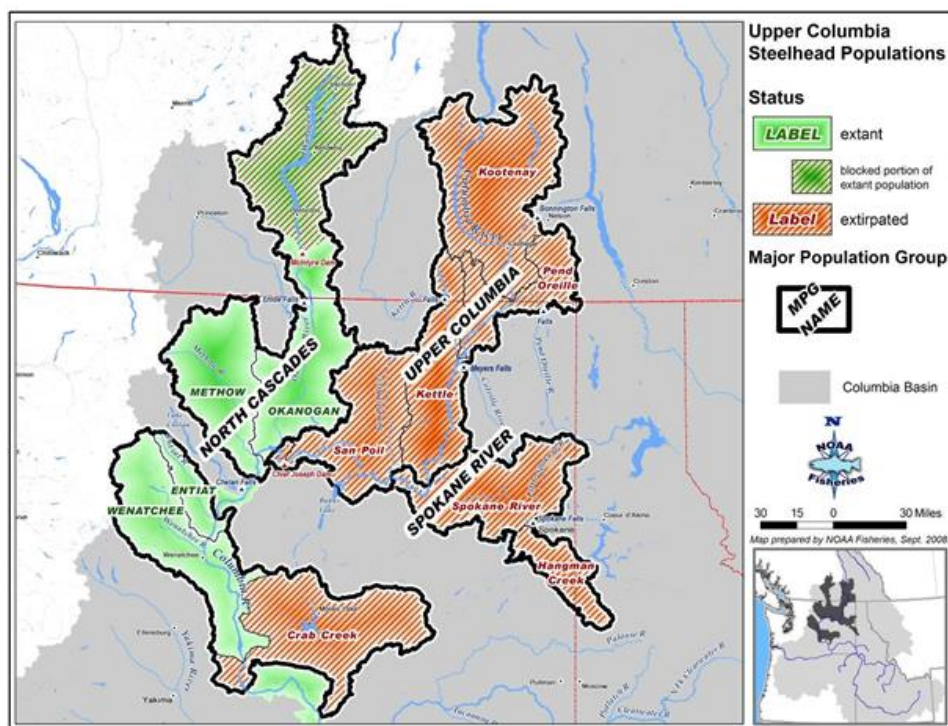


Figure 3. Upper Columbia River Steelhead DPS (ICTRT 2008).

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 8). However, natural-origin returns remain well below target levels for three of the four populations. Productivity remained the same for three of the four populations and decreased for the Entiat population relative to the last review (Ford et al. 2011). For spatial structure and diversity, hatchery origin returns continue to constitute a high fraction (Table 8) 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 8. Risk levels and viability ratings for natural-origin UCR steelhead populations (NWFSC 2015).

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

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

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

2.2.2. 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.

- (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.

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 2005a). 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 impoundments and withdrawals

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 2005a). The following are the major factors limiting the conservation value of critical habitat for UCR steelhead:

- Forestry practices
- Livestock 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

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 release site at Wells Hatchery down to the confluence with the Snake River. Because the releases are high up in the Upper Columbia River and total one million subyearling releases, we do not believe there are any discernible effects on ESA listed salmon and steelhead downstream of the Snake River. Downstream effects have been modeled in the Biological Opinion on the Mitchell Act Funded Hatchery programs (NMFS 2017e) as well as the *United States v Oregon* Biological Opinion (NMFS 2018), which support idea conclusion that there would unlikely be discernible effects from this program on EA listed salmon and steelhead downstream of the Snake River.

The Action Area also includes the Okanogan, Methow, Chelan, Entiat, and Wenatchee Subbasins and their tributaries, which are areas where they may be monitored or might stray. In addition we are also including the estuary (i.e., mouth of the Columbia River) which is an area where returning adults from this Proposed Action will concentrate and Southern Resident Killer Whales may prey on them. This results in a discontinuous Action Area for listed salmonids in the Upper Columbia River basin and Southern Resident Killer Whales in the estuary.

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

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 2017e). 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 in 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.

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 $<1^{\circ}\text{C}$ 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 2015b).

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

The effects of climate change are likely to be already occurring, though the effects are difficult to distinguish from effects of climate variability in the near term. Climate change is currently causing, and is predicted to cause in the future, a variety of impacts on Pacific salmon as well as their ecosystems (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.

- More frequent high intensity wildfires may also significantly change the landscape to promote more erosion and result in less large woody debris recruitment.

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 (2017e).

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 2017e).
- *United States v Oregon* Biological Opinion (NMFS 2018)
- Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin (NMFS 2017b)
- Methow/Winthrop spring Chinook salmon programs (NMFS 2016b).
- WNFH/Wells Complex steelhead programs (NMFS 2017f).
- Entiat National Fish Hatchery summer Chinook salmon program (NMFS 2013b).
- Wenatchee spring Chinook salmon programs (NMFS 2013a).
- Wenatchee steelhead program (NMFS 2016a).
- Upper Columbia River unlisted spring chinook salmon, summer chinook salmon, fall chinook salmon, coho salmon, and sockeye salmon Yakama Nation hatchery programs (NMFS 2003a)

- Confederated Tribes of the Colville Reservation TRMP (NMFS 2017d)

Included in the Environmental Baseline are the ongoing effects of hatchery programs or facilities that have undergone Federal review under the ESA, as well as the past effects of programs that have not yet undergone such review. A more comprehensive discussion of hatchery programs in the Columbia Basin can be found in our opinion on Mitchell Act funded programs (NMFS 2017e). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species (NWFSC 2015) and were 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 9) because the release from the Proposed Action is in the UCR Basin, and the returning adults from the Proposed Action would return to the UCR Basin.

Table 9. Upper Columbia River hatchery programs with releases in the Action Area.

Biological Opinion	Program Name	Maximum Release Level
Wells Complex and WNFH steelhead programs (NMFS 2017f)	Wells Complex ¹	308,000
	Winthrop National Fish Hatchery	200,000
Entiat National Fish Hatchery summer Chinook salmon program (NMFS 2013b)	Entiat National Fish Hatchery	400,000
Chelan Falls summer Chinook program (NMFS 2017b)	Chelan Falls Hatchery	576,000
Wenatchee summer Chinook program (NMFS 2017b)	Wenatchee/Eastbank Fish Hatchery	500,001
Wenatchee spring Chinook salmon programs (NMFS 2013a)	Chiwawa	205,000
	Nason Creek	223,760
Wenatchee steelhead program (NMFS 2016a)	Wenatchee	247,300
Leavenworth spring Chinook salmon program (NMFS 2017c)	Leavenworth National Fish Hatchery	1,200,000
Methow Hatchery Spring Chinook (NMFS 2016a)	Methow Hatchery	223,765
CTCR TRMP hatchery programs (NMFS 2017d)	Spring Chinook	700,000
	Summer/fall Chinook	2,000,000

Biological Opinion	Program Name	Maximum Release Level
	Steelhead	100,000

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

Encounters of UCR spring Chinook salmon during broodstock collection for summer Chinook salmon occur concurrently with RM&E associated with the spring Chinook salmon. These effects are included in the Biological Opinions on the Methow/Winthrop spring Chinook salmon programs (NMFS 2016b) and the WNFH/Wells Complex steelhead programs (NMFS 2017f).

2.4.4. Harvest

Fisheries within the Action Area that harvest or encounter ESA-listed fish include fisheries above Priest Rapids Dam.

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 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 2003b). 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 10 summarizes the incidental take associated with the mark-selective steelhead fisheries from 2010 through 2016.

Table 10. Summary of natural-origin UCR steelhead encounters associated with mark-selective steelhead fisheries above Priest Rapids Dam (2010-2016).

Season	Area	Natural-origin escapement	Allowable incidental take	Realized incidental take ¹
2010-2011	Methow River	1773	71	70
	Columbia River ¹	4050	81	34
2011-2012	Methow River	1187	24	24
	Columbia River ²	1185	24	10
2012-2013	Methow River	905	18	14
	Columbia River ²	545	11	12
2013-2014	Methow River	1481	30	23
	Columbia River ³	359	7	5
2014-2015	Methow River	2168	43	17

Season	Area	Natural-origin escapement	Allowable incidental take	Realized incidental take ¹
2015-2016	Columbia River³	283	6	8
	Methow River	1248	25	25
	Columbia River³	98	2	4

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.

³ This includes the reach from Rock Island to Wells Dam.

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 11). The summer Chinook and sockeye salmon fishery has incidentally killed up to 10 adult steelhead annually (Table 11), which is within their allotted take under permit 1554 (NMFS 2008e). 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). In addition, there are Confederated Tribes of the Colville Reservation (CTCR) fisheries in the Upper Columbia River. These fisheries target summer Chinook and may incidentally encounter ESA-listed spring Chinook salmon and steelhead through a purse seine fishery in the mouth of the Okanogan and a snag fishery below Chief Joseph Dam (NMFS 2017d).

Table 11. 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).

Year	Fishery	Allowable steelhead	Realized steelhead	Allowable spring Chinook salmon	Realized spring Chinook salmon
2012	Methow River resident trout	1250 juveniles 20 adults	429 juveniles 12 adults	8 juveniles	0 juveniles
	Summer Chinook and sockeye salmon	10 adults	9 adults	0	0

Year	Fishery	Allowable steelhead	Realized steelhead	Allowable spring Chinook salmon	Realized spring Chinook salmon
	Icicle Creek spring Chinook salmon	10 adults	0	3 adults	1 adult
2013	Methow River resident trout	1250 juveniles 20 adults	650 juveniles 12 adults	8 juveniles	8 juveniles
	Summer Chinook and sockeye salmon	10 adults	4 adults	0	0
	Icicle Creek spring Chinook salmon	10 adults	14 adults	3 adults	No information
2014	Methow River resident trout	1250 juveniles 20 adults	302 juveniles 4 adults	8 juveniles	8 juveniles
	Summer Chinook and sockeye salmon	10 adults	10 adults	0	0
	Icicle Creek spring Chinook salmon	10 adults	0	3 adults	No information
2015	Methow River resident trout	1250 juveniles 20 adults	396 juveniles 0 adults	8 juveniles	2 juveniles
	Summer Chinook and sockeye salmon	10 adults	9 adults	0	0
	Icicle Creek spring Chinook salmon	10 adults	0	3 adults	No information
2016	Methow River resident trout	1250 juveniles 20 adults	495 juveniles 0 adults	8 juveniles	4 juveniles
	Summer Chinook and sockeye salmon	10 adults	3 adults	0	0
	Icicle Creek spring Chinook salmon	10 adults	2 adults	3 adults	No information

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 2004; NMFS 2005b; NMFS 2008a; NMFS 2011). 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, Upper Columbia River spring Chinook salmon and Upper Columbia River steelhead, in the Action Area.

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 program in this Proposed Action propagates non-ESA-listed summer 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. Therefore, there is no overall effect of this factor on these species. Inadvertent collection of listed species will be considered under Factor 2.

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

The proposed hatchery program poses 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.

Genetic Effects

Because the fish from the Proposed Action return to the UCR Basin as an adult to potentially spawn, only listed species that 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 Chinook salmon from the early part of the run (Table 12) in some areas where spatial and temporal spawning distributions overlap. However, based on spring Chinook salmon spawning timing in subbasins where hatchery summer Chinook salmon are released (e.g., Snow et al. (2016), Hillman et al. (2016)), there is little to no temporal overlap with summer Chinook salmon spawning, so interbreeding between hatchery-origin summer Chinook salmon and UCR spring Chinook salmon is unlikely.

Table 12. Timing of adult return and spawning for UCR salmonids.

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

Sources: (WDFW 2002)

Ecological Effects

Ecological effects from returning adult hatchery-origin fish include redd superimposition, competition for spawning grounds, and contribution of marine derived nutrients. Predation by the returning adult hatchery-origin fish is not likely to be an ecological effect because these adult fish cease to eat upon freshwater entry.

In Table 13 below, the average number of fish from releases out of the Wells Hatchery that have strayed to other basins is summarized. While we do not have data for the proposed hatchery program, we expect these results to be similar to past releases. These numbers are the number of

hatchery-origin fish that could interact with ESA-listed fish in the recipient basins, as discussed below.

Table 13. Average number of hatchery-origin summer salmon straying into other basins.

Program	Chelan¹	Entiat¹	Hanford Reach²	Methow³	Okanogan³	Wenatchee³
Wells	63	8	(not reported)	108	69	4

¹ Source: (Hillman et al. 2017)

² Source: (Richards and Pearsons 2015)

³ Source: (Snow et al. 2016)

Spawning site competition and redd superimposition are possible ecological effects between spring Chinook salmon and hatchery-origin summer Chinook salmon. The potential effects of spawning site competition could occur in September when spawning timing of UCR spring and summer Chinook salmon runs could briefly overlap (Table 12). However, the likelihood of spatial overlap is minimal because spring Chinook salmon tend to spawn farther upstream than summer Chinook salmon (e.g., Snow et al. (2016), Hillman et al. (2016)).

Even though summer and spring Chinook salmon may overlap spatially in some tributary mainstems, the likelihood of redd superimposition appears to be low even in target areas. In the Wenatchee River, which is a target area of the previously consulted on Wenatchee program (NMFS 2017b) redd superimposition of spring Chinook salmon redds by summer Chinook salmon from the Wenatchee summer Chinook program were observed to be very limited, typically 2 or 3 per year (Willard 2017), compared to the average of 48 spring Chinook salmon redds 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 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 Chinook salmon program. Because the Wenatchee summer Chinook hatchery program fish return to the Wenatchee River and the fish from the Wells summer Chinook hatchery program are intended to return to the mainstem Columbia (with a few exceptions, Table 13) we do not expect any fish from this new program to superimpose on spring Chinook salmon redds in the tributaries where spring Chinook salmon spawn. We, therefore, conclude that the likelihood of redd superimposition on UCR spring Chinook salmon by hatchery-origin summer Chinook salmon from the Wells summer Chinook salmon program is low, and the adverse effects, therefore, minimal.

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

Because the average total numbers of strays from all programs into other basins are small and because the likelihood of competition or redd superimposition is minimal to none, the strays

from this hatchery program are unlikely to have any detectable ecological effects on any of the naturally spawning ESA-listed species.

Hatchery fish contribute marine-derived nutrients to the ecosystem in the Upper Columbia River. This program does not intend for returning adults to spawn naturally. Fish are removed through harvest and by the Wells Hatchery volunteer channel for broodstock, surplus, and gene flow management. Fish that are not removed would contribute marine derived nutrients to the ecological system.

Adult Collection Facilities

Negligible: While broodstock collection for these programs target summer 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 these encounters do not lead to mortality. Most of the encounters of UCR spring Chinook salmon during broodstock collection for summer Chinook salmon occur concurrently with RM&E associated with the spring Chinook salmon. Broodstock collection for this program occurs prior to the arrival of most of the steelhead run, limiting the number of steelhead encountered. 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 14 summarizes where the effects have already been considered in other opinions.

Table 14. Broodstock collection for summer Chinook salmon and associated biological opinions where effects on listed species have been already analyzed.

Program	Collection Location	Collection Duration	Spring Chinook Salmon Analysis	Summer Steelhead Analysis
Wells Hatchery	Wells Hatchery/Dam	July 1-August 28	NMFS (2016b)	NMFS (2017f)

Operators use visual inspection combined with genetic samples from spring Chinook salmon to verify that the correct runs are used in broodstock. In addition, summer Chinook predominantly return to the volunteer channel in Wells Hatchery whereas spring Chinook tend to return through the fish ladders in the Wells Dam. Fish are collected at each of these locations, accordingly.

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

NMFS also analyzes the potential for competition and predation when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas and migratory corridors. Because the fish released under the Proposed Action are likely to affect natural-origin fish as they emigrate, the effects analysis here includes the distance from release to the confluence of the Snake 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 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 (Pearsons and Busack 2012), to quantify the potential number of natural-origin salmon and steelhead juveniles lost to competition and predation from the release of hatchery-origin juveniles. Although model logic is still largely as described in the Pearsons and Busack 2012 paper the PCD Risk model has undergone considerable modification since then to increase supportability and reliability. Notably, the current version no longer operates in a Windows environment and no longer has a probabilistic mode. We also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run. The one modification to the logic was a 2018 elimination of competition equivalents and replacement of the disease function with a delayed mortality parameter. The rationale behind these changes was to make the model more realistic; competition rarely directly results in death in the model because it takes many competitive interactions to suffer enough weight loss to kill a fish. Weight loss is how adverse competitive interactions are captured in the model. However, fish that are competed with and suffer some degree of weight loss are likely more vulnerable to mortality from other factors such as disease. Now, at the end of each run, the competitive impacts for each fish are assessed, and the fish has a probability of delayed mortality based on the competitive impacts. This function will be subject to refinement based on research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20% probability of delayed death, ($0.2 = 0.1/0.5$). Parameter values used in the model runs are shown in Table 15 -Table 17.

For our model runs, we assumed a 100 percent population overlap between hatchery fish and all natural-origin species present. Hatchery summer Chinook salmon are volitionally released in mid-May. These releases may overlap with natural-origin coho; sockeye; spring, summer, 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. We acknowledge that a 100-percent population overlap in microhabitats is likely an overestimation.

The model was run from release site at the Wells Hatchery to the confluence of the Snake River. The following explains the caveats regarding each step of this model run from release to the confluence of the Snake River:

- Travel (residence) time was calculated using mean miles per day and distance from point A to point B. The reported value is the arithmetic mean travel days over the years 2009 to 2019 (Tonseth 2020).

- Survival information to the confluence of the Snake River does not exist (no PIT detection array in this location) so we used the ten year arithmetic mean of survival data from release (Wells Hatchery) to Rocky Reach and release to McNary Dam in the years 2009 to 2019 as a proxy (Tonseth 2020).
- Water 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 Spring Chinook salmon and age-2 steelhead because rearing fish (age-0 Spring Chinook salmon and age-1 steelhead) are not present in substantial numbers in the mainstem Columbia River. The negligible amount of age-1 steelhead that may be present would largely be included in the age-2 steelhead class (Tonseth 2020).

Table 15. Parameters from the PCD Risk model that are the same across all programs.

Parameter	Value ¹
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for Chinook salmon; 0.6 for all other species
Dominance mode	3
Piscivory	0 for all species interacting with subyearling summer Chinook salmon
Maximum encounters per day	3
Predator:prey length ratio for predation	0.25 ²

¹ All values from HETT (2014) unless otherwise noted.

² Daly et al. (2014)

Table 16. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

Species	Age Class	Size in mm (SD)	Source
Chinook salmon	0	38 (4)	HETT (2014)
	1	98 (4)	HETT (2014)
Steelhead	1	126 (24)	HETT (2014)
	2	170 (24)	HETT (2014)

Table 17. Hatchery fish parameter values for the PCD Risk model run from release of fish to the confluence of the Snake River.

Program	Release Site	Release Number	Size in mm (SD) at release	Survival Rates to Snake confluence (mean)¹	Travel (residence) Time (mean days) from release to confluence of the Snake River²	Temp. at release³ (°C)
Wells summer Chinook salmon (subyearlings)	Columbia River (RM 515)	1,000,000	103 (20)	0.43	31.01	9.7

¹ Survival information to the confluence of the Snake River does not exist (no array) so we found the arithmetic mean of survival data from release (Wells Hatchery) to Rocky Reach and release to McNary Dam in the years 2009 to 2019 (Tonseth 2020)

² Travel time was estimated by dividing the number of miles between Wells Dam and the confluence of the Snake River by the number of miles per day between Wells and McNary dams.

³ Data from http://www.cbr.washington.edu/dart/query/river_graph_text; access date August 16, 2017. 10 year average (2007-2016) of temperature (WQM).

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. 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 the confluence of the Snake River on an annual basis (using a 5-year rolling median) compared to the values used in our analyses (see Table 17). The resulting juveniles lost from release to the confluence of the Snake River for all natural-origin species are summarized in Table 18. Using the smolt-to-adult survival rate (SAR) representative of each species, these lost juveniles equate to 32 adult Spring Chinook salmon and 1 adult steelhead (Table 18) from release to the confluence of the Snake River.

Table 18. Maximum numbers of juvenile natural-origin salmon and steelhead lost to competition (C) from hatchery-origin summer Chinook salmon from the Proposed Action for model runs from release to the Confluence of the Snake River. There are no losses due to predation (P) because the hatchery subyearling summer Chinook salmon are too small to eat age-one Chinook

in the mainstem Columbia at this point in time, and assumed no predation occurs on steelhead or sockeye salmon from subyearling Chinook salmon in the mainstem Columbia (HETT 2014).

Program	Release Site	Chinook Salmon ¹	Steelhead ²
		C ³	C ³
Wells summer Chinook salmon (subyearlings)	Columbia River (RM 515)	8,778	15
SAR ⁴		0.0037	0.011
Adult Equivalents		32	1

¹ The Chinook salmon lost here includes age-1 fish from release site (Wells Hatchery) to the confluence of the Snake River.

² The steelhead lost here includes age-2 fish from release site (Wells Hatchery) to the confluence of the Snake River.

³ 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.

⁴ SAR for Chinook salmon (average of: Grant County PUD et al. 2009b; NMFS 2016b) and steelhead (NMFS 2017f).

Similar to the use of models for biological systems elsewhere, this model cannot possibly account for all the variables that could influence competition and predation of hatchery juveniles on natural juveniles. For example, the model assumes that if a hatchery fish is piscivorous and stomach capacity allows the fish to consume prey it will be natural-origin prey. The reality is hatchery-origin fish could choose to eat a wide variety of invertebrates, other fish species (e.g., shad, minnows), and other hatchery-origin fish in addition to natural-origin smolts. However, we believe that with this model we are estimating, to the best of our ability, a worst-case estimate for the effects on natural-origin juveniles.

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 confluence of the Snake River 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). 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 in the ESU, then the loss our model predicts would be some percentage of the 5 percent contribution of that population to the ESU.

To understand the potential effect on the UCR Spring Chinook salmon ESU and Steelhead DPS, we calculated the likely percentage of adults that would be lost from competition and predation from each ESU and DPS. In other words, we divided the total amount of adult equivalents lost by the most recent five year average natural-origin escapement of the ESU or DPS (ODFW and WDFW 2016) and multiplied this by one hundred. These would equate to a potential loss of <1 percent of the potential adult return from competition and predation during the adult life stage (Table 19) Based on the assumptions used in NMFS' simulations, even before taking into account the very conservative nature of these assumptions, it appears that ecological impacts from the release of the 1 million hatchery-origin subyearlings included in this Proposed Action is negligible.

Table 19. Maximum total ESA-listed natural-origin adult equivalents lost through competition and predation with juvenile hatchery fish by ESU/DPS compared to returning adults of respective ESU/DPS.

Listed Species (ESU/DPS)	Total adult returns	Total lost adult equivalents to competition and predation	Percentage of Lost Adults to Total Adults at confluence of the Snake River
UCR Spring Chinook Salmon ESU	5,064 ¹	32	0.63
UCR Steelhead DPS	6,929 ²	1	0.01

¹ 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).

² 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. Therefore, residuals from programs that release into mainstem Columbia River (i.e., Wells Hatchery summer Chinook program) 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 Chinook salmon migrate out as subyearlings, the risk that subyearlings released through the hatchery program remain to residualize and affect ESA-listed species is negligible.

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 because the natural-

origin juvenile rearing occurs in the tributary(ies), upstream and in other rivers than the release site.

Applicants have a Proposed Action that is expected to minimize their ecological impacts, and continue to improve their hatchery rearing practice to minimize early maturation. For example, subyearlings are reared on surface water that is at ambient natural temperatures before release. The fish are grown to a size target designed to balance survival and residualism. The release timing has been adjusted to maximize survival from release to adult, and it is possible that a component of this survival is gained by reduced residualism. Based on observations from similar programs, NMFS expects that no more than 5 percent of program fish from each release group should be observed as having the potential to residualize, using a running five-year average beginning with the 2020 release.

Naturally-produced progeny competition

Naturally spawning hatchery-origin 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 given the totality of hatchery releases. 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. This is unlikely because the fish are not released in the tributaries; therefore, since they are not homing to tributaries, only a small number of adults from this program are expected stray into tributaries to potentially spawn successfully. However, ecological impacts on listed species may increase in the future if the summer Chinook salmon populations grow.

Because summer 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. NMFS expects that the monitoring efforts would detect negative impacts before they reach problematic levels, and we include language in the Incidental Take Statement (ITS) (Section 2.9) to ensure that appropriate monitoring takes place.

Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is likely negligible for this hatchery program. This is because no detections of exotic pathogens have occurred in the last three years at a similar program out of the Wells Hatchery. Furthermore, epidemics have all been caused by endemic pathogens with available treatments (Table 20). Diseases that could be caused by pathogens outlined in Table 20 were treated accordingly (e.g., medicated feed, formalin) (WDFW 2017b).

Table 20. Pathogens detected in summer Chinook salmon reared in a similar program out of the Wells Hatchery.

Program		Pathogen Detected		
		2017	2018	2019
Wells Summer Chinook	Bacteria	<i>Flavobacterium columnare</i>	<i>Flavobacterium columnare</i>	<i>Flavobacterium columnare</i>
		<i>Renibacterium salmoninarum</i>	<i>Flavobacterium branchiophilum</i>	<i>Flavobacterium psychrophilum</i>
			<i>Pseudomonas fluorescens</i>	<i>Renibacterium salmoninarum</i>
	Protozoa	<i>Ichthyophthirius multifiliis</i>	<i>Ichthyophthirius multifiliis</i>	<i>Ichthyophthirius multifiliis</i>
		<i>Chilodonella</i> sp.	<i>Ichthyobodo necator</i>	
		<i>Ichthyobodo necator</i>	<i>Tetrahymena</i> sp.	<i>Ichthyobodo necator</i>
	Nematodes	N/A	N/A	<i>Anisakiasis</i>
	Copepods	<i>Salmincola</i> sp.	<i>Salmincola</i> sp.	<i>Salmincola</i> sp.
	Fungi	N/A	<i>Phoma herbarum</i>	<i>Phoma herbarum</i>
	Water molds	<i>Saprolegnia parasitica</i>	<i>Saprolegnia parasitica</i>	<i>Saprolegnia parasitica</i>

Douglas County PUD has endeavored to mitigate fish loss and morbidity through therapeutic intervention when appropriate. FDA-approved chemicals, such as formalin, have been used successfully to treat external water mold and protozoan infestations. Infections caused by bacteria, namely those in the genus *Flavobacterium*, have been managed with Diquat Reward™ (an herbicide permitted for aquaculture use through a special investigational new animal drug [INAD] study) or florfenicol medicated feed. Other conditions that are caused by developmental abnormalities, adverse environmental conditions, nutritional deficiencies, or pathogens without proven efficacious remedies, are approached with emphasis on prevention (i.e. changes in fish culture practices) or increased biosecurity standards if the ailment is believed to be caused by an infectious agent. Control strategies have been largely successful in reducing fish morbidity, mortality, and the spread of disease, with few exceptions. The most significant fish health event concerning Chinook at Wells Hatchery within the last few years occurred in October 2017. Summer Chinook adults (broodstock) were afflicted with columnaris disease for the first time in the hatchery's known history, and the acute and virulent nature of the infection caused substantial pre-spawning mortality. Other hatcheries in the region experienced a similar event that year. This disease is now considered enzootic to the upper Columbia River and is largely attributed to changing river conditions. Today, returning adults are screened for lesions before entering the hatchery and treated early if clinical symptoms are observed; this has proven to be an effective approach. Wells Hatchery aspires to maintain a high standard of fish culture and disease management practices. 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

There are no direct sampling efforts made for summer Chinook salmon for the Wells Hatchery programs. Therefore, we conclude that ESA-listed species are not likely to be affected.

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

Best available information indicates that most hatchery facility operations have no effect on ESA-listed species. 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.

As described in Table 21, the operation of this facility has been analyzed in a previous consultation (NMFS 2017f) Please refer to this consultation for more information regarding facility water withdrawal, effluent, and discharge analyses. In addition, this facility is appropriately screened and in compliance with NMFS criteria for their intake pipes and is operated under an NPDES permit Table 5.

Table 21. Program facility and water use

Program	Facility	Surface Water (cfs)	Ground Water (cfs)	Water Source	Water Diversion Distance	Discharge Location
Wells Hatchery Summer/Fall Chinook Salmon	Wells Hatchery ¹	150	38	Columbia River	~650 ft.	Columbia River

¹The operation of Wells Hatchery was analyzed in NMFS (2017f).

As previously described in (NMFS 2017f), this facility is not likely to adversely affect ESA-listed salmonids.

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

There are no fisheries that exist because of the Proposed Action. The effects of fisheries that may impact fish produced by this program is 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 2015a; NMFS 2015b; NMFS 2016c; NMFS and ODFW 2011; UCSRB 2007) are such plans and they describe, 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 2008c), the *U.S. v Oregon* Biological Opinion (NMFS 2018), the Mitchell Act Biological Opinion (NMFS 2017a), and the Biological Opinion for Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin (NMFS 2017b), many of which are relevant to this Action Area. These include effects from hydropower operations, harmful land-use practices, fisheries, and hatchery operations on ESA listed salmon and steelhead. These effects may interfere with salmon and steelhead passage/migration, food web interactions, ecological interactions, genetics, and spawning as well as abiotic factors like water quantity/quality, temperature, total dissolved oxygen, and sediment transport. Downstream ecological interactions have been modeled in the Biological Opinion on the Mitchell Act Funded Hatchery programs (NMFS 2017e) as well as the *United States v Oregon* Biological Opinion (NMFS 2018), which helps support our idea that there would unlikely be discernible effects from this program on EA listed salmon and steelhead downstream of the Snake River. It should be noted that the actions in these Biological Opinions are included in the Environmental Baseline Section 2.4.

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 had to undergo review under the ESA to ensure that listed species are not jeopardized and that “take” under the ESA from salmon and steelhead hatchery programs is minimized or avoided. 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 (and have been occurring) 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

In addition to the effects described above, climate change may increase temperatures, decrease snowpack, shift seasonal hydrology, and increase the frequency of wildfires. We may reasonably expect these effects to alter the physiology, stream flow patterns, and food webs of salmon and steelhead. 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 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 and continue to constitute limiting factors in species recovery, 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. 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 from the proposed program. Our analysis showed that the impacts of this program could equate to up to a loss of 32 Chinook salmon adult equivalents from the ESU, which constitutes 0.63 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 32 adult equivalents includes all Chinook juveniles within a size range, and thus could also include unlisted summer or fall Chinook salmon as well (i.e., not all 32 would necessarily be UCR spring Chinook).

Assuming the worst-case scenario that all 32 adult equivalents would be UCR spring Chinook, the total impacts on the UCR Spring Chinook ESU as a result of the Proposed Action would be the loss of an estimated maximum of 0.63 percent of adult equivalents from ecological interactions during juvenile outmigration. The effect of these losses would be to reduce the abundance and productivity of the ESU. As described in Section 2.2.1.2, 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 7). 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 a maximum 0.21 percent of the outmigrating juvenile abundance as a result of the Proposed Action. This 0.21-percent 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 salmon. 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 this ESA-listed ESU in the wild.

2.7.2. UCR Steelhead DPS

Best available information indicates that the UCR Steelhead DPS is at high risk and remains at threatened status (Ford et al. 2011). Ford et al. (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. 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 returning from the proposed program. However, natural-origin juveniles may potentially experience a negative effect because of the overlap in outmigration timing with the hatchery-origin juveniles from the proposed program. Our analysis showed that the impacts of this program equates to a loss of 1 steelhead adult equivalents from the DPS, which constitutes 0.01 percent of returning adults from this DPS at the mouth of the Columbia River.

The total impacts on the UCR Steelhead DPS as a result of the Proposed Action would be the loss of estimated 0.01 percent of adult equivalents from ecological interactions during juvenile outmigration. The effect of these losses would be to reduce the abundance and productivity of the DPS. As described in Section 2.2.1.2, 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 8). 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 0.0025 percent of the outmigrating juvenile abundance as a result of the Proposed Action. This 0.0025 percent 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 plan for this DPS describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect the listed steelhead DPS. 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 this ESA-listed DPS in the wild.

2.7.3. Critical Habitat

Only the PBFs for UCR spring Chinook salmon and UCR steelhead may be affected from the Proposed Action. However, the proposed action will not increase the amount of trapping conducted over that which is ongoing for existing programs. 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. Moreover, the operation of these facilities will occur whether or not the Proposed Action is implemented, so the proposed hatchery program will not increase the trapping activity. Therefore, the number of natural-origin adults delayed is not expected to increase over current conditions. Thus, there will be very little to no additional impact on the spawning, rearing, and migration PBFs of UCR spring Chinook salmon and UCR steelhead, 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 6 and Table 22), or destroy or adversely modify designated critical habitat.

Table 22. Summary of NMFS determination of effects.

ESA-Listed Species	Is the Action Likely to Adversely Affect Species?	Is the Action Likely to Adversely Affect Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
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Upper Columbia River Spring Chinook salmon	Yes	Yes	No	No
Upper Columbia River steelhead	Yes	Yes	No	No

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass², harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that 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

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

Incidental take of UCR spring Chinook and steelhead associated with broodstock collection for this program occurs concurrently with RM&E associated with the spring Chinook salmon. These effects are evaluated in the Biological Opinions on the Methow/Winthrop spring Chinook salmon programs and the amount or extent of incidental take associated with those actions is described there (NMFS 2016b) and the WNFH/Wells Complex steelhead programs (NMFS 2017f).

² NMFS recognizes the benefit of providing guidance on the interpretation of the term "harass". As a first step, for use on an interim basis, NMFS will interpret harass in a manner similar to the USFWS regulatory definition for non-captive wildlife: "Create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." NMFS interprets the phrase "significantly disrupt normal behavioral patterns" to mean a change in the animal's behavior (breeding, feeding, sheltering, resting, migrating, etc.) that could reasonably be expected, alone or in concert with other factors, to create or increase the risk of injury to an [ESA-listed] animal when added to the condition of the exposed animal before the disruption occurred. See Weiting (2016) for more information on the interim definition of "harass."

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 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 quantify the extent of take through ecological effects using two different surrogates, one specifically addressing residualism of hatchery summer Chinook and the second related to how quickly hatchery summer Chinook salmon leave the system.

For residualism, the take surrogate is the percentage of summer Chinook salmon from the yearling release group, used as a proxy for the subyearling 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 Chinook salmon and parr 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 5 percent of program fish from each release group should be observed as having the potential to residualize, using a running five-year average beginning with the 2020 release³. The take surrogate can be monitored by either of the following methods: 1) lethal visual assessment that would look for precociously mature fish; or 2) non-lethal visual assessment that would look for precociously mature males 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 precociously 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 effective method of monitoring.

For ecological effects of competition and predation caused by emigrating hatchery summer Chinook salmon, NMFS applies a take surrogate that relates to the median travel time for hatchery fish to reach the confluence of the Snake River 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 Chinook salmon is five days longer than the median value (which equates to 50% of the fish) identified in Table 17 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 17 is 20 days, and then the median for the next three of five years for a particular release group is 23 days, this would not exceed the

³ However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed percent after five years, operators will contact NMFS in the year the likely exceedance is discovered.

take threshold, but if it was 25 (or more) days for three of five years, 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.

- The proposed action is not expected to result in any single release of smolts in numbers that exceed 110% of the targeted release number identified above through ecological interactions;
- The proposed action is not expected to result in any five-year average calculation of smolt releases that exceed 105% of the applicable targeted release number identified above through ecological interactions;
- The proposed action is not expected to result in any change in release location from the locations identified in the HGMPs for the programs included in the Proposed Action through ecological interactions;
- The proposed action is not expected to result in any change from the planned average size of fish released for each program in the Proposed Action through ecological interactions.

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 shall ensure that:

1. The applicants implement the hatchery program and operate the hatchery facilities as described in the Proposed Action (Section 1.2) and in the submitted HGMPs.
2. The applicants provide reports to SFD annually for the hatchery program, 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.

NMFS shall ensure that:

1a. The applicants implement the Wells Summer Chinook Hatchery Program for Southern Resident Killer Whales program as described in the Proposed Action (Section 1.2) and the submitted HGMP 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.
2. The applicants provide reports to NMFS SFD annually on or before December 31st of the year following data collection 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: Natasha Preston (503) 231-2178, *natasha.preston@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.
 - a. Annual reports to SFD for hatchery programs should include:
 - i. The number and origin (hatchery and natural) of each listed species handled and incidental mortality across all activities Hatchery Environment Monitoring Report
 - Number and composition of broodstock, and dates of collection
 - Numbers, pounds, dates, locations, size (and coefficient of variation), and tag/mark information of released fish
 - Survival rates of all life stages (i.e., egg-to-smolt; smolt-to-adult)
 - Disease occurrence at hatcheries
 - Precocious maturation rates prior to release
 - Any problems that may have arisen during hatchery activities
 - Any unforeseen effects on listed fish
 - ii. Natural Environmental Monitoring Report
 - The number of returning hatchery and natural-origin adults, including stray information to tributaries

- The number and species of listed fish encountered at each adult collection location, and the number that die
- The contribution of fish from these programs into ESA-listed populations (i.e., Methow River) based on CWT recoveries/PIT tag detections
- Post-release out-of-basin migration timing (median travel time) of juvenile hatchery-origin fish to the confluence of the Snake River.
- Number and species of listed juveniles and adults encountered and the number that die during RM&E activities

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 no conservation recommendations.

2.11. Re-initiation of Consultation

This concludes formal consultation on the approval and implementation of one hatchery program rearing and releasing summer 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 Southern Resident Killer Whale DPS.

2.12.1. 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).

The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008d). Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, it is likely that multiple threats are acting together to impact the whales (NMFS 2008d).

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 2008d). During the spring, summer, and fall, Southern Residents have typically spent a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Hanson and Emmons 2010; Krahn et al. 2004). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Ford et al. 2016; Hanson and Emmons 2010; Osborne 1999). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research conducted have provided an updated estimate of the whales' coastal range that extends from the Monterey Bay area in California, north to Chatham Strait in southeast Alaska. For example, acoustic recorders have detected SRKWs off Washington coast in all months of the year (Emmons et al. 2019), indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, and in other coastal waters more often than previously believed (Hanson et al. 2017).

As part of a collaborative effort between NWFSC, Cascadia Research Collective and the University of Alaska, satellite-linked tags were deployed on eight male SRKW (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon (Hanson et al. 2017). The tags transmitted multiple locations per day to assess winter movements and occurrences of SRKW (Hanson et al. 2017).

Over the course of the study, the satellite tagging resulted in data range of duration days, from 3 days to 96 days depending on the tag, of monitoring with deployment durations from late December to mid-May. The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from central west coast of Vancouver Island, British Columbia to northern California (Hanson et al. 2017) (Hanson *et al.* 2017). J pod had high use areas in the northern Strait of Georgia and the west entrance to the Strait of Juan de Fuca where they spent approximately 30 percent of their time there. K/L pods occurred almost

exclusively on the continental shelf during December to mid-May, primarily on the Washington coast, with a continuous high use area between Grays Harbor and the Columbia River and off Westport and spending approximately 53 percent of their time there (Hanson et al. 2018).

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).

Observations of SRKWs overlapping with salmon runs (Wiles 2004; Zamon et al. 2007) and collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months. Although fewer predation events have been observed and less fecal samples collected in coastal waters, recent data indicate that salmon, and Chinook salmon in particular, remains an important dietary component when the SRKWs occur in outer coastal waters during these timeframes (NMFS 2019). Results of the available prey samples indicate that, as is the case in inland waters, Chinook are the primary species detected in diet samples on the outer coast, although steelhead, chum, lingcod, and halibut were also detected in samples. Despite J pod utilizing much of the Salish Sea – including the Strait of Georgia – in winter months (Hanson et al. 2018), few diet samples have been collected in this region in winter.

The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 U.S. west coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpublished data). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90 percent of the 55 diet samples collected for SRKW's in coastal areas (NWFSC unpublished data).

The diet data suggest that SRKWs are consuming mostly larger (*i.e.*, generally age 3 and up) Chinook salmon (Ford and Ellis 2006). Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods (Ford and Ellis 2006). Factors of potential importance include the species' large size, high fat and energy content, and year-round occurrence in the SRKWs' geographic range. 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). For example, in order for a SRKW to obtain the total energy value of one adult Chinook salmon, they would need to consume approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014).

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). NMFS and WDFW developed a framework in the Southern Resident Killer Whale Priority Chinook Stocks Report (NOAA and WDFW 2018) to identify Chinook salmon stocks that are important to SRKW. According to this report, the Upper Columbia Summer Chinook Salmon were rated a total score of 3.31 out of 5 points. These total scores are a sum of the following three factors: FACTOR 1- Observed part of SRKW diet (using tissues/scales and fecal samples), FACTOR 2- Consumed during reduced body condition or diversified SRKW diet (using aerial photogrammetry), and FACTOR 3- Degree of spatial and temporal overlap (recent prey mapping to overlap in time and space distribution of all Chinook salmon stocks). It is important to note that this stock was detected in SRKW diet and consumed during a period when there may be a higher likelihood of poor body condition. The primary reason for scoring in the middle of the point system was that the spatial and temporal factor was relatively low for them (Upper Columbia Summer Chinook Salmon have a northerly distribution and do not congregate off of the coast of Washington). A score of 3.31 places this stock in the middle of the Chinook salmon prey list, and qualifies it as priority prey to help aid in the recovery of SRKW.

The annual release of 1,000,000 summer Chinook salmon subyearlings under the Proposed Action could potentially increase the number of Chinook salmon available to the SRKW in coastal waters by 84,000 summer Chinook salmon adults returning annually to the river. These adult survival numbers are calculated by applying the Chinook salmon SARs to the release numbers⁴. 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 (2017e) 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 Chinook salmon to this total from the release of hatchery fish under the Proposed Action is less than 4.13% 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 0.63 percent of returning adults at the mouth within the UCR Spring Chinook salmon ESU, though, as mentioned above, these numbers are likely an overestimate (see section

⁴ For the summer Chinook subyearling releases, we used the average SAR% for the Wells subyearling program for brood year 1993–2010, which was 0.084.

2.5.2.3 and Table 19); 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 19) 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 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 Chinook salmon in the Upper Columbia River under the Proposed Action is not likely to adversely affect the SRKW.

Southern Resident Killer Whale Critical Habitat

Critical habitat in inland waters of Washington was designated on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters of Washington in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi²) (40,472.7 square kilometers (km²)) of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California. In the proposed rule (84 FR 49214), NMFS states that the “proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection.” The three physical or biological features essential to conservation in the 2006 designated critical habitat were also identified for the six new areas along the U.S. West Coast. In the proposed rule (84 FR 49214), NMFS identified six areas off the U.S. west coast delineated based on SRKW use and the habitat features.

In addition to the direct and indirect effects to the species discussed above, the proposed action affects critical habitat proposed in coastal waters for Southern Resident killer whales. While SRKW critical habitat is not located within the boundaries of the Action Area, the Proposed Action has the potential to affect the quantity and availability of prey within SRKW critical habitat. As discussed above, the annual release of 1,000,000 summer Chinook salmon subyearlings under the Proposed Action could potentially increase the number of Chinook salmon available to the SRKW in coastal waters by 84,000 summer Chinook salmon adults

returning annually to the river. The contribution of summer Chinook salmon to this total from the release of hatchery fish under the Proposed Action is less than 4.13% 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 0.63 percent of returning adults at the mouth within the UCR Spring Chinook salmon ESU, though, as mentioned above, these numbers are likely an overestimate (see section 2.5.2.3 and Table 19). Similar to the above arguments above, any adverse effect on SRKW critical habitat as a result of reductions in natural-origin Chinook salmon as prey would be insignificant. We do not anticipate any effects to water quality or passage conditions in proposed critical habitat.

Given the Proposed Action is likely to benefit SRKW critical habitat with production of hatchery summer 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 Chinook salmon in the Upper Columbia River under the Proposed Action is not likely to adversely affect the SRKW 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 one summer Chinook salmon hatchery program, as described in Section **Error! Reference source not found.** 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 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 program typically spawn from late September to early December (Table 12). 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 Chinook salmon from the program may stray into other rivers (Section 2.5.2.2), but not in numbers that would exceed the carrying capacities of natural production areas, or that would result in increased incidence of disease or predators. Some predation by adult hatchery Chinook salmon on juvenile natural-origin Chinook or coho salmon may occur as summer Chinook salmon hold for a potentially long period of time before spawning. Predation and competition by juvenile hatchery summer 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 32 Chinook salmon adult equivalents and 1 steelhead adult equivalent are likely to be lost to predation and competition with hatchery summer Chinook salmon at the juvenile stage within our Action Area for this consultation.

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 summer Chinook salmon hatchery program 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 (authorizing entity); the WDFW (co-manager and funding entity); and the Douglas Public Utility District (operating entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in summer Chinook salmon in the ocean for southern resident Orca populations and to the Upper Columbia River basin, 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/>). 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 23. Generally speaking, effects range from beneficial to negative when programs use local fish⁵ for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock⁶. 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,

⁵ 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).

⁶ Exceptions include restoring extirpated populations and gene banks.

- (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 2005b). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population's current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

Table 23. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	<p>Positive to negative effect</p> <p>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).</p>	<p>Negligible to negative effect</p> <p>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).</p>
Diversity	<p>Positive to negative effect</p> <p>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.</p>	<p>Negligible to negative effect</p> <p>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).</p>
Abundance	<p>Positive to negative effect</p> <p>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.</p>	<p>Negligible to negative effect</p> <p>Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects.</p>
Spatial Structure	<p>Positive to negative effect</p> <p>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).</p>	<p>Negligible to negative effect</p> <p>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).</p>

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

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

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

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

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

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

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

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

5.2.1. Genetic effects

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

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

Hatchery programs, simply by virtue of creating more fish, can increase N_e . In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., 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)⁷ 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

⁷ 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.

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 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 fish⁸. 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 4).

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)⁹. 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

⁸ 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.

⁹ 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.

not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

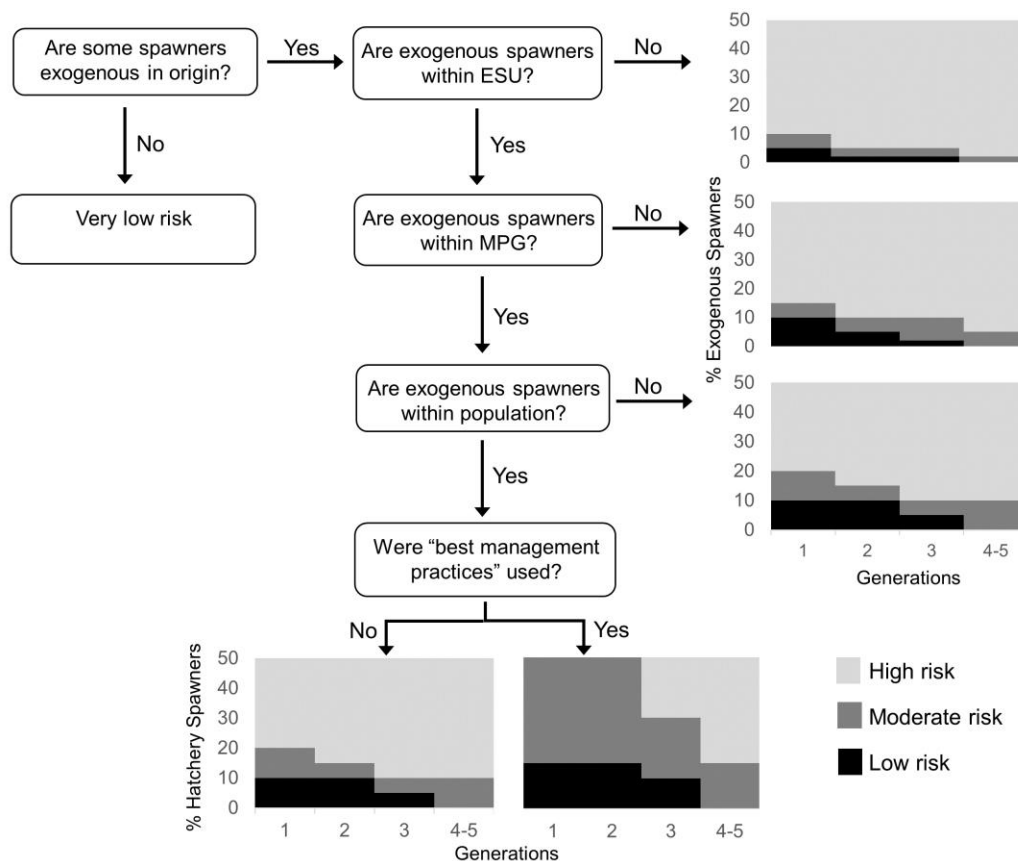


Figure 4. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as “the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity.” They recommended that program-specific plans be developed with corresponding

population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with “the proportion of the natural spawning population that is made up of hatchery fish” in the Conclusion, Principles and Recommendations section (HSRG 2009), but with “the proportion of *effective* hatchery-origin spawners” in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (appendix C in HSRG 2009) they introduce a new term, *effective pHOS* (pHOS_{eff}) defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference the HSRG defined *effective* pHOS as:

$$\text{pHOS}_{\text{eff}} = \text{RRS} * \text{pHOS}_{\text{census}}$$

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:

$$\text{PNI} = \frac{\text{pNOB}}{(\text{pNOB} + \text{pHOS}_{\text{eff}})}$$

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon

(Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the “effective” pNOB might be much lower than the census pNOB.

It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 5 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 randomly¹⁰. 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.

¹⁰ These computations are purely theoretical, based on a simple mathematical binomial expansion $((a+b)^2=a^2 + 2ab + b^2)$.

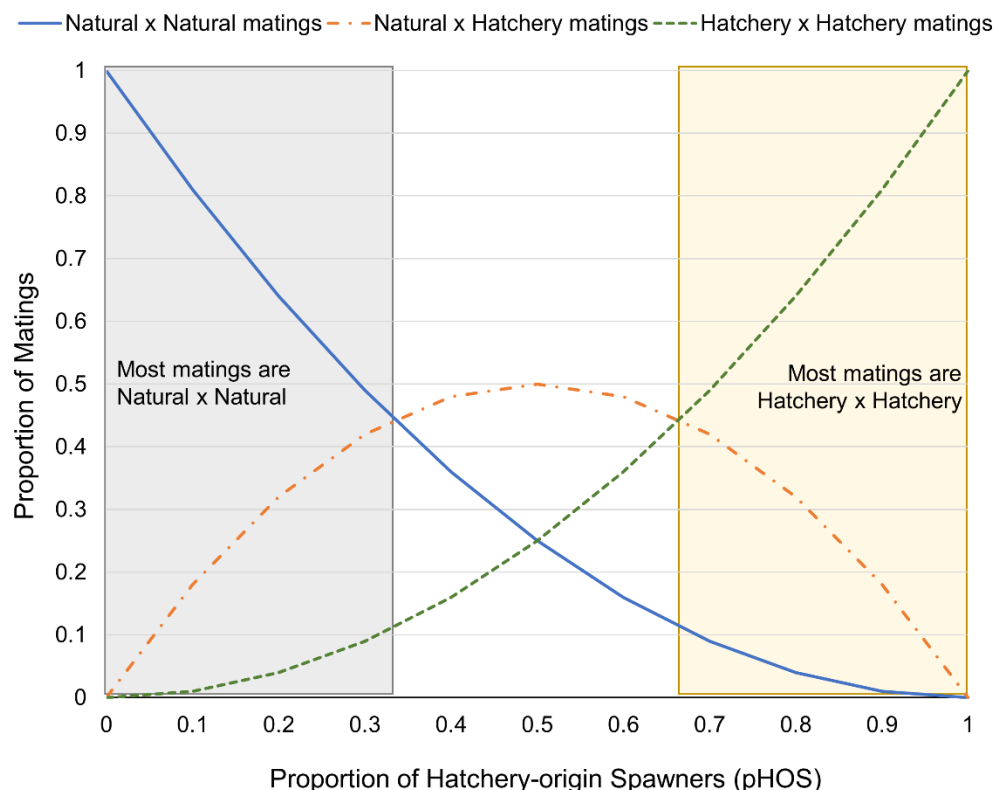


Figure 5. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

5.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (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 2012). 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,¹¹ 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

¹¹ “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.

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 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 salmon and steelhead may prey on juvenile fall Chinook and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon 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; Pearsons 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 unsetttable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

5.3.4. Acclimation

One factor 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 2014). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (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 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 recovery needs of the ESU, in accordance with approved harvest plans” (NMFS 2005b). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

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