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

Two Steelhead Hatchery Programs in the Methow River

NMFS Consultation Number: WCR-2017-6986

Action Agencies: National Marine Fisheries Service (NMFS)
U.S. Fish and Wildlife Service (USFWS)
Bureau of Reclamation (BOR)

Affected Species and Determinations:

<table>
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<th>ESA-Listed Species</th>
<th>Status</th>
<th>Is the Action Likely to Adversely Affect Species or Critical Habitat?</th>
<th>Is the Action Likely To Jeopardize the Species?</th>
<th>Is the Action Likely To Destroy or Adversely Modify Critical Habitat?</th>
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<td>Chinook salmon</td>
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<td>Upper Columbia River Spring</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Steelhead (O. mykiss)</td>
<td>Threatened</td>
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<td>No</td>
<td>No</td>
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<tr>
<td>Upper Columbia River</td>
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Fishery Management Plan That Describes EFH in the Project Area

<table>
<thead>
<tr>
<th>Fishery Management Plan That Describes EFH in the Project Area</th>
<th>Does the Action Have an Adverse Effect on EFH?</th>
<th>Are EFH Conservation Recommendations Provided?</th>
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<tbody>
<tr>
<td>Pacific Coast Salmon</td>
<td>Yes</td>
<td>No</td>
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Consultation Conducted By: National Marine Fisheries Service, West Coast Region, Sustainable Fisheries Division

Issued By: Barry A. Thom
Regional Administrator

Date: 10/10/2017
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1. **INTRODUCTION**

This introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below. The underlying activities that drive the Proposed Actions by the federal agencies (see Section 1.3 for details) are funding and operating the operation and maintenance of two hatchery programs rearing and releasing Methow River steelhead in the Methow River sub-basin of Washington State and mainstem Columbia River downstream of Wells Dam. Because the actions of the federal agencies are subsumed within the effects of the hatchery program operation, the details of each hatchery program are summarized in Section 1.3 of this biological opinion based on a Hatchery and Genetic Management Plan (HGMP), which was submitted to NMFS for review.

NMFS defines integrated hatchery programs as those that are reproductively connected or “integrated” with a natural population, promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species, and are included in a salmon ESU or steelhead DPS. When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as “isolated” or “segregated.” Isolated programs promote domestication or selection in the hatchery over selection in the wild and culture a stock of fish with different phenotypes (e.g., different ocean migrations and/or spatial and temporal spawning distribution) compared to the natural population.

**Table 1. Programs included in the Proposed Action and ESA coverage pathway requested.**

<table>
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<tr>
<th>Program</th>
<th>Program Component</th>
<th>HGMP Receipt</th>
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<td>Twisp</td>
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<td>WDFW/D PUD</td>
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<td>Integrated Recovery</td>
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<td>July 31, 2009; resubmitted November 16, 2012</td>
<td>USFWS</td>
<td>BOR</td>
<td>Integrated Recovery</td>
<td>Section 4(d) Limit 5</td>
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* This component uses returns from the integrated program at Winthrop and the Twisp component for broodstock. Thus, it is more closely genetically linked to the Methow River population than a typical segregated program.

1.1. **Background**

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

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS’ Public Consultation Tracking System. A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

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

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

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

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

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

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008c) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008b). 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 2008c, p. 5-40).

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

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

The proposed operation of two steelhead hatchery programs is described in a series of documents submitted to NMFS by DPUD, WDFW, USFWS, and BOR (hereafter referred to as applicants). From 2009 to 2012, the applicants submitted final HGMPs for formal consultation (Table 1). Once submitted, NMFS reviewed the HGMPs for sufficiency, and issued letters indicating that the HGMPs were sufficient for consultation (Jones 2013; Jones Jr. 2013). Since that time, the applicants have also submitted supplemental documents detailing minor changes in the programs since sufficiency. As of this spring, NMFS has been working with the applicants on developing a gene flow plan for the Methow Subbasin. The outcomes of these discussions and updates are captured below.

1.3. Proposed Federal Action

“Action,” as applied under the ESA, means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. For EFH consultation, “Federal action” means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

There are three action agencies, each with its own proposed action:

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1 Sufficient” means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful.
National Marine Fisheries Service (NMFS): approval of an HGMP for the WNFH program under Limit 5 of the ESA section 4(d) Rule, and issuance of an ESA section 10(a)(1)(A) permit to DPUD and WDFW for the funding and operation of the Wells Complex program.

U.S. Fish and Wildlife Service (USFWS): operation and maintenance, and monitoring and evaluation, of the WNFH steelhead program.

Bureau of Reclamation (BOR): funding of the operation and maintenance, and monitoring and evaluation, of the WNFH steelhead program.

A consistent goal of the WNFH steelhead program since it was initiated in 1995 has been to compensate for a portion of lost fish abundance due to the construction of Grand Coulee Dam. Since the 1997 ESA listing, the program has evolved towards aiding recovery and has transitioned from a more traditional harvest augmentation program to an integrated conservation program. The program operates to aid in recovery of the Methow River steelhead population by maintaining genetic and ecological integrity and support harvest where and when it is consistent with recovery objectives. Returns from this program are externally marked and are able to be managed for fishery harvest when deemed appropriate by fisheries co-managers, but remain available to support natural spawning and broodstock needs in years of low escapement.

The purpose of the Wells Complex Summer Steelhead Program is to meet No Net Impact (NNI) passage loss mitigation and Fixed Hatchery Compensation (harvest) established in the Wells Hydroelectric Project Anadromous Fish Agreement and Habitat Conservation Plan (HCP; Douglas County Public Utility District 2002). The decision-making body for hatchery issues under the Wells HCP is the Wells HCP Hatchery Committee, which provides oversight of the programs as part of the HCP implementation process. Decisions made by the HCP Hatchery Committee are dynamic and adaptive; thus, future updates to the program may be necessary during the ongoing implementation of the HCP. The goal of the Twisp component of the program is to aid in the recovery of the Methow River summer steelhead population in its native habitats by using broodstock collected from the natural population to maintain genetic and ecological integrity and supporting harvest where and when it is consistent with recovery objectives. The goal of the Methow safety-net and mainstem Columbia River releases is to support steelhead harvest. The safety-net component also serves the secondary goal of bolstering the Twisp component and WNFH program in years of very low returns to meet brood and escapement goals. This program component is genetically linked with the local population according to the “stepping-stone” concept described by the Hatchery Scientific Review Group (HSRG 2014). Thus, broodstock is comprised of returns to either the WNFH program or the Twisp component of the Wells Complex program.

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from these Federal actions. This opinion will determine if the actions proposed by the operators comply with the provisions of sections 7, 4(d), and 10(a)(1)(A) of the ESA. For Section 10, NMFS considers enhancing the propagation or survival of the affected species to mean improving the viability status of the species (McElhany et al. 2000) and/or reducing the species extinction risk. The duration of the Proposed Action of issuance of the Section 10 permit is 10 years from the date of issuance and unlimited for the 4(d) approval. More information on each program follows in the description below based on the
program HGMPs, and additional supplemental information (DPUD 2012; DPUD and WDFW 2011; USFWS 2012a; USFWS 2012b).

1.3.1. Proposed hatchery broodstock collection, mating and adult management

The two steelhead programs in the Methow Subbasin are genetically linked; returns from the integrated WNFH program and Twisp component of the Wells Complex program are used as
broodstock for the Methow component of the Wells Complex program. As a backup to potential collection shortfalls in the Methow component, up to 30 hatchery-origin adults may be collected at Wells Dam in the fall. If not used for broodstock, these fish will be surplused.

The methods, timing, and duration of facility operation for broodstock collection and surplus hatchery-origin fish removal vary by site. Broodstock are collected at hatchery ladders, temporary traps/weirs, one permanent weir, and by angling. One permanent weir, located on the Twisp River, operates from approximately March 1 to May 30 for steelhead broodstock collection. The East and West ladder traps at Wells Dam do not begin operation for steelhead broodstock until August and end trapping on approximately November 15. The Wells Hatchery volunteer trap operates from September through mid-June of the following year for steelhead. The ladders at Methow and WNF Hatcheries are operated from approximately March 1st to June 15th for steelhead broodstock collection.

All structures may operate up to 7 days a week, 24 hours a day as needed and will be checked daily. One exception is the Wells Dam ladders; specific hours of operation are decided annually by the Wells HCP Coordinating Committee. Angling is used to collect (primarily natural-origin) broodstock for the WNFH programs in the Methow River beginning in February each year. In addition, for all locations and methods, if daily river temperatures meet or exceed 21ºC (69.8º F) collection activities and fish handling will cease until temperatures drop below this threshold pending further consultation with NMFS to determine if continued trap operation poses substantial risk to ESA-listed species. This may require reducing trap operation to only nighttime hours with early morning trap checks to ensure the safety of the fish. Inter-program transfers occur cooperatively across various program broodstock (and adult management) efforts (e.g., natural-origin adults collected at Methow Hatchery are transferred to WNFH for use in the conservation program).

For the WNFH program, no minimum proportion of natural-origin broodstock (pNOB) restriction is placed on the program in poor escapement scenarios, and broodstock collection will seek to achieve program size of 100,000 regardless of broodstock origin/program. However, natural-origin steelhead will be incorporated as is feasible to maximize pNOB (subject to meeting minimum abundance thresholds on the spawning grounds and maximum natural-origin run extraction rates of ≤ 33%). This scenario would equate to broodstock collections between 28 and 41 natural-origin adults. Production levels will not exceed 100,000 unless a minimum pNOB of 0.5 has been achieved. If natural-origin broodstock collection is sufficient to meet a target pNOB of > 0.5 but < 0.75 (i.e., between 42 and 63 natural-origin adults), WNFH steelhead production would be increased to a release goal of 150,000 smolts. WNFH will target a maximum release goal of 200,000 smolts only when natural-origin broodstock collection is sufficient to target pNOB greater than 0.75 (i.e., between 82 and 110 natural-origin adults).
Table 2. Broodstock collection plans for the two summer steelhead hatchery programs; WNFH = Winthrop National Fish Hatchery.

<table>
<thead>
<tr>
<th>Program</th>
<th>Component</th>
<th>Origin and priority</th>
<th>Collection Location</th>
<th>Collection Method</th>
<th>Collection Number</th>
<th>pNOB Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Complex</td>
<td>Lower Methow safety-net</td>
<td>Conservation 1&lt;sup&gt;st&lt;/sup&gt;; Methow safety-net 2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Wells Hatchery, Wells Dam, Twisp Weir, WNFH, Methow Hatchery, Methow Subbasin</td>
<td>Ladder and adult trap; weir; angling</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wells mainstream Columbia</td>
<td>Wells stock</td>
<td></td>
<td></td>
<td>84</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Twisp</td>
<td>Methow Subbasin natural 1&lt;sup&gt;st&lt;/sup&gt;; Conservation 2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Methow Subbasin</td>
<td></td>
<td>26</td>
<td>1.0&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>WNFH</td>
<td>Not Applicable</td>
<td>Methow Subbasin natural 1&lt;sup&gt;st&lt;/sup&gt;; Conservation 2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Methow Subbasin, WNFH, Methow Hatchery</td>
<td></td>
<td>110</td>
<td>Varies 1</td>
</tr>
</tbody>
</table>

<sup>1</sup>If needed to avert genetic issues (i.e., Ryman-Laikre effect).  
<sup>2</sup>The goal for both programs is to maximize pNOB, but is dependent on availability of natural-origin steelhead.

The Methow Subbasin will be managed for steelhead recovery in two parts. The first part ensures that in years where the estimate of natural-origin spawners is below 500, sufficient hatchery-fish will be allowed to escape to meet a minimum total spawner abundance of 500 (measured as a preseason estimate at Priest Rapids Dam, with in-season refinements based on counts at Wells Dam). In these years, PNI and/or PHOS targets will be relaxed in order to ensure 500 natural-spawning fish in the population. The second part applies when total spawners are estimated to exceed 500 spawners, by targeting a five-year running average proportionate natural influence (PNI) of ≥ 0.67. In addition, the proportion of hatchery-origin spawners (pHOS) in the area that encompasses the Upper Methow River and primary tributaries (depicted in green in Figure 2), will be ≤ 0.25. Of this 0.25 proportion, 0.20 will be comprised of fish from either the WNFH program or the Twisp component of the Wells Complex program (Conservation programs). A maximum of 0.05 may come from the Methow safety-net component of the Wells Complex program. Wells Columbia River mainstem releases should not represent more than five percent of the naturally spawning population in the Methow Subbasin. Currently, the best method for assessing these metrics is with PIT-tag expansions, but alternative methods could be considered.
Natural-origin adults collected in excess of broodstock needs will be immediately returned to the collection location(s) in the Methow Subbasin. Excess hatchery steelhead may be removed at the Twisp Weir, Methow Hatchery outfall trap, Winthrop NFH outfall trap, Wells hatchery volunteer trap, and during angling efforts for broodstock collection. Fisheries in the Columbia and Methow Rivers may also be used to remove excess hatchery steelhead. In years of high returns, fish may also be removed at Wells Dam. Surplus WNFH-origin adults may be outplanted into natural spawning areas consistent with PNI goals or will be donated to tribes for ceremonial and
subsistence purposes, to local food banks, or used for nutrient enhancement programs in the Methow or Okanogan River subbasins. For the Wells Complex program, the Joint Fisheries Parties (i.e., USFWS, NMFS, CTCR, YN, and WDFW) will agree upon the distribution of excess hatchery-origin fish and WDFW is responsible for disposition of surplus fish.

Mating

Mating protocols for the WNFH program will be a minimum of 2x2 factorial crosses targeting wild-by-wild crosses for all broodstock pairings, with hatchery-by-wild crosses as needed. Hatchery by hatchery crosses will not be utilized unless in low escapement scenarios. Natural-origin males can be live spawned and/or used twice if necessary to help meet the pNOB objective. A second male will only be used when a problem is noticed with the milt (blood, water, etc.). Natural-origin females will be live spawned and may be transferred to the Methow Steelhead Kelt Facility operated by the Yakama Nation (YN) at WNFH, reconditioned, and released.

Mating for both the Methow safety-net and Wells mainstem components of the Wells Complex program is performed at a 1:1 ratio or in a factorial design, with additional males used as back-up to ensure the highest likelihood of fertilization. For the Twisp component, mating is usually factorial, but other mating protocols may be used if agreed to by the HCP Hatchery Committee. When males are limiting, natural-origin males may be used twice as primary and twice as backup (physically crossed twice, with sperm split for primary and backup each time). Natural-origin broodstock may be live-spawned so that they may be transferred to the Methow Steelhead Kelt Facility operated by the YN at WNFH, reconditioned, and released.

1.3.2. Proposed hatchery egg incubation and juvenile release

Steelhead programs may rear up to 10 percent over their target to offset the risk of losses.

Fish health staff monitor the fish throughout their rearing cycle for signs of disease. Mortalities are checked daily and live grab samples are taken monthly. Fish are also tested prior to transfer to acclimation sites and before release. Sampling, testing, and treatment/control procedures are outlined in multiple documents (IHOT 1995; NWIFC and WDFW 2006; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989).

In the event an emergency release is deemed necessary by the applicants, NMFS will be contacted within 24 hours after the release.

For both programs, non-migratory steelhead remaining in the acclimation pond(s) after the volitional release period will be collected and distributed to selected local lakes and reservoirs that are isolated from anadromous fish populations to provide for resident fisheries. For the Wells Complex program, specific release locations will be as approved by the HCP Hatchery Committee. When transfer is not feasible (likely due to fish health concerns), the USFWS, DPUD, and WDFW will work with local co-managers to determine the best outlet for non-migrant steelhead juveniles. To evaluate the assumption that removal of non-migrant fish will manage/control for the impacts of residual hatchery fish on wild populations, the USFWS may release the PIT-tagged portion of the non-migrant population (~ up to 600 steelhead).
Table 3. Proposed annual release protocols for each program. CWT = coded-wire tag; PIT = passive integrated transponder tag.

<table>
<thead>
<tr>
<th>Program Component</th>
<th>Number, life stage, and size released</th>
<th>Marking(^5)</th>
<th>Egg Incubation Location</th>
<th>Rearing Location</th>
<th>Acclimation Site; Duration(^2)</th>
<th>Volitional Release?</th>
<th>Release Location</th>
<th>Release Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Complex</td>
<td>Up to 160,000 yearling smolts; 4-8 fpp</td>
<td>100% ad-clip; 5,000 PIT</td>
<td>Wells Hatchery</td>
<td>Wells Hatchery</td>
<td>Wells Hatchery: entire rearing</td>
<td>Yes</td>
<td>Columbia River</td>
<td>April-May</td>
</tr>
<tr>
<td>Methow safety-net</td>
<td>Up to 100,000 yearling smolts; 4-8 fpp</td>
<td>100% ad-clip; 5,000 PIT</td>
<td>Wells Hatchery</td>
<td>Wells Hatchery</td>
<td>None</td>
<td>Yes</td>
<td>Lower Methow River: Lower Burma Bridge(^4)</td>
<td>May</td>
</tr>
<tr>
<td>Twisp</td>
<td>Up to 48,000 yearling smolts; 4-8 fpp</td>
<td>100% CWT; 5,000 PIT</td>
<td>Methow or Wells Hatcheries</td>
<td>Methow or Wells Hatcheries</td>
<td>Varies(^3)</td>
<td>Yes</td>
<td>Twisp River</td>
<td>May</td>
</tr>
<tr>
<td>WNFH</td>
<td>Up to 200,000 age-2 smolts(^1); 4-8 fpp</td>
<td>100% ad-clip and CWT; 5,000 PIT</td>
<td>WNFH</td>
<td>WNFH</td>
<td>WNFH; entire rearing</td>
<td>Yes</td>
<td>Methow Subbasin</td>
<td>April-May</td>
</tr>
</tbody>
</table>

\(^1\) Program size depends on the number of natural-origin adults collected for broodstock. See text above in Section 1.3.1 for details.

\(^2\) Additional acclimation sites may be used as approved by the HCP Hatchery Committees for the Wells Complex Program or the Joint Fisheries Parties for the WNFH program.

\(^3\) Fish may be acclimated at the Twisp Acclimation Pond (RM 6.8) for 2-8 weeks or truck planted at Buttermilk Bridge (RM 12.4). Evaluation is currently underway to determine the most effective release strategy.

\(^4\) These fish may be combined with the Columbia release group if homing of these fish upon return to the Lower Methow River mainstem is not meeting the expectations of the HCP Hatchery Committee.

\(^5\) Or other mark as determined by HCP Hatchery Committees for the Wells Complex Program or the Joint Fisheries Parties and through the US v Oregon process for the WNFH program to allow for gene flow management.
1.3.3. Proposed research, monitoring, and evaluation

The HCP Hatchery Committee has developed a rigorous Monitoring and Evaluation Plan (M&E Plan) for the Wells Complex summer steelhead program (DPUD and WDFW 2011). The M&E program is subject to review by the HCP Hatchery Committee at least every five years (or as needed). The program monitors survival and the effects of hatchery fish from these programs on population productivity, genetic diversity, run and spawn timing, spawning distribution, and age and size at maturity. This information is collected directly from or derived from spawning ground surveys, broodstock sampling, stock composition sampling (stock assessment), hatchery juvenile sampling, smolt trapping, PIT tagging, elastomer tagging, adipose clipping, genetic sampling, disease sampling, juvenile population assessment, and snorkeling. The list below summarizes those research, monitoring, and evaluation (RM&E) activities where encountering and handling of ESA-listed fish is required, or information is obtained to assess hatchery fish effects on listed natural-origin fish.

- Collect biological data from broodstock; age at maturity, length at maturity, spawn timing, fecundity, origin, tissue for genetic analysis and identification, tags (i.e., PIT, CWT)
- Collect biological data from juvenile fish prior to release; length/weight/condition factor, sexual development
- Monitor growth and health of juvenile fish during rearing and prior to release
- For the Twisp, determine the stock demographics, spawn timing, redd distribution, redd abundance, and estimate the spawning escapement of selected streams using redd surveys and PIT tags
- For the remainder of the Methow Subbasin, determine spawning escapement, distribution and composition using PIT tags and in-stream antenna arrays
- Estimate travel time, production, and survival rates of hatchery and wild fish
- Estimate the harvest contribution for each program and/or component
- Determine smolt-to-adult survival rates
- Calculate survival rates at various life stages for target species based on redd surveys, electrofishing for non-migrants, screw trap counts for migrants, and juvenile abundance estimates or other appropriate methods
- Determine if genetic stock structure of natural populations has changed due to effects of hatchery programs
- Determine if effective population size (Ne) of target natural spawning populations increases at rate expected given an increase in hatchery-origin fish on the spawning grounds
- Determine within- and out-of-basin stray rates for each program component

1.3.4. Proposed operation, maintenance, and construction of hatchery facilities

Diverted water used by these programs is returned to the creek or river of origin (minus any leakage and/or evaporation) along with any groundwater discharge (Table 4). Water at all facilities is withdrawn in accordance with state-issued water rights. The three hatcheries operate year round, but the Twisp acclimation site may operate from February 1 to May 31. All facilities
that rear over 20,000 pounds of fish comply with the National Pollutant Discharge Elimination System (NPDES) through a general permit (Permit number 300J) issued by the Washington Department of Ecology (Table 4). This permit requires periodic sampling of water flow, suspended solids, settleable solids, and chlorine in facility effluent. The facilities addressed in this opinion are covered by existing NPDES permits where applicable.

All facilities also comply with older NMFS screening criteria (Table 6; NMFS 1995a; NMFS 1996). In 2011, NMFS released updated screening and fish passage criteria (NMFS 2011b). Any modifications to fish passage design or facility screening for the hatchery facilities included in this opinion will comply with the most recent NMFS criteria.

**Routine Maintenance**

Several 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 and at the intake diversions, fish ladders, and effluent outfall. All in-water maintenance activities considered “routine” for the purposes of this action will occur within existing structures or the footprint of areas that have already been impacted. When maintenance activities occur within water, they will comply with the following guidance:

- **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 material storage sites, fueling operations, staging areas, cement mortars and bonding agents, hazardous materials, spill containment and notification, and debris management
  - Cease if fish are observed in distress at any time as a result of the activities
  - Include notification of NMFS staff prior to beginning the work in written form

- **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 4. Facility details for those facilities that divert water for hatchery operations.

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Program(s)</th>
<th>Surface Water (cfs)</th>
<th>Ground Water (cfs)</th>
<th>Water Diversion Distance (km)</th>
<th>Surface water source</th>
<th>Discharge Location</th>
<th>Instream Structures</th>
<th>Meet NMFS Screening Criteria?</th>
<th>NPDES Permit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Hatchery</td>
<td>Wells Complex</td>
<td>150</td>
<td>38</td>
<td>0.2</td>
<td>Columbia River</td>
<td>Columbia River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes (2008)</td>
<td>Yes</td>
</tr>
<tr>
<td>Methow Hatchery</td>
<td>Wells Complex</td>
<td>25</td>
<td>10</td>
<td>0.91</td>
<td>Foghorn Irrigation Ditch-Methow River</td>
<td>Methow River</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes (1995)</td>
<td>Yes</td>
</tr>
<tr>
<td>WNFH</td>
<td>WNFH</td>
<td>50</td>
<td>16.7</td>
<td>1.44</td>
<td>Foghorn Irrigation Ditch-Methow River</td>
<td>Spring Creek</td>
<td>3: Intake, outfall, ladder</td>
<td>Yes (2000)</td>
<td>Yes</td>
</tr>
<tr>
<td>Twisp Acclimation Pond</td>
<td>Wells Complex</td>
<td>6</td>
<td>0</td>
<td>0.2</td>
<td>Twisp River</td>
<td>Twisp River</td>
<td>2: Intake, outfall</td>
<td>Yes (1995)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Chewuch Acclimation Pond</td>
<td>Wells Complex</td>
<td>6</td>
<td>0</td>
<td>0.05</td>
<td>Chewuch River</td>
<td>Chewuch River</td>
<td>2: Intake, outfall</td>
<td>Yes (1995)</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

1 Fish screens are checked daily by staff to avoid impacts on listed fish.
1.4. Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS has not identified any interdependent or interrelated activities associated with the proposed action. The impacts of fisheries in the action area, including those that may target fish produced by the proposed programs, on ESA-listed salmonids are included in the environmental baseline.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency’s actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and/or an adverse modification analysis. 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. We use the term PCE as equivalent to PBF or
essential feature, due to the description of such features in applicable recovery planning documents.

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

Identify the 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.

Describe the environmental baseline in the action area
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.

Analyze the effects of the proposed action on both the species and their habitat
Section 2.4 first describes the various pathways by which hatchery operations can affect ESA-listed salmon and steelhead, then applies that concept to the specific programs considered here.

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 (Table 5). 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. This informs the description of the species’ likelihood of both survival and recovery. The species status section helps to inform the description of the species’ current “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.
Table 5. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA-listed species considered in this consultation.

<table>
<thead>
<tr>
<th>Species</th>
<th>Listing Status</th>
<th>Critical Habitat</th>
<th>Protective Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook salmon (O. tshawytscha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Columbia River spring-run</td>
<td>Endangered</td>
<td>70 FR 52630;</td>
<td>70 FR 37160;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sept 2, 2005</td>
<td>June 28, 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steelhead (O. mykiss)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Columbia</td>
<td>Threatened</td>
<td>70 FR 52630;</td>
<td>70 FR 37160;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sept 2, 2005</td>
<td>June 28, 2005</td>
</tr>
<tr>
<td></td>
<td>August 24, 2009</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“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. UCR Chinook Salmon

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

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

Approximately half of the area that originally produced spring Chinook salmon in this ESU is blocked by dams. What remains of the ESU includes all naturally spawned fish upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State, excluding the Okanogan River (64 FR 14208, March 24, 1999). The ESU includes six artificial propagation programs: the Twisp, Chewuch, Methow Winthrop NFH, Chiwawa, and White River hatchery programs (79 FR 20802, April 14, 2014). Since this listing the three Methow Subbasin programs (Twisp, Chewuch, Methow Composite) are considered a single program, with two components:
Twisp and Methow Composite (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 3. 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 6). 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 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 6). 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 6).
Table 6. Risk levels and viability ratings for natural-origin UCR spring Chinook salmon populations (NWFSC 2015).

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

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

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

2.2.1.2. **UCR Steelhead**

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 (Chapman et al. 1994), with spawning occurring between January and June. In general, summer steelhead spawn in higher-gradient streams relative to other Pacific salmon. They also 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 in the ocean (Hartt and Dell 1986).

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

The UCR Steelhead DPS consisted of three MPGs before the construction of Grand Coulee Dam, but it is currently limited to one MPG with four extant populations: Wenatchee, Methow, Okanogan, and Entiat. A fifth population in the Crab Creek drainage is believed to be functionally extinct. What remains of the DPS includes all naturally spawned populations in all tributaries accessible to steelhead upstream from the Yakima River in Washington State, to the U.S–Canada border (Figure 4).

Figure 4. 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 7). However, natural-origin returns remain well below target levels for three of the four populations. Productivity remained the same for three of the four populations and decreased for the Entiat population relative to the last review (Ford 2011). For spatial structure and diversity, hatchery-origin returns continue to constitute a high fraction (Table 7) 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—including the Methow—and the DPS itself remain at high risk of extinction.
Table 7. Risk levels and viability ratings for natural-origin UCR steelhead populations (NWFSC 2015).

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

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

- past management practices resulting in the comingling of stocks such as the Grand Coulee Fish Maintenance Project and collection of hatchery broodstock at mainstem dams (e.g. Wells stock).
- 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. Status of Critical Habitat

In this section, we examine the range-wide status of designated critical habitat for the affected salmonid species. UCR spring Chinook salmon critical habitat includes all Columbia River estuarine areas and river reaches as far upstream as Chief Joseph Dam, as well as specific stream reaches in the following subbasins: Chief Joseph, Methow, Entiat, and Wenatchee. UCR steelhead critical habitat includes river reaches proceeding upstream to Chief Joseph Dam, as well as specific stream reaches in the following subbasins: Columbia River/Lynch Coulee, Chief Joseph, Okanogan, Salmon, Methow, Similkameen, Chewuch, Twisp, Entiat, Wenatchee, Chiwawa, Nason, and Icicle. UCR steelhead and spring Chinook salmon have overlapping ranges, because of similar life history characteristics.

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 2005a). 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.

NMFS reviews the status of designated critical habitat affected by the Proposed Action by examining the condition and trends of PBFs throughout the designated area. These PBFs vary slightly for some species, due to biological and administrative reasons, but all consist of site types and site attributes associated with life history events (Table 8).

Table 8. PBFs of critical habitat designated for ESA-listed salmon and steelhead considered in this opinion (listed here as PCEs, consistent with the pertinent recovery plan descriptions).

<table>
<thead>
<tr>
<th>Primary Constituent Elements</th>
<th>Site Type</th>
<th>Site Attribute</th>
<th>Species Life History Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate</td>
<td>Freshwater spawning</td>
<td>Substrate</td>
<td>Adult spawning</td>
</tr>
<tr>
<td>Water quality</td>
<td>Freshwater spawning</td>
<td>Water quality</td>
<td>Embryo incubation</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Freshwater spawning</td>
<td>Water quantity</td>
<td>Alevin growth and development</td>
</tr>
<tr>
<td>Floodplain connectivity</td>
<td>Freshwater rearing</td>
<td>Natural cover</td>
<td>Fry emergence from gravel</td>
</tr>
<tr>
<td>Forage</td>
<td>Freshwater rearing</td>
<td>Water quality</td>
<td>Fry/parr/smolt growth and development</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Freshwater migration</td>
<td>Free of artificial obstruction</td>
<td>Adult sexual maturation</td>
</tr>
<tr>
<td>Natural cover</td>
<td>Freshwater migration</td>
<td>Natural cover</td>
<td>Adult upstream migration and holding</td>
</tr>
<tr>
<td>Water quality</td>
<td>Freshwater migration</td>
<td>Water quality</td>
<td>Kelt (steelhead) seaward migration</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Freshwater migration</td>
<td>Water quantity</td>
<td>Fry/parr/smolt growth, development, and seaward migration</td>
</tr>
<tr>
<td>Forage</td>
<td>Estuarine areas</td>
<td>Free of artificial obstruction</td>
<td>Adult sexual maturation</td>
</tr>
<tr>
<td>Natural cover</td>
<td>Estuarine areas</td>
<td>Natural cover</td>
<td>“Reverse smoltification”</td>
</tr>
<tr>
<td>Salinity</td>
<td>Estuarine areas</td>
<td>Water quality</td>
<td>Adult upstream migration and holding</td>
</tr>
<tr>
<td>Water quality</td>
<td>Estuarine areas</td>
<td>Water quantity</td>
<td>Kelt (steelhead) seaward migration</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Estuarine areas</td>
<td>Water quality</td>
<td>Fry/parr/smolt growth, development, and seaward migration</td>
</tr>
<tr>
<td>Forage</td>
<td>Nearshore marine areas</td>
<td>Free of artificial obstruction</td>
<td>Adult growth and sexual maturation</td>
</tr>
<tr>
<td>Natural cover</td>
<td>Nearshore marine areas</td>
<td>Natural cover</td>
<td>Adult spawning migration</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Nearshore marine areas</td>
<td>Water quantity</td>
<td>Nearshore juvenile rearing</td>
</tr>
<tr>
<td>Water quality</td>
<td>Nearshore marine areas</td>
<td>Water quality</td>
<td></td>
</tr>
<tr>
<td>Forage</td>
<td>Offshore marine areas</td>
<td>Free of artificial obstruction</td>
<td>Adult growth and sexual maturation</td>
</tr>
<tr>
<td>Natural cover</td>
<td>Offshore marine areas</td>
<td>Natural cover</td>
<td>Adult spawning migration</td>
</tr>
<tr>
<td>Water quantity</td>
<td>Offshore marine areas</td>
<td>Water quantity</td>
<td>Subadult rearing</td>
</tr>
<tr>
<td>Water quality</td>
<td>Offshore marine areas</td>
<td>Water quality</td>
<td></td>
</tr>
</tbody>
</table>
Habitat quality in tributary streams in the Interior Columbia Recovery Domain ranges from excellent in wilderness and road-less areas, to poor in areas subject to heavy agricultural and urban development (NMFS 2009; Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas.

Currently, state water law over-allocates water in many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain, with more allocated water rights than existing stream-flow conditions can support. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for all listed salmon and steelhead species in this area (NMFS 2011a).

Despite these degraded habitat conditions, the HUCs 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

**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
- 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

2.3. 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 Columbia River from Chief Joseph Dam to Priest Rapids Dam. Within this reach and included in the action is the Methow Subbasin. The action area includes locations where fish are captured, reared, and released, as well as areas where they may be monitored, or stray.

We did not extend the action area further down into the migratory corridor and the estuary/plume for several reasons. The first was that both of the programs in the Proposed Action combined release ~500,000 steelhead, a tiny proportion of the ~150 million hatchery fish released into the Columbia River annually, making it nearly impossible to detect any effects associated with the proposed action below Priest Rapids Dam. Second, steelhead move relatively quickly through the migratory corridor and estuary to the ocean, and therefore would be expected to have a low potential for interacting meaningfully with fish migrating through the mainstem or utilizing the estuary for rearing. Third, the NMFS (2017) opinion on Mitchell Act funding considered the effects of hatchery fish in the estuary and ocean, and found that subyearling Chinook salmon and coho salmon are the most likely hatchery fish to have effects in these areas due to their long residence times and relatively high predation rates, respectively. Together, these reasons suggest that the likelihood of detecting effects from the releases of hatchery steelhead considered in this opinion, in combination with other hatchery programs throughout the Columbia Basin, on natural-origin fish in the estuary and ocean, have already been examined to the best of our ability.
2.4. Environmental Baseline

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

2.4.1. Habitat and Hydropower (NMFS 2012a)

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

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

- Juvenile and adult passage survival (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)

The Methow Subbasin currently has a high proportion of good habitat in the upper portions of major tributaries. The primary habitat conditions in the Methow Subbasin that limit abundance, productivity, spatial structure, and diversity of ESA-listed species are mostly found in the middle and lower mainstem and lower portions of major tributaries. Many factors, including mining, grazing, water diversions and timber harvest, have historically contributed to habitat degradation in the Methow Subbasin. Although beaver trapping began in the early 1800s, and no doubt had an effect on riparian conditions, mining was probably the first major activity affecting riparian and stream conditions. Mining began in the Methow Subbasin in the 1870s (Mullan et al. 1992). After the advent of mining was a period of intense livestock grazing. Grazing pressure was highest from the late 1800s to the 1930s, with subsequent reductions as allotment systems replaced the open range. Water diversion began in the mid-1880s, reducing stream flow and in some cases, may have come close to completely drying up the river, undoubtedly affecting adult migration and juvenile rearing capacity (Mullan et al. 1992). Timber harvest began in the 1920s, and up until 1955, selective harvest targeting large trees or “high grading” was the primary harvest method. Since then, partial cutting and clear-cutting have been the predominant
practices, with the 1980s being the period of most intense harvest. More recently, the degraded habitat function, quantity and quality are partly a result of state highways, county roads, and housing and agricultural development. All of these anthropogenic alterations have impaired instream complexity, wood and gravel recruitment, floodwater retention, and water quality.

Natural processes can also influence habitat quality and quantity. For example, a major fire started by lightning strikes occurred in July 2014 (Carlton Complex) and burned approximately 260,000 acres. The amount of area burned by fires from 2000-2015 in the Methow subbasin is depicted in Figure 5. The large amount of new barren hillsides will result in higher runoff rates, greater snow accumulation and more rapid snowmelt and increased stream temperatures. Massive mudslides have occurred in the basin as a result of the fire (G. Mackey, DPUD, personal communication, August 2014). The impact on salmonids still remains to be seen, but it is likely that fires will have a serious impact on salmonid productivity for the next few years. Climate models have predicted that climate change has contributed to the frequency and magnitude of fires in the Pacific Northwest (Rogers et al. 2011).
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.

2.4.2. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). Average annual Northwest air temperatures have increased by approximately 1°C since 1900, or about 50 percent more than the global average over the same period (ISAB 2007). The latest climate models project a warming of 0.1 °C to 0.6 °C per decade over the next century. According to the Independent Scientific Advisory Board (ISAB), these effects pose the following impacts generally, across the greater landscape, over the next 40 years:

- 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, watersheds will see their runoff diminished earlier in the season, resulting in lower streamflows in the June through September period.
- River flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

Climate change is predicted to cause 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). 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). 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. Warming winter temperature and decreasing snowpack have been observed in the Blue
Mountains and the Pacific Northwest in general (Mote et al. 2005), which has an impact on the
snowmelt-driven basins in northeast Oregon and southeast Washington. This is problematic
because snowpack rather than man-made reservoirs are the primary form of water storage in the
region. 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 does provide
some justification for hatchery programs as reservoirs for some salmon stocks. For more detail
on climate change effects, please see NMFS (2017).

2.4.3. Hatcheries

A broader discussion of hatchery programs in the Upper Columbia River can be found in our
opinions on Mitchell Act funded programs and Methow spring Chinook salmon (NMFS 2016 ;
NMFS 2017). In summary, because most programs are ongoing, the past 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.

The remainder of this subsection will focus on steelhead hatchery programs in the Upper
Columbia River. The Wells steelhead program began in 1968. From 1964 to 1983, steelhead
broodstock were obtained at Priest Rapids Dam. From 1984 through 1995, broodstock for
steelhead production throughout the entire UCR were obtained from Wells Dam and Hatchery
and propagated at Wells Hatchery. WDFW initiated changes in mitigation hatchery steelhead
production in 1996, which re-directed artificial production programs toward development of
local broodstock and improvement in the perceived fitness of the Wells Fish Hatchery
population.

Wells stock continues to be released by Wells Hatchery in the mainstem Columbia River, but the
Wells Hatchery Committee continues to explore options for development of a local steelhead
broodstock program. The releases from Methow Hatchery in the Methow River are genetically
linked to the WNFH program through the use of WNFH adult returns for Methow Hatchery
program broodstock. WNFH is using an endemic Methow steelhead stock for conservation
purposes. Historically, the two programs have been authorized to release up to 548,000 steelhead
into the Methow Subbasin, but this has been reduced to 508,000 through NNI recalculation under
the Wells HCP.
Around the same time recalculation was taking place, the YN and WDFW were in discussion about adjusting the total number of steelhead to be released in the Methow sub-basin. These discussions (in coordination with the HCP Hatchery Committee) resulted in 160,000 of the 308,000 total DPUD obligation being released into the Columbia River at Wells Hatchery, while the remainder are released in the Methow sub-basin. Releases in the action area (including fish released into the Columbia River) have averaged nearly 413,000 fish from 1992 to 2013, ranging from approximately 260,000 to 711,000 (Figure 6). Returning fish from both programs interbreed with natural-origin fish and the percentage of hatchery-origin fish on the spawning grounds is very high (~76 percent; NWFSC 2015).

2.4.4. Harvest

Spring Chinook Salmon

Spring Chinook salmon are not harvested in the action area.

Steelhead

Mark-selective steelhead fisheries operate in the action area under permit 1395 (NMFS 2003). Allowable incidental take is based on natural-origin returns, with the idea being that as the number of natural-origin returns increases, the risk from incidental impacts decreases, and therefore a higher percentage of natural-origin fish can be allowed to be encountered in the fishery. No encounters with spring Chinook salmon have generally occurred or would be expected because these fisheries occur from September through March and do not overlap in time with the presence of spring Chinook adults. The steelhead fisheries may occur from September through March, although seasons are often shorter based on in-season assessment of ESA take of steelhead returns in the fisheries.
Table 9. Incidental mortality of natural-origin steelhead during WDFW’s mark-selective steelhead fisheries in the action area. Mortalities are based on a 5-percent assumed catch and release mortality.

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

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

¹This includes the reach from Priest to Wells Dam and the Entiat River.
²This includes the reach from Rock Island to Wells Dam.

Fisheries Targeting Non-listed Fish

In the action area, there are three 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 12 adult steelhead over the last five years, and remains within their allowed take through NMFS permit 1554 (Table 10). The summer Chinook and sockeye salmon fishery has incidentally killed up to 10 adult steelhead (Table 10), which is within their allotted take under permit 1554. This fishery is unlikely to encounter spring Chinook salmon, and has not in the past to any measurable extent, because it operates from July to October after spring Chinook salmon have already spawned in the tributary habitats, and does not take place in the Methow River. Creel surveys indicate that the non-game fishery above Priest Rapids has not resulted in take of listed spring Chinook and steelhead despite operating year-round (WDFW 2013; WDFW 2014b; WDFW 2015b; WDFW 2016b; WDFW 2017a).
Table 10. Incidental mortality of ESA-listed steelhead and spring Chinook salmon for fisheries targeting non-listed fish in the action area.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishery</th>
<th>Allowable steelhead mortalities</th>
<th>Realized steelhead mortalities</th>
<th>Allowable spring Chinook salmon mortalities</th>
<th>Realized spring Chinook salmon mortalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>429 juveniles 12 adults</td>
<td>8 juveniles</td>
<td>0 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>9 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>650 juveniles 12 adults</td>
<td>8 juveniles</td>
<td>8 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>4 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>302 juveniles 4 adults</td>
<td>8 juveniles</td>
<td>8 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>10 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>396 juveniles 0 adults</td>
<td>8 juveniles</td>
<td>2 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>9 adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>Methow River resident trout</td>
<td>1250 juveniles 20 adults</td>
<td>495 juveniles 0 adults</td>
<td>8 juveniles</td>
<td>4 juveniles</td>
</tr>
<tr>
<td></td>
<td>Summer Chinook and sockeye salmon</td>
<td>10 adults</td>
<td>3 adults</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

2.5. Effects of the Action 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. The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together later in this document 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 Jr. 2006; McElhany et al. 2000; NMFS 2004b; NMFS 2005b; NMFS 2008a; NMFS 2011c). 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 2.4.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.7).

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

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

Only the WNFH and the Twisp component of the Wells Complex program remove fish from the local natural population for broodstock leading to a negative effect for steelhead. However, the removal of natural-origin broodstock is guided by abundance-based sliding scales, and a limit of no more than 33 percent of the natural population can be used for broodstock to reduce risk to the natural-origin population. These guidelines and limits are analyzed in detail below (2.5.2.2.1). At most, 136 fish would be removed from the Methow population for broodstock, when natural-origin spawners are forecasted to be larger than 412. From 2005-2014, an average of 651 natural-origin returns spawned in the Methow sub-basin, with a range of 365 to 1,105 (Table 7). Thus, 146 natural-origin steelhead removed for broodstock would equate to ~20 percent of natural-origin spawners. This maximum value also assumed that the pNOB for the conservation program is 1.0, which was achieved in one year from 2014-2016. This would result in an adverse effect on the Methow steelhead population by reducing the number of natural-origin spawners and increasing pHOS. The effects on abundance are noted here; genetic effects are analyzed below. Regarding abundance, fish are spawned and their progeny are intended to supplement the natural population. Thus, the genetic contribution of these natural-origin fish used for hatchery broodstock to the population is not lost. Moreover, the 33 percent limit on removing natural-origin adults for broodstock would minimize impacts by reducing the number utilized in low-return years.

There is no Factor 1 effect on spring Chinook because propagation of these species is not the focus of these programs.
2.5.2.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

The proposed hatchery programs pose both genetic and ecological risks. However, there is some presumed benefit to the species from the integrated programs designed to supplement the natural populations. We believe this benefit, likely in the form of increased abundance and productivity outweighs the risks.

Only ecological effects and incidental handling effects related to adult collection are relevant for spring Chinook salmon because these proposed programs do not propagate this species. The overall effect of this factor on these species is negligible.

2.5.2.2.1. Genetic Effects

For each program, NMFS considers three major areas of genetic effects: within-population diversity, outbreeding effects, and hatchery-influenced selection. Rarely is it possible to measure the three types of effects separately, however. Until direct genetic tools are available, our metrics for inferring the magnitude of these effects are pHOS, pNOB, and, in the case of integrated programs, PNI.

NMFS has not adopted HSRG gene flow (i.e., pHOS, pNOB, PNI) recommendations. However, at present the HSRG recommendations and the 5% stray metric from Grant (1997) are the only widely acknowledged quantitative recommendations available, so NMFS considers them a useful screening tool2. Programs must be evaluated individually. For a particular program, NMFS may, based on specifics of the program, broodstock, and environment, consider a pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG recommendations, NMFS will consider the risk it poses to be acceptable.

Straying

For the purposes of this analysis, straying is defined as fish that return to locations that are not part of their population of origin, and is only a genetic concern when fish actually spawn in those locations. Thus, assuming that 100 percent of those fish that stray also spawn successfully, as is typically necessary, our analyses represent a worst-case scenario in terms of genetic effects of these stray fish into non-target areas. Assessing straying for steelhead is very difficult because they often return to tributary areas when water flows are high and water is turbid, and steelhead carcasses are seldom recovered because they are iteroparous, making it difficult to detect them spawning naturally using traditional assessment techniques (e.g., spawning ground surveys).

PIT-tag data are useful for assessing straying, but the level of confidence in these detection data depends on the sample size of adults. As Table 11 indicates, even though only a few PIT tag detections occurred out-of-basin, they can expand to a relatively large number of adults. This is because only a subset of juveniles are tagged prior to release and SARs are usually between 1

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2 In addition, HSRG recommendations have been used in multiple recent court cases regarding hatchery practices, and have been incorporated into policy by Washington’s Fish and Wildlife Commission Washington Fish and Wildlife Commission. 2009. Policy POL-C3619: Hatchery reform. Olympia, Washington.
and 2 percent. This means that PIT tagging 5,000 juveniles is only expected to yield about 50-100 returning adults with a tag, and some of those may go undetected due to tributary fisheries, low PIT-tag array efficiency, shed tags, etc. These data are also confounded by the propensity of steelhead to wander into adjoining basins during their migration and then fall back out to the mainstem and continue to the natal stream. In addition, the lack of differential marking has limited our ability to detect steelhead distribution in the UCR. For example, a number of release sites released ad-clip only fish. Lack of a differential mark makes it difficult to determine the release location of steelhead adults that returns to Priest Rapids Dam prior to PIT-tagging of those adults. Because of this and numerous modifications of release site location, strategy, and marking over the last few years, it is difficult to assess out-of-basin straying for these programs.

For now, only the 2016 return year, which incorporates fish from the 2012 and 2013 broods, provides the degree of resolution needed to differentiate between release groups. Snow (2017) expanded the number of returning adult PIT tag detections from each release group detected out-of-basin to estimate the number of fish that could be straying into each population. The escapement estimates in Table 11 are prior to removal of fish by fisheries. The data demonstrate that out-of-basin straying is relatively low (~10% of each recipient population), and monitoring will need to continue. We expect the proposal by the applicants to differentially mark certain release groups to gather release-group-specific adult-distribution information when returning adults are PIT-tagged at Priest Rapids Dam to decrease the uncertainty around the straying estimates from Table 11. We also anticipate that, once fish return that were released after implementing the Proposed Action in three or more consecutive years, we will have a more consistent baseline to evaluate how best to modify programs in the future, if needed to meet out-of-basin straying goals of no more than 5 percent of the recipient populations.

Table 11. Estimated number of steelhead from each release group that stray out-of-basin derived from actual returning adult PIT tag detections (shown in parentheses), for adults returning in 2016.

<table>
<thead>
<tr>
<th>Recipient River</th>
<th>Total Run Size/Spawners</th>
<th>Release Group Returns Expanded by PIT-tag Rate (Actual number of detections)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Columbia</td>
</tr>
<tr>
<td>Methow</td>
<td>2358</td>
<td>37 (1)</td>
</tr>
<tr>
<td>Entiat</td>
<td>498</td>
<td>37 (1)</td>
</tr>
<tr>
<td>Okanogan</td>
<td>1566</td>
<td>74 (2)</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>1764</td>
<td>0</td>
</tr>
</tbody>
</table>

1 In the Methow, only fish released from Wells Hatchery in the mainstem Columbia River would be considered strays.

**Gene Flow Management**

To perform our analysis, we will use models that consider the best available information for the target populations to determine the likely PNI of the population based on the applicants’ proposed proportion of natural-origin broodstock (pNOB) and the pHOS in the target populations’ natural spawning areas. A PNI of > 0.5 indicates that natural selection outweighs
hatchery-influenced selection and is the target for primary and contributing populations according to the HSRG (e.g., HSRG 2009), but the timeline associated with achieving a PNI > 0.5 is unique to each program.

We found in evaluating the programs that the simple well-known equation in which PNI is approximated as a simple function of pNOB and pHOS did not adequately model the genetic relationship between the hatchery programs and the natural spawning populations. As in the case of a recent biological opinion on Methow spring Chinook (NMFS 2016), we applied an expanded multi-population component model for estimation of PNI (Busack 2015) that explicitly considers these linkages. For this analysis, we used four population components: 1) the Conservation program, which combines broodstock from the Twisp component of the Wells Complex program and the WNFH program; 2) the safety-net program, which includes the Methow safety-net component of the Wells Complex program; 3) the upper Methow River and primary tributaries (Figure 2); and 4) the lower mainstem Methow River below the hatcheries (Figure 2).

Not included in this gene flow analysis is the release of steelhead into the mainstem Columbia River from Wells Hatchery. We did not include this release in the model because it is likely that few, if any, would return to the Methow River, and with the current methods available for assessing fish distribution, we do not have a way to differentiate this release group from the Methow safety-net component (see discussion above on straying). Therefore, we assumed all the fish with markings that currently apply to both of these release groups (adipose clip only), were from the Methow safety-net component. NMFS recommends differential marking of juveniles from these two release sites to enable us to track returning adults from these two release groups in the future.

Under current conditions, the average subbasin-wide PNI over the last three years is 0.48, and ranged from 0.45 to 0.51 (Table 12). However, a number of changes to the programs that are anticipated to improve the PNI have recently occurred or will be occurring. First, the Methow safety-net component of the Wells Complex program will only be reared at the Wells hatchery on the main-stem Columbia River, and releases of this program component will be moved downstream to Burma Bridge at RM 7 in the Methow River. This is likely to limit the number of these safety-net fish to areas farther upstream, which would decrease their pHOS contribution in those areas.

Second, more effective differential marking of release groups allows certain groups to be targeted more intensely for adult management than others. For example, removal of fish with both an adipose and ventral clip would select for fish from the Wells mainstem and Methow safety-net components of the Wells Complex program, but would protect fish from the Twisp component and the WNFH program. This should result in a decrease in pHOS attributable to safety-net and mainstem components of the Wells Complex program. Selectively removing hatchery fish from programs that are further away genetically from the natural-population will aid in obtaining a higher PNI value than what it is currently.

Third, release-site-specific marking also allows managers, when necessary, to selectively remove fish at Wells Dam or via a fishery in the mainstem Columbia River if management actions in the
Methow River itself are not projected to allow targets to be reached. The use of Wells Dam has been limited in the past due to the possibility of removing fish headed for the Okanogan River. More specific marking should also allow for a higher proportion of conservation program (Twisp component and WNFH) fish to be collected and used for safety-net component broodstock.

After taking into account the proposed changes to the operation of these programs, we believe it is feasible to reach the subbasin-wide PNI target of $\geq 0.67$ by 2022, measured as a five-year running average. However, from 2018 to 2021, PNI is likely to be between 0.45 and 0.67. Table 12 demonstrates what PNI would be given the guidelines in the proposed action and either over an average pHOS in the lower main-stem Methow River or the worst case pHOS in the lower main-stem Methow River of 1. We decided to include the latter in the table because there is no target for pHOS in the management area—it is allowed to vary as long as the PNI value of 0.67 is achievable (for those years where returns are managed for genetic targets and not for demographic targets (e.g., total spawners of 500)).

### Table 12. Proportionate natural influence (PNI) based on current conditions and the proposed action: pNOB = proportion of natural-origin broodstock; pHOB = proportion of hatchery-origin broodstock from the conservation program; pNOS = proportion natural-origin spawners; s = safety-net program; c = conservation program; NA = not applicable.

<table>
<thead>
<tr>
<th>Return Year</th>
<th>Conservation pNOB</th>
<th>Safety-net pHOBc</th>
<th>Upper Methow River and Major Tributaries</th>
<th>Lower Main-stem Methow River</th>
<th>Sub-basinwide PNI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>pHOSc</td>
<td>pHOSs</td>
<td>pNOS</td>
</tr>
<tr>
<td>Current Conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>1.00</td>
<td>0.13</td>
<td>0.23</td>
<td>0.12</td>
<td>0.65</td>
</tr>
<tr>
<td>2015</td>
<td>0.86</td>
<td>0.45</td>
<td>0.30</td>
<td>0.19</td>
<td>0.51</td>
</tr>
<tr>
<td>2016</td>
<td>0.77</td>
<td>0.27</td>
<td>0.17</td>
<td>0.22</td>
<td>0.61</td>
</tr>
<tr>
<td>Proposed Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NA; average</td>
<td>0.75</td>
<td>0.90</td>
<td>0.20</td>
<td>0.05</td>
<td>0.75</td>
</tr>
<tr>
<td>NA; worst-case</td>
<td>0.75</td>
<td>0.90</td>
<td>0.20</td>
<td>0.05</td>
<td>0.75</td>
</tr>
</tbody>
</table>

2.5.2.2.2. Ecological Effects

**Adult Nutrient Contribution**

The return of hatchery fish likely contributes nutrients to the action area. Table 13 shows that adult hatchery steelhead, if all estimated returning fish spawn naturally, would potentially contribute an estimated 108 kg of phosphorous to the action area annually. With the use of mark-selective fisheries, the iteroparous life history of steelhead, and fish collected for broodstock, the true contribution is likely less than this value, around 30 percent less or 32 kg. Regardless, hatchery-origin steelhead increase phosphorous concentrations, which likely compensates for some marine-derived nutrients lost from declining numbers of natural-origin fish.
Table 13. Total phosphorous imported by adult returns from the proposed hatchery steelhead programs based on the equation (Imports= hatchery adults*mass*phosphorous concentration) in Scheuerell et al. (2005).

<table>
<thead>
<tr>
<th>Program</th>
<th>Release number</th>
<th>SAR (%)(^1)</th>
<th>Estimated number of hatchery-origin adults(^2)</th>
<th>Adult mass (kg)</th>
<th>Phosphorous concentration (kg/adult)</th>
<th>Phosphorous imported (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Complex</td>
<td>348,000</td>
<td>1.77</td>
<td>6160</td>
<td>4</td>
<td>0.0038</td>
<td>94</td>
</tr>
<tr>
<td>WNFH</td>
<td>200,000</td>
<td>0.46</td>
<td>920</td>
<td>4</td>
<td>0.0038</td>
<td>14</td>
</tr>
</tbody>
</table>

\(^1\) Smolt-to-adult survival rate; data from brood years 2007-2011 (Snow et al. 2016) and from 2008-2012 for 2-year smolts at WNFH (Humling 2017).

\(^2\) Calculated by multiplying the release number by the smolt to adult survival (SAS) values.

**Competition with Natural-origin Steelhead for Spawning Sites**

Natural and hatchery-origin steelhead spawning naturally overlap in their selection of spawning sites due to similar niche requirements. Data from 2009-2015 indicated that spawn timing between hatchery and natural-origin steelhead only differed significantly in 2013 (Figure 8). However, a consequence of having any hatchery fish on the spawning grounds is the potential for spawning site competition and redd superimposition. Efforts to assess spawning distribution in the Twisp River have demonstrated that from 2009 to 2013 there was no difference in spawning sites between natural and hatchery steelhead. However, data for 2014 and 2015 showed that natural-origin fish were spawning further upstream (Snow et al. 2016). Thus, it may be that natural-origin steelhead are moving further upstream to avoid competition with hatchery-origin steelhead, but it is difficult to discern a cause and effect, and this is just one plausible explanation for a result witnessed two out of seven years where data were available. Some other equally plausible explanations are that adult management of the weir limits the number of hatchery-origin fish passed above to spawn naturally, or homing of natural-fish to the portion of the river where they were born. Therefore, NMFS recommends continuing this monitoring to see if the spawning distribution or timing differences continue over the next five years.
Figure 7. Mean spawning location (center point), 95% confidence intervals (box) and minimum and maximum values (whiskers) by origin of female steelhead released upstream of the Twisp River weir based on PIT tag detections and Floy tag observations from 2009-2015. Figure 5.1 from Snow et al. (2016)
Competition with Listed Salmon for Spawning Sites

Competition between adult spring Chinook salmon and adult hatchery-origin summer steelhead is likely negligible due to differences in run-timing, holding, and spawn timing. Steelhead begin their entry into freshwater during the last portion of the Chinook salmon migration and reach the action area after spring/summer Chinook salmon have held over the summer and spawned (Table 14). Thus, there is unlikely to be any spawning competition effect between steelhead from these programs and spring Chinook salmon.

Table 14. Run-timing, holding, and spawn timing of spring/summer Chinook salmon and summer steelhead (UCSRB 2007).

<table>
<thead>
<tr>
<th>Species</th>
<th>Run Timing</th>
<th>Holding</th>
<th>Spawning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring/Summer Chinook Salmon</td>
<td>May-mid-July</td>
<td>May-August</td>
<td>Early August-mid September</td>
</tr>
<tr>
<td>Summer Steelhead</td>
<td>May-April</td>
<td>September-April</td>
<td>March-early June</td>
</tr>
</tbody>
</table>
2.5.2.2.3. **Adult Collection**

The use of facilities for broodstock collection would result in the capture and handling of natural-origin spring Chinook salmon and steelhead, and some incidental mortality associated with these actions. The numbers of steelhead affected by this activity are included in Table 15. From 2011 to 2015, an average of about 1,581 (maximum of 2,503) natural- and 7,942 (maximum of 11,728) hatchery-origin steelhead were counted at Wells Dam, composed of fish from both the Okanogan and Methow populations (Mackey 2016). Thus, based on handling of steelhead in Table 15, handling of steelhead likely impacts about 10 to 20 percent of the steelhead counted (1278/11,728 = 11 percent for hatchery, and 431/2503 = 17 percent for natural), when considering maximum values across all facilities. However, in the future the removal of hatchery-origin steelhead at Wells Hatchery may increase to achieve gene flow targets. Thus, in some years, it may be necessary to handle up to ~50 percent of the steelhead at all facilities to achieve gene flow management objectives.

**Table 15. Number of steelhead handled by origin. Mortalities, if any, are shown in parentheses and exclude those used as broodstock or treated as surplus; these mortalities are attributed only to the act of handling and collecting adults.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Hatchery</td>
<td>Hatchery</td>
<td>Not Applicable</td>
<td>141 (0)</td>
<td>136 (0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td></td>
<td>34 (0)</td>
<td>28 (0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells Dam</td>
<td>Hatchery</td>
<td>726 (3)</td>
<td>590 (2)</td>
<td>508 (0)</td>
<td>362 (1)</td>
<td>296 (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>130 (0)</td>
<td>86 (0)</td>
<td>78 (0)</td>
<td>158 (0)</td>
<td>129 (1)</td>
<td></td>
</tr>
<tr>
<td>Methow Hatchery</td>
<td>Hatchery</td>
<td>Not Available</td>
<td>22 (0)</td>
<td>44 (0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td></td>
<td>10 (0)</td>
<td>11 (0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twisp Weir¹</td>
<td>Hatchery</td>
<td>225 (2)</td>
<td>167 (0)</td>
<td>116 (3)</td>
<td>103 (2)</td>
<td>165 (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td>145 (1)</td>
<td>126 (0)</td>
<td>74 (2)</td>
<td>87 (1)</td>
<td>66 (0)</td>
<td></td>
</tr>
<tr>
<td>WNFH Trap</td>
<td>Hatchery</td>
<td>Not Available</td>
<td>7 (0)</td>
<td>20 (2²)</td>
<td>12 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td></td>
<td>0 (0)</td>
<td>2 (0)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angling</td>
<td>Hatchery</td>
<td>Not Available</td>
<td>29 (2)</td>
<td>99 (0)</td>
<td>122 (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural</td>
<td></td>
<td>71 (0)</td>
<td>38 (0)</td>
<td>81 (2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: (Humling 2017c; Snow 2017b; Snow et al. 2016)

¹ Most of the mortalities included here are actually carcasses or kelts that are encountered at the weir weeks after handling.
² These are prespawn mortalities.

Any handling and incidental mortality of spring Chinook salmon has previously been covered in the Methow spring Chinook biological opinion, which utilizes the same facilities for broodstock collection for those programs (NMFS 2016). It is difficult, if not impossible, to separate handling that occurs as a result of the operation of these adult collection facilities for the steelhead programs versus what is targeted handling for the spring Chinook salmon programs, but our analysis of the effects of this action assume that handling is related to the steelhead programs, in order to assure that this opinion relies on conservative assumptions.
The Twisp weir is the only weir operated in the Methow Subbasin associated with this proposed action. Other effects of weir operation besides the capture and handling of fish are the potential for delayed migration and changes in spawn timing and spatial distribution of listed species. However, these effects are largely limited to adult passage upstream as the weir is designed to allow juvenile and kelt passage.

Though adult passage may be delayed slightly, weir operation guidelines and monitoring of weirs by the co-managers (Section 1.3.1) minimize the delays to and impacts on fish; the weir is checked at least once a day when in operation so fish would be delayed for 24 hours at the most. Data from the last five years demonstrates that spawn timing and distribution between hatchery and natural steelhead has been similar for most of the years surveyed (Figure 7 and Figure 8), and no take is expected via this pathway. However, the lack of a consistent trend makes it difficult to pinpoint the cause of the differences found in certain years. Therefore, NMFS recommends continued monitoring of these metrics to see if more consistent patterns emerge.

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

We have drawn our action area for this action down to Priest Rapids Dam on the Columbia River and thus only consider effects of juvenile hatchery fish in juvenile rearing areas and the migratory corridor down to Priest Rapids Dam. The effects of this factor on both listed species considered in this opinion is negative.

2.5.2.3.1. Hatchery release competition and predation effects

Pearsons and Busack (2012) developed a model that quantifies the potential number of natural-origin salmon and steelhead juveniles lost to competition and predation from the release of hatchery-origin juveniles, and we have employed this model to analyze impacts to listed populations that could occur as a result of the proposed action. Since the publication of the paper, software bugs have been identified by model users that prevented completion of model runs. To use this model for the current analysis, we modified some model code, and shut off some aspects of the model, specifically parameters related to disease, and the ability to obtain probabilistic (as opposed to deterministic) results. The remaining parameters and their values considered in the model are shown in Table 16-Table 18.

For our model runs, we assumed a 100 percent population overlap between hatchery steelhead and all natural-origin species present. Hatchery steelhead are released from mid-March to May, and may overlap with natural-origin Chinook salmon and steelhead. However, our model does not consider ecological effects on age-0 steelhead because steelhead spawn from March to June with a peak from April to May in the action area (Busby et al. 1996). Eggs incubate and then fry emerge, peaking in mid to late July. Thus, it is unlikely that any age-0 steelhead would have emerged in time to interact with the hatchery steelhead smolts as they migrate downstream.
Table 16. Parameters in the PCDrisk model that are the same across all programs. All values from HETT (2014) unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat complexity</td>
<td>0.1</td>
</tr>
<tr>
<td>Population overlap</td>
<td>1.0</td>
</tr>
<tr>
<td>Habitat segregation</td>
<td>0.3 for steelhead, 0.6 for Chinook salmon</td>
</tr>
<tr>
<td>Dominance mode</td>
<td>3</td>
</tr>
<tr>
<td>Piscivory</td>
<td>0.0023</td>
</tr>
<tr>
<td>Maximum encounters per day</td>
<td>3</td>
</tr>
<tr>
<td>Predator:prey length ratio for predation</td>
<td>0.25¹</td>
</tr>
<tr>
<td>Average temperature across release sites</td>
<td>7°C</td>
</tr>
</tbody>
</table>

¹Daly et al. (2009)

Table 17. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

<table>
<thead>
<tr>
<th>Species</th>
<th>Age Class</th>
<th>Size in mm (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook salmon</td>
<td>0</td>
<td>38 (4)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>98 (4)</td>
</tr>
<tr>
<td>Steelhead</td>
<td>1</td>
<td>126 (24)</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>170 (24)</td>
</tr>
</tbody>
</table>

Source: (HETT 2014)
Table 18. Hatchery fish parameter values for the PCDRisk model. PRD = Priest Rapids Dam; RRD = Rocky Reach Dam; WNFH = Winthrop National Fish Hatchery; RM = River Mile. The WNFH releases in the Chewuch and the Upper Methow are analyzed to encompass possible release sites in the future.

<table>
<thead>
<tr>
<th>Program: Release Site</th>
<th>Proposed Release #</th>
<th>Size in mm (SD)</th>
<th>Survival to PRD</th>
<th>Median Residence/Travel Time to PRD (Days; RRD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Complex: Wells Hatchery</td>
<td>160,000</td>
<td>190 (20)</td>
<td>0.87</td>
<td>6 (2)</td>
</tr>
<tr>
<td>Well Complex: Methow RM 7</td>
<td>100,000</td>
<td>190 (20)</td>
<td>0.82</td>
<td>7 (5)</td>
</tr>
<tr>
<td>Wells Complex: Twisp River</td>
<td>48,000</td>
<td>190 (20)</td>
<td>0.45</td>
<td>35 (19)</td>
</tr>
<tr>
<td>WNFH: WNFH</td>
<td>200,000</td>
<td>190 (20)</td>
<td>0.64</td>
<td>11 (6)</td>
</tr>
<tr>
<td>WNFH: Chewuch RM 20(^1)</td>
<td>100,000</td>
<td>190 (20)</td>
<td>0.64</td>
<td>12 (7)</td>
</tr>
<tr>
<td>WNFH: Upper Methow RM 67(^1)</td>
<td>100,000</td>
<td>190 (20)</td>
<td>0.64</td>
<td>12 (7)</td>
</tr>
</tbody>
</table>

Sources: (Humling 2017a; Humling 2017b; Snow 2017a)

\(^1\)These releases would replace the release of 200,000 steelhead at WNFH as a worst-case estimate of ecological effects.

Based on the data above, our model results show that hatchery steelhead are likely to have the largest ecological effect on natural-origin Chinook juvenile salmon, followed by their effects on natural-origin steelhead juveniles. The maximum numbers of fish lost are shown in Table 19, and these maximums would not change if more natural-origin fish were present because this is the value where all possible hatchery fish interactions with natural-origin fish are exhausted at the end of each day (i.e., larger hatchery releases require more natural-origin fish to be included in the model to ensure all possible interactions are exhausted). This equates to about 18 returning adult Chinook salmon, and 28 steelhead adult equivalents calculated using average smolt-to-adult survival rates from the spring Chinook salmon programs (0.0029; NMFS 2016) and steelhead programs in the Methow River (0.011; Table 13). Summing the number of natural-origin steelhead and Chinook salmon that comprise each extant population in the DPS or ESU from the NWFSC (2015) status review, this would equate to a 1.4 percent (28/2,011) and a 1.7 percent (18/1,090) reduction in potential adult natural-origin spawners during the juvenile life stage from the UCR Steelhead DPS and UCR spring Chinook Salmon ESU, respectively. In addition, our model considers all Chinook runs together, so it is likely that some of the juvenile Chinook salmon preyed upon and/or competed with are unlisted summer Chinook salmon, likely overestimating adverse effects on this ESU.
Table 19. Maximum numbers and percent of natural-origin salmon and steelhead juveniles lost to competition and predation with hatchery-origin steelhead smolts released from the Proposed Action.

<table>
<thead>
<tr>
<th>Program</th>
<th>Chinook salmon</th>
<th>Steelhead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pred.</td>
<td>Comp.</td>
</tr>
<tr>
<td>Well Complex: Columbia mainstem</td>
<td>833</td>
<td>281</td>
</tr>
<tr>
<td>Well Complex: Methow RM 7</td>
<td>653</td>
<td>231</td>
</tr>
<tr>
<td>Wells Complex: Twisp River</td>
<td>1004</td>
<td>774</td>
</tr>
<tr>
<td>WNFH: WNFH</td>
<td>1678</td>
<td>611</td>
</tr>
<tr>
<td><strong>Total Number</strong></td>
<td><strong>6065</strong></td>
<td><strong>2532</strong></td>
</tr>
<tr>
<td><strong>Adult Equivalents</strong></td>
<td><strong>18</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

1 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.

2 This was calculated by using the smolt-to-adult survival rates for hatchery fish of each species (see above text) and multiplying by the total number of fish lost.

We conducted another analysis that was similar but, instead of releasing all of the steelhead produced at WNFH on-station, we replaced this release with releases of these fish at the furthest point upstream. While the applicants are not planning on releasing WNFH steelhead at these upstream sites at this time, there is active discussion on this topic. Because this would likely increase the travel time to Priest Rapids Dam, we believe this analysis to account for the largest possible adverse effect of hatchery-origin juveniles competing and preying on listed natural-origin fish. This resulted in an additional 1 natural-origin Chinook salmon and 2 natural-origin steelhead adult equivalents lost during the juvenile life stage (Table 20).

Table 20. Maximum numbers and percent of natural-origin salmon and steelhead lost to competition and predation with hatchery-origin steelhead smolts released from the Proposed Action with consideration of potential upstream releases to replace the WNFH on-station release.

<table>
<thead>
<tr>
<th>Program</th>
<th>Chinook salmon</th>
<th>Steelhead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pred.</td>
<td>Comp.</td>
</tr>
<tr>
<td>Well Complex: Columbia mainstem</td>
<td>833</td>
<td>281</td>
</tr>
<tr>
<td>Well Complex: Methow RM 7</td>
<td>653</td>
<td>231</td>
</tr>
<tr>
<td>Wells Complex: Twisp River</td>
<td>1004</td>
<td>774</td>
</tr>
<tr>
<td>WNFH: Chewuch RM 20</td>
<td>955</td>
<td>362</td>
</tr>
<tr>
<td>WNFH: Upper Methow RM 67</td>
<td>955</td>
<td>362</td>
</tr>
<tr>
<td>Total Number</td>
<td>6410</td>
<td>2698</td>
</tr>
<tr>
<td>--------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Adult Equivalents&lt;sup&gt;2&lt;/sup&gt;</td>
<td>19</td>
<td>30</td>
</tr>
</tbody>
</table>

<sup>1</sup> 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.

<sup>2</sup> This was calculated by using the smolt-to-adult survival rates for hatchery fish of each species (see above text) and multiplying by the total number of fish lost.

Residual hatchery steelhead 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 fish for a longer period of time relative to migrants, and could impart some genetic effects when they spawn naturally. Residuals are not explicitly accounted for in our model at this time, but the applicants have proposed actions, which are expected to minimize their ecological and genetic impacts. At WNFH, volitional release will allow for the retention of non-migratory parr and early maturing males (expected to be 5-15 percent of production annually; potential residuals). The transfer of these fish to local lakes and reservoirs would eliminate the risk of residualism in anadromous waters by the transferred fish. Data provided by the USFWS suggests that the proportion of production likely to residuaize has averaged 7.4 percent (range of 2.6-11.3) from 2013-2017 (Michael Humling, USFWS, personal communication October 6, 2017).

The same method applied to WNFH is applied for the Columbia River mainstem releases associated with the Wells Complex program. However, for the safety-net fish that are released directly into the Methow and Twisp Rivers, any steelhead that do not volitionally emigrate from the dirt ponds for a few weeks (approximately mid-April to mid-May) each spring are forced from the pond. These fish are then considered non-migrants and can also be transferred to co-managers for release into non-anadromous waters, as determined by fisheries managers. Data provided by WDFW demonstrates that for the Columbia and Methow River releases, the proportion of migrants that may residualize has averaged ~ two percent (range from 0.5-3.0) from 2012-2016 (Charles Snow, WDFW, personal communication, September 13, 2017).

Therefore, while the transfer or removal of non-migrants makes residualism less likely to occur, we would still monitor for this phenomenon through visual assessment of migrant fish at release. Supporting methods of estimating residual rates, such as comparing survival values between volitional migrant and forced-out releases and assessment of sexual development via gonadosomatic index (GSI), may be conducted to provide reliable estimates for some release groups. We anticipate the number of residual fish to be no more than 10 percent of the number of fish within each release group, based on a 5-year running average, leading to a small negative effect on listed natural-origin salmon and steelhead. In addition, NMFS expects the applicants to continue work on minimizing residualism of hatchery fish.

When transfer is not feasible (likely due to fish health concerns), the USFWS will work with local co-managers to determine the best outlet for non-migrant steelhead juveniles. To evaluate the assumption (supported by the findings of Gale et al. 2009; Viola and Schuck 1995) that removal of non-migrant fish will manage/control for the impacts of residual hatchery fish on
wild populations, the USFWS may release the PIT tagged portion of the non-migrant population (~ up to 600 steelhead).

2.5.2.3.2. Naturally-produced progeny competition

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

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

2.5.2.3.3. Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these steelhead programs. This is because no detections of exotic pathogens have occurred in the last three years and epidemics have all been caused by endemic pathogens with available treatments (Table 21). In June of 2014, fish were transferred from Wells Hatchery to WNFH with Flavobacterium psychrophilum, which causes coldwater disease, and they were treated with medicated feed. The second epidemic at WNFH occurred in July of 2015, which was caused by Icthyophtirius multifiliis. Some of these fish were treated with formalin, however increasing flows and turnover rates proved to be a more effective treatment for this parasite.

Furthermore, to prevent outbreaks and reduce the amplification of IHNV in natural environments, hatchery staff drain the coelomic fluid from females during spawning and treat eggs with an iodophor solution, controlling, to some extent, the transmission of IHNV (IHOT 1995; NWIFIC and WDFW 2006; ODFW 2003; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989). Because of these preventative measures, no epidemics of IHNV associated with these four programs have occurred in recent years. Thus, NMFS believes the risk of pathogen transmission to wild fish from hatchery fish and amplification of pathogens in the natural environment is low.
Table 21. Pathogen Detections in steelhead being reared for both steelhead programs.

<table>
<thead>
<tr>
<th>Program</th>
<th>Pathogen Detected</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>WNFH Steelhead</td>
<td><em>Flavobacterium psychrophilum</em></td>
<td>F. psychrophilum, IHNV,</td>
<td>F. psychrophilum, IHNV,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Renibacterium salmoninarum,</td>
<td>R. salmoninarum,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Ichthyophthirius multifiliis</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells Complex</td>
<td><em>Flavobacterium psychrophilum</em> (x2),</td>
<td>Saprolegnia spp. (x3),</td>
<td>Ichthyophthirius multifiliis,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>bacterium causing environmental gill disease</td>
<td>Gyrodactylus spp.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: (Humling 2016)(WDFW 2017b)
* Resulted in an epidemic

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

The monitoring and evaluation activities directly related to the proposed hatchery programs are part of a larger effort to determine the overall status of the UCR steelhead DPS. Because the intent is to improve our understanding of listed population status, the information gained outweighs the risks to the populations based on the small proportion of fish encountered, resulting in an overall negligible effect of RM&E on steelhead. Effects on spring Chinook salmon are negligible.

The proposed RM&E directly related to fish culture uses well-established (e.g., AHSWG 2008) methods and protocols. For the integrated programs included in this proposed action, the eyed-egg-to-smolt survival was 70 and 85 percent, respectively, for the Wells Complex and WNFH programs (DPUD and WDFW 2011; USFWS 2012b). These rates are anticipated prior to egg takes, and generally pose little to no risk to the population because these survival rates greatly exceed survival expectations of egg-to-smolt survival in the wild (e.g., egg-to-smolt survival was 7 percent for natural-origin Chinook salmon (Bradford 1995)).

Surveying for redds and adults to estimate steelhead abundance, distribution, and spawn timing occurs in the Twisp River and the Methow River from the town of Winthrop downstream to the mouth of the Columbia River. Some smaller sections of tributaries are also surveyed if spawning areas existed downstream of active PIT tag arrays. The effects of these surveys are limited to the visual observation of listed steelhead. The typical response of fish to this activity is within the range of normal behaviors (i.e., startling response to a predator).

Sampling of juveniles occurs in the Methow River subbasin between February and December using screw traps to assess juvenile outmigration and abundance. The number of natural-origin steelhead juveniles encountered ranged from approximately 800 to 2,000 a year with about a 1 percent incidental mortality rate for both screw traps combined (Table 22). Listed hatchery-origin fish encountered ranged from approximately 5,000 to 8,500 a year with less than a 0.5
percent mortality rate. An additional approximately 2,300 to 5,500 natural-origin steelhead juveniles may be encountered each year during electrofishing and angling activities (Table 23). Delayed mortality after tagging and release could occur in up to 1 percent of fish tagged. This equates to an average of 16 natural-origin, and 83 hatchery-origin ESA-listed adults encountered and handled during the juvenile life stage with no resulting mortalities (Table 22). This low level of encounter and mortality likely has a negligible effect on the steelhead population, especially when considering adult equivalents, and is outweighed by the benefits of collecting the information needed to assess the hatchery program. Encounter of spring Chinook salmon was covered in the consultation for the Methow River spring Chinook salmon programs (NMFS 2016b), which resulted in a no-jeopardy determination.
Table 22. Number of juvenile steelhead encountered during juvenile steelhead rotary screw trapping, with those that died shown in parentheses; NA = not available.

<table>
<thead>
<tr>
<th>Trap</th>
<th>Fish origin</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Average Adult Equivalents&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2010</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Methow River RM 18.6</td>
<td>Natural</td>
<td>552 (1)</td>
<td>271 (0)</td>
<td>518 (8)</td>
<td>900 (13)</td>
<td>781 (5)</td>
<td>550 (2)</td>
<td>7 (0)</td>
</tr>
<tr>
<td></td>
<td>Hatchery</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>2887</td>
<td>5087 (7)</td>
<td>3295</td>
<td>41 (0)</td>
</tr>
<tr>
<td>Twisp River RM 1.2</td>
<td>Natural</td>
<td>992 (2)</td>
<td>523 (2)</td>
<td>759 (2)</td>
<td>886 (6)</td>
<td>844 (3)</td>
<td>779 (1)</td>
<td>9 (0)</td>
</tr>
<tr>
<td></td>
<td>Hatchery</td>
<td>4825 (4)</td>
<td>7005 (18)</td>
<td>NA</td>
<td>3865 (13)</td>
<td>3459 (0)</td>
<td>3641 (26)</td>
<td>42 (0)</td>
</tr>
</tbody>
</table>

Sources: (Snow et al. 2015; Snow et al. 2016; Snow et al. 2014; Snow et al. 2012; Snow et al. 2011; Snow et al. 2013)

<sup>1</sup>This was calculated by taking the average across all years and then multiplying that number by the average hatchery-origin SAR of 1.1 for both steelhead programs (Table 13).
Table 23. Number of natural-origin juvenile steelhead caught and PIT tagged using a combination of angling and electrofishing.

<table>
<thead>
<tr>
<th>Trap</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Average Adult Equivalents$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow River</td>
<td>318</td>
<td>516</td>
<td>1029</td>
<td>1849</td>
<td>0</td>
<td>35</td>
<td>7</td>
</tr>
<tr>
<td>Twisp River</td>
<td>1496</td>
<td>1861</td>
<td>2366</td>
<td>1988</td>
<td>2890</td>
<td>3803</td>
<td>26</td>
</tr>
<tr>
<td>Chewuch River</td>
<td>508</td>
<td>1059</td>
<td>2034</td>
<td>2321</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: (Snow et al. 2016)

$^1$ This was calculated by taking the average across all years and then multiplying that number by the average hatchery-origin SAR of 1.1 for both steelhead programs (Table 13).

Handling and sampling of adults at Priest Rapids Dam was previously covered in the opinion on the Wenatchee Steelhead Program and associated permit (NMFS 2016a). For this RM&E, about 15 percent of the steelhead passing over Priest Rapids Dam are sampled annually and PIT tags may be inserted to track distribution of these fish. The use of marking to be able to better differentiate release groups of adults originating from the Methow Basin and at Wells should improve our ability to track the distribution of these steelhead by release group.

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

Operation and maintenance of the facilities associated with the hatchery programs included in the Proposed Action would have a negligible effect on ESA-listed spring Chinook salmon and steelhead or their designated critical habitat. No construction is included as part of the Proposed Action.
Table 24. Program water source and use.

<table>
<thead>
<tr>
<th>Facility1</th>
<th>Surface Water Rights (cfs)</th>
<th>Surface Water Source</th>
<th>Average Flow2</th>
<th>Lowest Monthly Flow2</th>
<th>Average % of River Flow (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Hatchery</td>
<td>150</td>
<td>Columbia River</td>
<td>132,670</td>
<td>76,500</td>
<td>0.1 (0.2)</td>
</tr>
<tr>
<td>WNFH</td>
<td>50</td>
<td>Methow River via Foghorn irrigation Ditch</td>
<td>768.8</td>
<td>103.1</td>
<td>6.5 (48.5)3</td>
</tr>
<tr>
<td>Methow Hatchery</td>
<td>25</td>
<td>Methow River via Foghorn irrigation Ditch</td>
<td>768.8</td>
<td>103.1</td>
<td>3.3 (24.2)</td>
</tr>
<tr>
<td>Twisp River Acclimation Pond</td>
<td>6</td>
<td>Twisp River</td>
<td>324</td>
<td>32.8</td>
<td>1.9 (18.3)</td>
</tr>
<tr>
<td>Chewuch River Acclimation Pond</td>
<td>6</td>
<td>Chewuch River</td>
<td>600</td>
<td>48.9</td>
<td>1.0 (12.3)</td>
</tr>
</tbody>
</table>

1 The effects of all facilities in this table, except for Wells Hatchery, were previously considered in the spring Chinook salmon opinion for the Methow River subbasin (NMFS 2016).
2 Flow values are taken from the USGS gauging station 17020016 (Columbia River below Priest Rapids Dam). The average flow is calculated from years 2012 to 2016, and the lowest monthly flow occurred in February 2014. Surface water withdrawal for Wells Hatchery is only used from December to June of the following year.
3 The infrastructure at Foghorn Dam does not allow for the removal of full water rights (50 cfs) during low flow periods. Max withdrawal by WNFH during low flows is ~25 cfs.

The effects of all facilities except for Wells Hatchery were considered in the Methow spring Chinook salmon consultation (NMFS 2016), and were determined to have a negligible effect on the listed species because of the short diversion distance, the non-consumptive use of water, and the small percent of overall flow diverted. These effects are included in the environmental baseline for this Opinion. Similar to the other facilities, surface water diversions for Wells Hatchery occur over a small distance and the water use is non-consumptive (Table 24). In addition, for both Wells and Methow Hatcheries, water use switches from surface water to well water from June to the end of November, or later depending on river water temperatures. This results in the discharge of cooler water into the recipient water body, which may provide a small local benefit during the summer months when warm water temperatures occur.

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

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

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

All intake facilities were designed to meet the NMFS screening criteria that were current at the time of facility construction (NMFS 1995a). These criteria ensure that the mesh or slot-size in the screening material and the approach velocity of water toward the intake screening meet standards that reduce the risk of both entrainment and impingement of listed juvenile salmonids. Facilities are routinely observed for any signs that screens are not effectively excluding fish from intakes. The screen on the surface-water intake for Wells Hatchery was replaced in early 2008 and is inspected annually by divers. The new intake screening is in accordance with NMFS’ most recent screening criteria (NMFS 2011b).

The Foghorn Irrigation Ditch is cleaned every 3-5 years to remove sediment. Although this may be a concern for ESA-listed fish, cleaning of the ditch occurs downstream from the intake screens, which effectively exclude listed salmonids from entering the work area. In addition, the ditch is cleaned in late summer when the Methow and WNF Hatcheries do not use surface water, and the water intakes are blocked off during cleaning to prevent sediment-laden effluent from going through the hatchery. As a result, sediment from ditch cleaning is not expected to enter the Methow River where it could affect listed Chinook salmon or steelhead.

Hatchery maintenance activities may displace juvenile fish through noise and instream activity or expose them to brief pulses of sediment as activities occur instream. The Proposed Action includes best management practices that limit the type, timing, and magnitude of allowable instream activities. The measures would limit any potential short-term effects that are within the normal range of fish behaviors in response to noise or a periodic habitat disturbance.

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

The effects of fisheries that may impact fish produced by these programs are described in Section 2.4.4.
2.5.2.7. Effects of the Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on designated critical habitat. NMFS has determined that operation of the hatchery programs would have a negligible effect on designated critical habitat PBFs in the action area. We believe this is the case for several reasons. The first is the existing hatchery facilities have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity since their construction. Second, no new facilities are proposed. Third, hatchery maintenance activities are expected to retain existing conditions, and would have minimal adverse effects on designated critical habitat. Fourth, WNFH, Wells Hatchery and Methow Hatchery return surface water to the river a short distance from the diversion point and typically use only a small proportion of the total surface water volume (Table 24). Although maximum values could potentially result in 48 percent of surface water withdrawal from the Methow River, this is a worst-case scenario estimate and is unlikely to occur due to the switch to well-water during the summer months when surface water flow is lowest. Because the uses are non-consumptive, these withdrawals would not affect critical habitat of ESA-listed Chinook salmon or steelhead.

Fifth, at this time, no information exists to suggest the use of the chemicals and their subsequent dilution to manufacturer’s instructions would cause adverse effects on ESA-listed fish. Last, the use of abatement ponds at WNFH, Wells Hatchery and Methow Hatchery allows chemical degradation into less toxic components, and the mixing of effluent with the remaining water in the creek or river, is not likely to lead to a detectable change in water quality. Thus, the effects on water quantity and quality in spawning and rearing critical habitat are negligible.

Furthermore, the steelhead programs may actually provide a beneficial effect to critical habitat in the form of marine-derived nutrients (see section 2.5.2.2.2) and as prey for larger natural-origin salmon and steelhead in the action area.

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 of our opinion evaluating Mitchell Act funding (NMFS 2017). 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 a section 10 permit or section 4(d) determination in the future until an opinion for the permit or 4(d) plan has been completed.

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. It is acknowledged, however, that such future state, tribal, and local government actions would likely be in the form
of legislation, administrative rules, or policy initiatives, and land-use and other types of permits, and that government actions are subject to political, legislative, and fiscal uncertainties.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area’s future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline section.

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 1.3) to the environmental baseline (Section 2.4) and to cumulative effects (2.6) taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency’s biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

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

2.7.1. UCR Steelhead DPS

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

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

The majority of the effects of the Proposed Action on this DPS are genetic and ecological in nature. Effects of facility operation and broodstock collection are small and localized, and, while RM&E requires handling of a substantial portion of the juvenile population, when converted to adult equivalents, no adults are expected to die because of handling for RM&E. In addition, the information gained from conducting the work is essential for understanding the effects of the hatchery program on natural-origin steelhead population abundance, productivity, and genetic diversity.

The ecological and genetic effects on the adult life stage are influenced by the proportion of hatchery-origin fish spawning naturally in each area of the river, and the number of natural-origin fish used for broodstock, which allows for calculation of the population PNI. Thus, through implementation of the Proposed Action we anticipate an increase of PNI from an average of 0.48 from 2014-2016 to ≥ 0.67 once adult returns from the proposed action are realized in 2021. This is likely to improve the abundance, diversity, and productivity of the population.

Ecological effects on natural-origin juvenile steelhead associated with releases from the hatchery programs, when converted to adult equivalents, equates to a loss of ~14 adult natural-origin steelhead in the DPS, most likely primarily from the Methow River population. Although this population is essential for DPS recovery, we believe this loss to be a relatively small negative effect, given the benefit to the population and DPS provided by the conservation programs in terms of increased spawning abundance and possibly productivity. It is important to also note, that some levels of competition and predation are likely to occur within hatchery and natural juveniles groupings as well as between them; within group interactions are not currently accounted for in our model.

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 (UCSRB 2007). Such actions are improving habitat conditions and hatchery and harvest practices to protect ESA-listed steelhead DPSs, and NMFS expects this trend to continue, and could lead to increases in abundance, productivity, spatial structure and diversity.

2.7.2. UCR Spring Chinook Salmon ESU

Best available scientific information indicates that the UCR Spring Chinook Salmon ESU is at high risk of extinction and remains Endangered (NWFSC 2015). After taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

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

The effects of our proposed action on this ESU is limited to ecological effects, broodstock collection, and RM&E. Adverse ecological effects on adults are small because of the differences in spatial and temporal overlap of this species with steelhead. However, juveniles may potentially undergo larger effects because of the overlap in outmigration timing. Our ecological analysis showed that the impacts of these programs equates to a loss of ~18 Chinook salmon adult equivalents from the ESU, with the majority most likely from the Methow River population. Because the model differentiates fish by size and not by run timing, these 18 adult equivalents could also include the unlisted summer Chinook salmon as well, and so the estimated maximum impacts on the ESA-listed spring Chinook salmon ESU from ecological effects may prove to be a conservative estimate.

Effects of RM&E and broodstock collection targeting steelhead are also small because monitoring and collection targeting the other species generally occurs using the same traps in the same locations, and is therefore an effect associated with the spring Chinook salmon hatchery programs. Thus, there is very little additional effect due to the steelhead programs on the abundance, productivity, spatial structure and diversity of the UCR Spring Chinook Salmon ESU.

The recovery plan for this ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon (UCSRB 2007). Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs, and NMFS expects this trend to continue, and could lead to increases in abundance, productivity, spatial structure and diversity.

2.7.3. Critical Habitat

The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat for UCR spring Chinook salmon and 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 weirs and other hatchery facilities may impact migration PBFs due to delay at these structures and possible rejection. However, the number of natural-origin adults delayed is expected to be small and the delay would be for only a short period. Thus, the impact on the spawning, rearing, and migration PBFs will be small in scale, and would not alter PBFs essential to the conservation of a species or preclude or significantly delay development of such features.

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, and
considering future anticipated effects of climate change, NMFS has determined that the Proposed Action would not diminish the conservation value of this critical habitat for the UCR Spring Chinook Salmon ESU or the UCR Steelhead DPS.

2.8. Conclusion

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS’ biological opinion that the Proposed Action is not likely to jeopardize the continued existence of the UCR Spring Chinook Salmon ESU and UCR Steelhead DPS (Table 5), or destroy or adversely modify their designated critical habitat.

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, 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 impaireing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). For purposes of this consultation, we interpret “harass” to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered. 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

The primary form of take of ESA-listed summer steelhead is direct take, authorized in the permit for the Wells Complex program and the 4(d) Limit 5 authorization for the WNFH program. However, NMFS also expects incidental take of ESA-listed steelhead and Chinook salmon will occur as a result of the proposed action for the following factors.

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

Effects of hatchery steelhead on the genetics of natural-origin UCR steelhead can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. Take due to these genetic effects cannot be directly measured because it is not possible to observe gene flow or interbreeding between hatchery and wild fish in a reliable way. NMFS will therefore rely on a surrogate take indicator that relates to the type of take identified: the pHOS or PNI for each program as defined here:
• A PNI of $\geq 0.67$ will be targeted, based on a five-year running average, beginning in 2022 for the Methow River Subbasin steelhead population. Prior to 2022, PNI will be $\geq 0.45$.

• pHOS will be limited to 0.25 for steelhead populations in the Upper Methow River and primary tributaries, with 0.2 percent of that pHOS attributable to the Conservation programs (WNFH and the Twisp Component of the Wells Complex program), and 0.05 percent attributable to the Methow River and Columbia River mainstem releases from the Wells Complex program using detections of PIT-tagged adults at in-stream arrays.

Limiting hatchery-origin fish on the spawning grounds also limits the opportunity for spawning with natural-origin steelhead and Chinook salmon, which reduces the potential for ecological interactions between hatchery and natural adults. Therefore, the take surrogate is logically related to the take pathway. Moreover, through PIT-tag detections, the take surrogate can be reliably measured and monitored.

Take may also occur in the form of removal of listed hatchery-origin steelhead for management of gene flow within the Methow population. To achieve pHOS/PNI targets it may also be necessary to remove up to 100% of hatchery-origin adults entering the Methow subbasin.

There is another separate take pathway; handling/tagging of listed hatchery and natural-origin steelhead at adult collection facilities to facilitate broodstock collection, adult removal and sampling of fish for monitoring and evaluation. The level of take resulting from this take pathway is shown in Table 25.

Table 25. Permissible annual incidental take of listed adipose-present and natural-origin adult steelhead associated with handling/tagging at collection facilities.

<table>
<thead>
<tr>
<th>Maximum listed hatchery-origin captured and handled (mortality)</th>
<th>Maximum natural-origin captured and handled (mortality)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ up to 50% of UCR run measured at Wells Dam; ~6000 (60)</td>
<td>~ 50% of UCR run measured at Wells Dam; ~1250 (12)</td>
</tr>
</tbody>
</table>

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

Competition with and predation by residual hatchery-origin steelhead could result in take of natural-origin Chinook salmon and steelhead. However, it is difficult to quantify this take because ecological interactions between natural-origin fish and residual hatchery steelhead cannot be observed. Thus, we will monitor ecological effects using two different surrogates, one specifically addressing residualism of hatchery steelhead and the second related to how quickly hatchery steelhead leave system.

There is a second take pathway associated with the presence of residuals, which is genetic effects caused by residual steelhead that spawn naturally (particularly precocial males). This too cannot be observed, and will require a surrogate measurement, but the surrogate for the level of take by this route is the same as that used to measure effects of competition and predation. Thus, for the three take pathways described under this section, there are two surrogates.
For take associated with residualism, the surrogate take variable is the percentage of steelhead from the migrant (release) that are either parr, precociously maturing, or precociously mature prior to release. This surrogate has a rational connection to the amount of take expected from residualism because precocious steelhead and parr may residualize after release from the hatchery, leading to take from competition and predation as well as genetic effects from residual fish spawning naturally. NMFS considers, for the purpose of this take surrogate, that no more than ten percent of program fish from each release group should be precociously mature or parr (based on visual observation), using a running five-year average beginning with the 2018 release\(^3\). Between 2017 and 2022, the annual proportion of potential residuals should be no more than 12 percent. The take surrogate can be reliably measured and monitored through visual assessment of the hatchery population and/or migrant fish prior to release.

For ecological effects of competition and predation caused by emigrating hatchery steelhead, NMFS applies a surrogate take variable that relates to the median travel time for hatchery steelhead to reach Rocky Reach Dam after release. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids above Rocky Reach Dam are as follows: the travel time\(^4\) for emigrating juvenile hatchery steelhead is three days longer than the median value (which equates to 50% of the fish) identified in Table 18 for each program for 3 of the next 5 years of 5-year running medians. For example, if the 5-year running median of the median value in Table 19 is 20, and then the median for the next three years for a particular release group is 23, this would exceed the take threshold. This is a reasonable, reliable, and measurable surrogate for incidental take because if travel time increases, it is a sign that fish are not exiting the action area as quickly as expected. This threshold will be monitored using emigration estimates from PIT tags, screw traps, or other juvenile monitoring techniques developed by the operators and approved by NMFS.

### 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. BOR and the USFWS shall ensure that:

1. The USFWS implement the hatchery program and operate the WNFH facility as described in the Proposed Action (Section 1.3) and in the submitted HGMP.

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\(^3\) However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 5 percent after five years, operators will contact NMFS in the year the likely exceedance is discovered.

\(^4\) NMFS recognizes that this metric can be influenced by factors other than hatchery operation.
2. The applicant provide reports to Sustainable Fisheries Division (SFD) annually for the WNFH program, and associated RM&E.

NMFS shall ensure that:

1. The DPUD and WDFW implement the hatchery program and operate the Wells and Methow hatchery facilities as described in the Proposed Action (Section 1.3) and in the submitted HGMP.

2. The applicant provides reports to SFD annually for the Wells Complex Hatchery program, and associated RM&E.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply, NMFS would consider whether it is necessary to reinitiate consultation.

The BOR and USFWS shall ensure for the WNFH program that:

1. The applicants implement the hatchery program as described in the Proposed Action (Section 1.3) and in the submitted HGMPs, including:
   a. Providing advance notice to NMFS of any change in hatchery program operation (including early releases) that potentially increases the amount or extent of take, or results in an effect of take not previously considered
   b. 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
   c. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion
   d. Developing a marking scheme, in coordination with the HCP Hatchery Committee and US v Oregon processes, to be implemented before fish are marked for the 2019 release, with the goal of facilitating adult management, broodstock collection, and assessment of hatchery escapement into the wild

2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
   a. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Charlene Hurst (503) 230-5409, charlene.n.hurst@noaa.gov
   b. Applicants will notify NMFS SFD within 48 hours after knowledge of exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded, and/or discuss the take exceedance with NMFS (determined at NMFS discretion) within two weeks of the event
   c. Applicants will include the reporting information detailed in their 4(d) Authorization in their reports
NMFS shall ensure that:

1. The applicants implement the Wells Complex Program as described in the Proposed Action (Section 1.3) and the submitted HGMPs, including:
   a. 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.
   b. 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.
   c. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.
   d. Developing a marking scheme, in coordination with the HCP Hatchery Committee, to be implemented before fish are marked for the 2019 release, with the goal of facilitating adult management, broodstock collection, and assessment of hatchery escapement into the wild.

2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
   a. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Charlene Hurst (503) 230-5409, charlene.n.hurst@noaa.gov.
   b. The annual report provided to the HCP Hatchery Committee will suffice for monitoring the effects of the program on listed species, but must include those elements detailed in each permit.
   c. 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.
   d. Applicants will include the reporting information detailed in their section 10 Permit in their reports.

2.10. Conservation Recommendations

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

1. Limit any major program modifications (e.g., marking, release site movement) until at least three return years (2021-2023) implemented under the current Proposed Action can be realized.
2. Develop electrofishing population estimate methods for the entire Methow Basin to inform metrics such as juvenile abundance, and proportion of hatchery smolt residualism with more confidence than smolt traps and PIT tagging of production fish.
3. Continue work on identifying and implementing strategies and methods to minimize residualism of hatchery-origin steelhead.

2.11. Re-initiation of Consultation

This concludes formal consultation on the approval and implementation of two hatchery programs rearing and releasing steelhead in the Methow 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.

3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or Proposed Actions that may adversely affect EFH. The MSA (Section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effects include the direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

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

3.1. Essential Fish Habitat Affected by the Project

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

As described by PFMC (2003), the freshwater EFH for Chinook and coho salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions on natural-origin Chinook and coho.
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 Twisp weir is the only barrier to upstream migration once fish reach the Methow River and data indicate that no changes in fish distribution above and below the weir have occurred (Section 2.5.2.2.3).

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 6). 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 fish 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, steelhead spawn timing typically occurs from March through June.

Some steelhead from the programs would stray into other rivers (Section 2.5.2.2.1), 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 steelhead on juvenile natural-origin Chinook or coho salmon may occur as steelhead hold for a potentially long period of time before spawning. Predation and competition by juvenile hatchery steelhead on juvenile natural-origin Chinook or coho salmon is likely small. Our analysis in Section 2.5.2.3.1 shows that fewer than 20 Chinook salmon adult equivalents are likely to be lost to predation and competition with hatchery steelhead at the juvenile stage within our action area for this consultation. Although our ecological model did not account for effects on unlisted fish, such as coho salmon, sizes of Chinook and coho salmon are similar and thus, we anticipate similar adult equivalents for coho salmon as Chinook salmon.

NMFS has determined that the Proposed Action is likely to adversely affect EFH for Pacific salmon.

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 as modified by the Incidental Take Statement (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS has no conservation recommendations specifically for Chinook and coho salmon EFH. However, the Reasonable and Prudent Measures and Terms and Conditions included in the ITS 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 two steelhead salmon hatchery programs in the Methow subbasin as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are the NMFS (permitting entity), the WDFW (operating entity), the DPUD (funding entity) the BOR (funding entity), and USFWS (funding and operating entity). The scientific community, resource managers, and stakeholders benefit from the consultation through
the anticipated increase in returns of steelhead to the Methow basin for conservation and harvest, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of UCR steelhead and Chinook salmon. 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 28. Generally speaking, effects range from beneficial to negative when programs use local fish for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Analysis of a Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. These factors are:

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

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

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

The effects of hatchery fish on ESU/DPS status will depend on which of the four VSP criteria are currently limiting the ESU/DPS and how the hatchery program affects each of the criteria (NMFS 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

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

Table 26. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

<table>
<thead>
<tr>
<th>Natural population viability parameter</th>
<th>Hatchery broodstock originate from the local population and are included in the ESU or DPS</th>
<th>Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS</th>
</tr>
</thead>
</table>
| **Productivity**                      | Positive to negative effect  
Hatcheries are unlikely to benefit productivity except in cases where the natural population’s small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004c). | Negligible to negative effect  
Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect). |
| **Diversity**                         | Positive to negative effect  
Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity. | Negligible to negative effect  
Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect). |
| **Abundance**                         | Positive to negative effect  
Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects. | Negligible to negative effect  
Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects. |
| **Spatial Structure**                 | Positive to negative effect  
Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. “Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations” (70 FR 37204, June 28, 2005 at 37213). | Negligible to negative effect  
Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect). |
5.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

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

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

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

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

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

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

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

5.2.1. Genetic effects

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

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

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

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

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population’s level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McCllelland 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 intrapopulation genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

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

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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.
reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

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

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

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

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.
Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 7).

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

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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.
Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as “the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity.” They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.
Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with “the proportion of the natural spawning population that is made up of hatchery fish” in the Conclusion, Principles and Recommendations section (HSRG 2009), but with “the proportion of effective hatchery-origin spawners” in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (appendix C in HSRG 2009) they introduce a new term, effective pHOS (pHOSeff) defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

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

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

where \( pHOS_{census} \) is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014). In the 2014 report, the HSRG explicitly addressed the differences between \( census \) pHOS and \( effective \) pHOS, by defining PNI as:

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

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

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the “effective” pNOB might be much lower than the census pNOB.
It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be 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 8 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly\(^{10}\). For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

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

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\(^{10}\) These computations are purely theoretical, based on a simple mathematical binomial expansion \((a+b)^2=a^2 + 2ab + b^2\).
Figure 10. 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 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at “high risk” due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

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

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

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

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

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

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

5.3.2. Predation

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

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.
Predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

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

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

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (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 unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

5.3.4. **Acclimation**

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be
released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or “natal” stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008).

(Dittman and Quinn 2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Beckman et al. 2000; Hoar 1976). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Bentzen et al. 2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Quinn 1997; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Clarke et al. 2011; Kenaston et al. 2001).

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

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

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

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

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

5.4.1. Observing/Harassing

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

5.4.2. Capturing/handling

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

5.4.3. Fin clipping and tagging

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

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

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

Coded-wire tags are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deep 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.

6. REFERENCES


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