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

National Marine Fisheries Service (NMFS) Evaluation of Hatchery and Genetic Management Plans for Hood Canal Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule (Reinitiation 2021)

NMFS Consultation Number: WCRO-2021-03133

Action Agencies: Bureau of Indian Affairs (BIA)
National Marine Fisheries Service (NMFS)
United States Fish and Wildlife Service (USFWS)

Affected Species and Determinations:

ESA-Listed Species	Status	Is the Action Likely to Adversely Affect Species or Critical Habitat?	Is the Action Likely To Jeopardize the Species?	Is the Action Likely To Destroy or Adversely Modify Critical Habitat?
Hood Canal summer chum salmon (*Oncorhynchus keta*)	Threatened	No	No	No
Puget Sound Chinook salmon (*O. tshawytscha*)	Threatened	No	No	No
Puget Sound steelhead (*O. mykiss*)	Threatened	Yes	No	No

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

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

Issued By: ______________________

Ryan J. Wulff
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Date: March 8,2022

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1. INTRODUCTION

On October, 2016, the National Marine Fisheries Service (NMFS) made a determination that ten hatchery programs for Chinook salmon, coho salmon, chum salmon, pink salmon, and steelhead in the Hood Canal satisfy requirements under Limit 6 of the Endangered Species Act (ESA) Section 4(d) Rule. To reach the determination, NMFS completed a biological opinion (2016 opinion) that evaluated the effects of its determination that the ten programs for Chinook salmon, coho salmon, chum salmon, pink salmon, and steelhead hatchery programs would meet the standard for an exemption under Limit 6 of the Endangered Species Act section 4(d) regulations (50 CFR 223.203(b)(6)) on May 31, 2016.

In March, April, and June 2020 NMFS received requests from the co-managers to modify five of the ten HGMPs in the ten program bundle. The requested changes include: increases to the size of the coho net pen program at Port Gamble Bay and the fall chum salmon program at Hoodsport Hatchery; broader release timing of fall Chinook salmon at the Hoodsport Hatchery; and increase number of steelhead collected for the Hood Canal steelhead supplementation program. NMFS is now proposing to make a new determination under Limit 6 of the 4(d) Rule of the ESA.

In this reinitiated biological opinion, the National Marine Fisheries Service (NMFS) evaluates whether the newly submitted HGMPs meet the requirements of Section 4(d) Limit 6. The 2016 opinion (WCR-2014-1688), which analyzes its prior determination regarding the HGMPs, is superseded by this biological opinion, although this opinion incorporates by reference elements of the 2016 opinion that remain valid.

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.

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 within two weeks at the NOAA Library Institutional Repository (https://repository.library.noaa.gov/welcome). A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

The consultation history leading up to the issuance of the 2016 opinion is described in (NMFS 2016d). Since the 2016 opinion was issued, the applicants submitted revised HGMPs (WDFW 2019) as follows:

- On July 23, 2019 the Skokomish Tribe sent a letter to NMFS requesting to release an additional 400,000 fall chum salmon at the fry life stage from the Enetai Hatchery.
- On March 12, 2020 the Washington Department of Fish and Wildlife (WDFW) sent a letter to NMFS requesting modifications to the Hoodsport fall Chinook salmon program and the Hood Canal steelhead supplementation program.
- On May 18, 2020 the WDFW sent a letter to NMFS requesting modifications to the Hoodsport fall chum salmon program.
- On June 23, 2020 the Port Gamble S'Klallam Tribe (PGST) requested modifications to the Port Gamble coho net pen program. The PGST submitted an updated HGMP on August 11, 2020. NMFS initiated consultation at this time after having reviewed all requests for modifications and/or new HMGPs.

In its supplemental information report of these proposed modifications under the National Environmental Policy Act (NEPA) NMFS found that the five new HGMPs did not represented a substantial change from the analysis conducted in the 2016 Environmental Assessment (EA) (NMFS 2020). NMFS also found the proposed modification of the Hood Canal steelhead supplementation program would result in additional collection and incidental take of Puget Sound (PS) steelhead. In this biological opinion NMFS evaluates the effects of the proposed action on ESA-listed Hood Canal summer chum salmon, PS Chinook salmon, and PS steelhead and their critical habitats because additional take associated with capture, handling, and tissue collection of steelhead was not characterized in the previous opinion and will be analyzed 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).

The Hood Canal steelhead supplementation program is intended to improve conservation of PS steelhead by increasing the fish abundance and genetic diversity of this designated population segment (DPS) throughout the Hood Canal region. The co-managers have proposed changes to five hatchery genetic management plans (HGMPs) that were authorized by NMFS under the Endangered Species Act limit 6 of the 4(d) for salmon and steelhead in 2016. This opinion will address whether the proposed modifications comply with sections 7 and 4(d) of the ESA. The duration of the Proposed Action is unlimited for the 4(d) determination. More information on the management of these programs can be found in the 2016 biological opinion (NMFS 2016).

- Hood Canal steelhead supplementation program: the co-managers propose to collect additional biological samples from juvenile or adult steelhead in the Dosewallips River from river mile (RM) 0-15.6 to assess the demographics and life history of the DPS in the watershed after cessation of the supplementation program. The co-managers may collect biological samples such as scales and otoliths, potentially resulting in lethal take either as a direct result of the proposed sampling (i.e., removal of otolith, which is lethal). The co-managers propose to use the collected biological samples to determine age structure and genetic heritage of steelhead in the Dosewallips watershed.

- Hoodsport fall Chinook salmon: release three experimental groups of 100,000 subyearling Chinook salmon during early (April/May), June (normal), and late (August/September) release periods. Each experimental group represents approximately 4.3 percent of the 2.3 million fall Chinook salmon released annually by the program. The early and late experimental release groups will accompany the normally-timed release of two million fall Chinook salmon measuring approximately 92 millimeters (mm) in length. As a result of the early or late timing fish included in the experimental release groups will be either smaller (82 mm) or larger (120 mm), respectively, in comparison to fish released in June. The purpose of the experimental release schedule is to investigate the effect of juvenile release timing and size on survival of adult fall Chinook salmon.
- Hoodsport fall chum salmon: increase production by three million chum salmon fry. Current releases of fall chum salmon at the Hoodsport hatchery is 12 million fry. The increase of fall chum salmon released to a total of 15 million fish is a 20 percent increase. The co-managers have purposed to release additional juvenile fall chum salmon to increase the number of adults available as forage to southern resident killer whales (*Orcinus orca*), a species, hereafter referred to as SRKW that is listed as endangered under the ESA.
- Enetai fall chum salmon: increase production by 1.8 million chum salmon fry. Current releases of fall chum salmon at the Hoodsport hatchery is 3.2 million fry. The increase of fall chum salmon released to a total of 5 million fish is a 27 percent increase. The co-managers have purposed to release additional juvenile fall chum salmon to increase the number of adults available as forage to SRKW.
- Port Gamble coho net pen; increase the current production of 400,000 yearling coho salmon to 650,000 fish in two phases, 125,000 fish in the first phase and 125,000 fish in the second phase. The aggregate amount of additional production constitutes a 38 percent, which may occur in two roughly equal phases. The co-managers have proposed releasing additional coho salmon to increase forage of adult salmon available to SRKW.

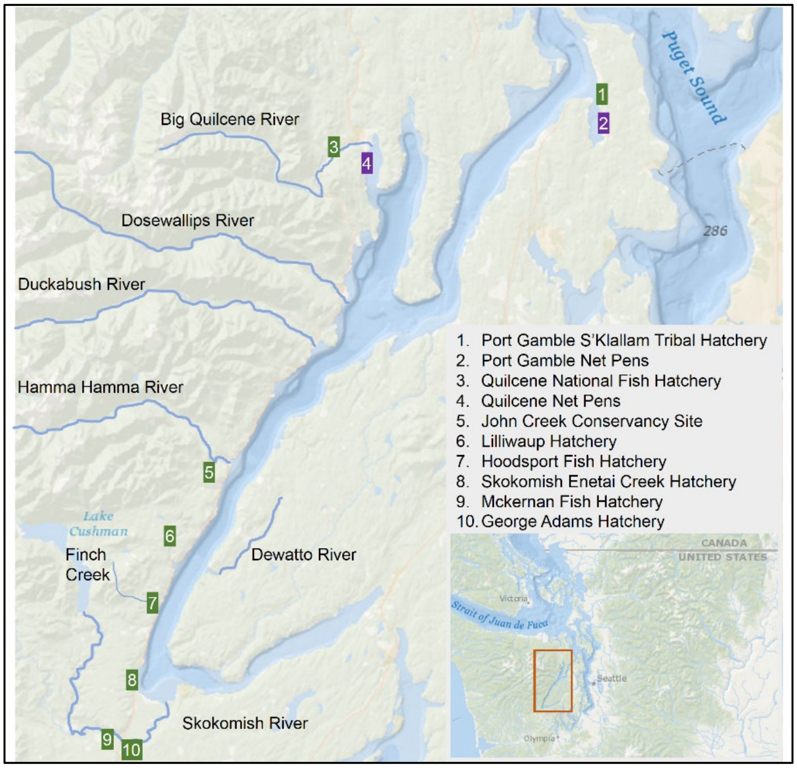
NMFS analyzed effects associated with modifications to these three programs and found none of the requested changes resulted in substantial changes to the 2016 Environmental Assessment (NMFS 2020). NMFS addresses the effects to ESA-listed species resulting from requested changes to five HGMPs in this reinitiation.

1.4. Effects as Consequences of the Proposed Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). We considered these actions, previously referred to as interrelated and interdependent actions 50 CFR 402.17(a) and (b), in our effects analysis that can be found in Section 2.5.2. 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.

1.5. 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 described in the 2016 biological opinion included 'all of the freshwater tributaries and marine waters of the Hood Canal region' where salmon and steelhead are collected as broodstock, spawned, incubated, reared, acclimated, and released (Figure 1).



No hatchery programs were operating in the Dosewallips River in the 2016 opinion. However, due to the potential for interactions among adult and juvenile fishes of natural and hatchery-origin from river mile 0 to 15 (e.g., habitat available to anadromous salmonids) this portion of Dosewallips watershed was included in action area described in the 2016 opinion. Thus, requested changes to the five HGMPs described above in Section 1.3 do not modify the action area as previously defined in NMFS 2016 opinion.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the FWS, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

NMFS has determined that the Proposed Action is not likely to adversely affect species in Table 1 or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations Section (2.11).

Table 1. Species not likely adversely affected by the Proposed Action.

Species	Listing Status	Critical Habitat	Protective Regulations
Hood Canal summer run chum salmon	Threatened	February 16 2000; 65 FR 7764	June 28, 2005; 70 FR 37160
Puget Sound Chinook salmon	Threatened	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160

2.1. Analytical Approach

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. “To jeopardize the continued existence of a listed species” means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by reducing the reproduction, numbers, or distribution of that species or reduce the value of designated or proposed critical habitat (50 CFR 402.02).

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

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

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

Range-wide status of the species and critical habitat

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

Describing the environmental baseline

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

Cumulative effects

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

Integration and synthesis

Integration and synthesis occurs in Section 2.7 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 1.3) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.4) and to cumulative effects (Section 2.6). 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 2.7, the opinion determines whether the proposed action is likely to jeopardize ESA protected species or destroy or adversely modify designated critical habitat in Section 2.5.3.

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

As described above, alterations to the RM&E proposed for the Hood Canal steelhead supplementation program are limited to Puget Sound steelhead (*Oncorhynchus mykiss*). The Puget Sound Steelhead DPS was listed as threatened on May 11, 2007 (72 FR 26722) and its critical habitat designation on February 24, 2016 (81 FR 9252). NMFS has not revised its species status and critical habitat assessments for the listed species addressed within this opinion since the 2016 opinion was issued, and we consider the descriptions in the 2016 opinion to still represent the best available science. The potential for effects to other listed species are described below in Section 2.11.

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: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000a). These VSP parameters therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are 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 (e.g., on spawning grounds). "Productivity," as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per their 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. (2000a) 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 habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population. "Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000a).

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. 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 metapopulations (McElhany et al. 2000a).

2.2.1.1. Life History and Status of Puget Sound Steelhead

Seaward emigration commonly occurs from April to mid-May when fish are two-years of age. Steelhead typically move directly offshore during their first summer and spend one to three years in the ocean before returning to freshwater. The timing of re-entry into freshwater for spawning determines which of the two major life history types steelhead express. Summer steelhead enter freshwater at an early stage of maturation from May to October, migrate to headwater areas and hold until spawning the following January to May (Hard et al. 2007). Winter steelhead enter freshwater from December to April and spawn in spring and early summer of the following year, with peak spawning from April to May (Busby et al. 1996; Hard et al. 2007). Although an overlap in spawn timing exists between the two life history types, particularly in northern Puget Sound where both are present, summer steelhead typically spawn farther upstream (Behnke and American Fisheries Society 1992; Busby et al. 1996).

The Puget Sound Steelhead DPS includes all naturally spawned anadromous winter and summer steelhead populations in streams and rivers of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). This DPS also includes the Green River natural, White River, and Hamma Hamma winter-run steelhead hatchery stocks (72 FR 26722, NMFS & NOAA 2007). The Puget Sound steelhead populations are tentatively aggregated into three extant MPGs (Northern Cascades, Central and South Puget Sound, and Hood Canal and Strait of Juan de Fuca) containing 32 "Demographically Independent Populations" (DIPs) based on genetic, environmental, and life history characteristics (Myers et al. 2015). In August 2011, NMFS conducted a five-year status review and concluded that the species should remain listed as threatened (76 FR 50448, NMFS & NOAA 2011) as neither the three MPGs nor the DPS are viable (Hard et al. 2015a). There is currently no recovery plan available for this DPS.

Because the action area is located in the Hood Canal, we will focus on the status of the Hood Canal DIPs within the Hood Canal/Strait of Juan de Fuca MPG. This MPG contains eight DIPs, including two summer/winter and six winter DIPs, which account for 12 percent of the steelhead abundance in the DPS (Hard et al. 2015a). The four winter Hood Canal DIPs comprise the majority of steelhead in the MPG. Steelhead abundance in all four DIPs is below the intrinsic potential based on current conditions (Table 2). There is some uncertainty about the presence of summer-run life histories, but, if present, they are likely small in number (Myers et al. 2015). In addition, further research on the rate of straying and life history characteristics of steelhead populations in Hood Canal has not altered these classifications and criteria (NMFS 2016a; NMFS 2017a).

Table 2. Steelhead DIPs within the Hood Canal and Strait of Juan de Fuca MPG.

Population	**Primary Tributaries**	Geometric Mean total natural spawners (number of fish 2010-2014)[1]	Growth rate (1995 to present)[2]	Intrinsic potential (number of fish)[2]	Extinction risk[2]
South Hood Canal	Tahuya and Union Rivers	64 (64)	0.90	2,985-5,970	High 0.9
West Hood Canal	Quilcene, Hamma Hamma, Duckabush, Dosewallips Rivers	(74)	1.06	3,608-7,216	Low < 0.2
East Hood Canal	Big Beef and Anderson Creeks, Dewatto River	60 (60)	0.99	1,270-2,540	Low 0.4
Skokomish River	Skokomish River	(580)	1.01	10,030-20,060	High 0.7
South Hood Canal	Tahuya and Union Rivers	64 (64)	0.90	2,985-5,970	High 0.9

[1]Source: NWFSC (2015a)

[2]Source: Hard et al. (2015a); Probability of reaching the quasi-extinction risk threshold within 100 years.

2.2.2. Status of Critical Habitat

NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (also known as primary constituent elements (PCEs)), identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., spawning, rearing, migration and foraging). For salmon and steelhead, physical and biological features generally include:

1. Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development
2. Freshwater rearing sites with:
    - (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility
    - (ii) Water quality and forage supporting juvenile development
    - (iii) Natural cover
3. Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover supporting juvenile and adult mobility and survival
4. Estuarine areas free of obstruction and excessive predation with:
    - (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater
    - (ii) Natural cover

    (iii) Juvenile and adult forage supporting growth and maturation.
5. Nearshore marine areas free of obstruction and excessive predation with:
    (i) Water quality and quantity conditions and forage supporting growth and maturation
    (ii) Natural cover
6. Offshore marine areas with water-quality conditions and forage supporting growth and maturation.

2.2.2.1. Status of Critical Habitat for Puget Sound steelhead

Designated critical habitat for Puget Sound steelhead includes the following subbasins: Strait of Georgia, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, Skokomish, Hood Canal, Kitsap, and Dungeness/Elwha (81 FR 9252; NMFS 2009). The designation does not identify specific areas in the nearshore zone in Puget Sound because steelhead move rapidly out of freshwater and into offshore marine areas, making it difficult to identify specific foraging areas where the essential features are found.

Within Hood Canal, the entire Skokomish subbasin has a high conservation value rank. Four (Hamma Hamma, Duckabush and Dosewallips Rivers, and West Kitsap) of the seven watersheds included in the Hood Canal subbasin also have a high conservation rank due to recent supplementation efforts in the Hamma Hamma River and the presence of high quality PCEs. Primary management activities that may affect the PCEs (section 2.2) in the areas of high conservation value include; channel modifications/diking, agriculture, forestry, urbanization, road building/maintenance and the Cushman dam on the Skokomish River (NMFS 2013).

2.2.3. 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 1ºC since 1900, or about 50% more than the global average over the same period (ISAB 2007). The latest climate models project a warming of 0.1 ºC to 0.6 ºC per decade over the next century. According to the Independent Scientific Advisory Board (ISAB), these effects pose the following impacts over the next 40 years:

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

These changes will not be uniform across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).

To mitigate for the effects of climate change on listed salmonids, the ISAB (2007) recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures, as well as protective hydropower mitigation measures. In particular, the ISAB (2007) suggests: increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary; and the protection and restoration of riparian buffers, wetlands, and floodplains.

Temperatures in the Pacific Northwest increased by about 1.3 degrees Fahrenheit from 1895 to 2011. In the 21st century, researchers have observed a warming rate of 0.5 degrees Fahrenheit per decade. By 2070, air temperatures are predicted to increase an additional 3.3 to 9.7 degrees Fahrenheit, with the greatest increases occurring in the summer months (Hood Canal Coordinating Council 2015). This may have the greatest effects on those salmon species that run and spawn during the summer and early fall (e.g., Hood Canal summer chum, and pink salmon).

However, there have not been statistically significant changes in extreme precipitation within Puget Sound. Historically, the watersheds in Hood Canal have been a rain-snow mixture and models predict that systems will become rain-dominant over time and that the peak streamflow will shift from late spring to early winter (Hood Canal Coordinating Council 2015). These effects will likely limit the water storage in the system and could affect salmon and steelhead habitat availability, spawn timing, and their distribution.

2.3. Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The 'Environmental Baseline' includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area 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).

Historical harvest of salmon, steelhead and rockfish species has caused declines in PS populations. In the past, fisheries exploitation rates were generally too high for the conservation of many rockfish populations, and for naturally spawning salmon and steelhead populations. In response, over the past several decades, the co-managers have implemented strategies to manage fisheries to reduce harvest impacts and to implement harvest objectives that are more consistent with the underlying productivity of the natural populations. The effect of these overall reductions in harvest has been to improve the baseline condition and help to alleviate the effect of harvest as a limiting factor.

Since 2010, the state and Tribal fishery co-managers have managed Chinook salmon mortality in PS salmon and Tribal steelhead fisheries to meet the conservation and allocation objectives described in the jointly-developed 2010-2014 PS Chinook salmon Harvest RMP (PSIT and WDFW 2010), and as amended in 2014 (Grayum and Anderson 2014; Redhorse 2014), 2015, 2016, and 2017, and 2018 (Grayum and Unsworth 2015; Shaw 2015; 2016; Speaks 2015). The 2010-2014 PS Chinook salmon Harvest RMP was adopted as the harvest component of the PS Salmon Recovery Plan for the PS Chinook salmon ESU (NMFS 2011c).

NMFS observed that previous harvest management practices likely contributed to the historical decline of PS steelhead, but concluded in the Federal Register Notice for the listing determination (72 FR 26732, May 11, 2007) that the elimination of the direct harvest of wild steelhead in the mid-1990s has largely addressed this threat. The recent NWFSC status review update concluded that current harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially reduce spawner abundance of most PS steelhead populations (NWFSC 2015).

Recent abundance and productivity estimates from 2002-2011 varied from 15-96 steelhead (Hard et al. 2015). The modeled productivity of natural spawning winter-run steelhead in the West Hood Canal tributaries from 1985 to 2009 is 1.022 (0.997–1.048). This suggests the West Hood Canal tributaries DIP is at low abundance and the rate of population increase is slow, which is characteristic of most tributaries in the Hood Canal. The Hood Canal steelhead Supplementation Program has improved genetic diversity and spatial distribution of this DPS.

Three hatchery programs associated with the Hood Canal Supplementation Program that are considered part of the Puget Sound steelhead DPS (Dewatto River, Skokomish River, and Duckabush River) have been terminated, with the last adult fish produced returning in 2019. The environmental baseline associated with habitat described in the 2016 opinion remains the same, including land use, fish habitat, and water use in the Dosewallips watershed. Habitat restoration projects described in the 2016 opinion are currently ongoing, and no additional habitat restoration activities have been identified, other than those identified in the 2016 opinion that are funded through the Pacific Coastal Salmon Recovery Fund. Such projects include:

- Installation of three engineered logjams at river mile 8.1 to improve fluvial and floodplain habitat function.
- Over 100 acres of floodplain were acquired for restoration purposes.
- Over 14 acres of riparian floodplain were restored along with 0.29 mi of streambank.

The largest landowners in the Dosewallips River watershed are the Olympic National Park and the U.S. Forest Service (USFS). Together, these agencies manage 93 percent of the watershed; a significant portion of this landscape is protected as designated wilderness area. The remaining 7 percent is divided between privately held forestlands, rural residential, parkland and commercial uses. Commercial zoning is concentrated in the lower reaches. The predominant residential zoning in the watershed is one resident per 20 acres. The Riparian Reserve Program adopted by the USFS has the potential to improve riparian conditions, including temperature control, large woody debris recruitment, streambank and migratory corridor stability, and riverine functions downstream.

Major parts of the Dosewallips River floodplain have been disconnected from its channel due to various channel and flood control measures. These reductions in floodplain function have degraded in-channel conditions, which in turn, adversely affect adult migration, spawning, incubation, and juvenile salmonid habitat quality (Lestelle 2015). Recent instream placements of wood piles at the mouth of the Dosewallips River has improved rearing habitats for steelhead and Chinook salmon while at the same time reducing spawning habitat for summer-run chum salmon.

Section 2.2.3 of the 2016 opinion describes how climate change may affect salmon and steelhead habitat in the Pacific Northwest. In addition, More detailed discussions about the likely effects of large-scale environmental variation on salmonids, including climate change, are found in biological opinions on the Snohomish Basin Salmonid Hatchery Operations (NMFS 2017b 5836 5836) and the implementation of the Mitchell Act (NMFS 2017c).

2.3.1. Fisheries

The Hood Canal supplementation program is intended as a restoration program and not for the purposes of harvestable fisheries. The Hood Canal Steelhead supplementation program propagates winter-run steelhead that are included in the ESA-listed ESU. Because there are no directed fisheries for ESA-listed steelhead in the action area and changes to the proposed action discussed in this reinitiation are solely related to RM&E activities the proposed modifications will have no effect on fisheries harvest. However, NMFS does note that listed Hood Canal summer chum salmon, PS Chinook salmon, and PS steelhead are caught incidentally in fisheries targeting coho salmon and non ESA-listed, hatchery winter steelhead outside the action area in marine waters of the Strait of Juan de Fuca (NMFS (2001); (NMFS 2019a). The effects related to harvest of Chinook salmon and other species were analyzed by NMFS in separate consultations (NMFS 2001; NMFS 2019a), the relevant effects to Hood Canal populations are summarized in NMFS (2016c).

2.3.2. Hatcheries

In 2000, the SCSCI provided guidelines for summer chum supplementation programs within Hood Canal to minimize adverse genetic and demographic effects on listed summer chum salmon as well as ecological effects on other listed-species. These guidelines included modified juvenile release timing and size, release of only seawater ready life stages, and delayed broodstock collection timing for fall chum salmon, to reduce interactions with listed summer chum salmon. In addition, most supplementation programs were terminated after 12 years of operation (three generations). These measures are likely contributing to the increase in abundance, diversity, and productivity of summer chum detailed in section 2.2.3.1. The effects of Federal and non-Federal hatchery programs on summer chum were evaluated by NMFS and determined to not reduce the likelihood for survival and recovery of the ESU (NMFS 2002).

The measures implemented for summer chum salmon also likely benefit other salmonids, such as the release of seawater ready life stages to limit competition between hatchery and natural fish. In 2004, a number of hatchery programs were further modified after managers considered the recommendations of the Hatchery Salmon Review Group (HSRG 2004). In addition, the HSRG broadly recommended external marking for Chinook salmon programs to monitor the straying of hatchery-origin spawners into natural spawning areas and to allow for selective harvest of hatchery fish.

Because most hatchery programs are ongoing, the effects of each program are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015b) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion. In addition, Table 3 summarizes the section 7 consultations that have been completed on other hatchery programs since the 2016 opinion.

Table 3. Summary of section 7 consultations that have been completed since the 2016 opinion.

Biological opinion	Programs Authorized in opinion	Signature Date	Citation
Snohomish	Tulalip Hatchery Chinook Sub-yearling	September 27, 2017	NMFS (2017b)
	Wallace River Hatchery Summer Chinook		
	Wallace River Hatchery Coho		
	Tulalip Hatchery Coho		
	Tulalip Hatchery Fall Chum		
	Everett Bay Net-Pen Coho		
Hood Canal	Hoodsport Fall Chinook	September 30, 2016	NMFS (2016b)
	Hoodsport Fall Chum		
	Hoodsport Pink		
	Enetai Hatchery Fall Chum		
	Quilcene NF Hatchery Coho		
	Quilcene Bay Net-Pens Coho		
	Port Gamble Bay Net-Pens Coho		
	Port Gamble Hatchery Fall Chum		
	Hamma Hamma Chinook Salmon		
	Hood Canal Steelhead Supplementation		
Duwamish/Green	Soos Creek Hatchery Fall Chinook	April 15, 2019	NMFS (2019b)
	Keta Creek Coho (w/Elliott Bay Net-pens)		
	Soos Creek Hatchery Coho		
	Keta Creek Hatchery Chum		
	Marine Technology Center Coho		
	Fish Restoration Facility (FRF) Coho		
	FRF Fall Chinook		
	FRF Steelhead		
	Green River Native Late Winter Steelhead		
	Soos Creek Hatchery Summer Steelhead		
Stillaguamish	Stillaguamish Fall Chinook Natural	June 20, 2019	NMFS (2019c)
	Stillaguamish Summer Chinook Natural Restoration		

Biological opinion	Programs Authorized in opinion	Signature Date	Citation
	Stillaguamish Late Coho		
	Stillaguamish Fall Chum		

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

2.4.1. Factors Considered When Analyzing Hatchery Effects

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

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

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the seven factors of hatchery operation on each listed species at the population level (in Section 2.5), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.8).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors[1]. 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) Research, monitoring, and evaluation (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.

In this case, the proposed action involves a minor modification to the proposed RM&E associated with collecting additional juvenile steelhead in an adjacent watershed (i.e., the Dosewallips River). The effects of sampling additional fish co-managers had not previously proposed sampling in this watershed although the effects of all ten hatchery programs described in detail and evaluated in the 2016 opinion.

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[1] Of note, seven factors were used in the 2016 BiOp. Factors 3 and 4 in the 2016 BiOp is now analyzed as one factor under Factor 3, with the subsequent factors remaining the same categories of analysis.

2.4.2. Effects of the Proposed Action on ESA-listed species

This section discusses effects of the proposed action on the ESA-listed species in the action area. These effects may result from changes in the habitat features such as water quality of streambank habitat, or occur to the species themselves. For example, in the case of salmon and steelhead hatcheries, effluent discharges from these facilities may change water quality (e.g., a habitat effect) and interactions (e.g., an effect to the species). In this opinion NMFS considers effects associated with adding RM&E activities conducted within seven tributaries of the Hood Canal into an eighth tributary, the Dosewallips River, while also evaluating the changes in hatchery production of juvenile salmonids and associated release timing.

2.4.2.1. Factor 1: Broodstock Collection

There are no changes associated with broodstock collection in the proposed action. Therefore, the effects remain consistent with those described in NMFS 2016 opinion.

2.4.2.2. Factor 2: Hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds

The effects of hatchery adults on the spawning grounds are the same as those described in NMFS 2016 opinion and are briefly summarized below for continuity.

- Non-listed chum, pink, and coho salmon adults originating from the segregated hatchery programs that escape to natural spawning areas may compete with Chinook salmon for spawning sites and superimpose their redds on Chinook salmon redds
- Coho salmon stray rates are low, with less than 5 percent of the fish straying from all three programs combined
- Overlap with fall chum is likely only to occur in October, after the peak of the natural-origin portion of the Chinook salmon run
- none of the segregated programs release fish into rivers or streams where listed independent Chinook salmon populations are established
- The likelihood of ESA-listed natural-origin Chinook salmon in Enetai, Finch, or Little Boston Creeks is low because these small creeks are unable to support fish as large as Chinook salmon
- Competition for spawning habitat and redd superimposition associated with fish straying from the other nine programs are unlikely to occur with Puget Sound steelhead because all other salmon species have returned and spawned prior to the timing of the steelhead return

We anticipate that releasing more juvenile fish from the Hoodsport Hatchery and Port Gamble net pen programs potentially increases the number of adult fish returning to the Hood Canal, the co-managers have selected species that are compatible with the foraging needs of SRKW and least likely to have impacts on listed salmonids. Thus, we expect effects from additional adults straying into nearby Hood Canal watersheds where listed salmonids may be present (e.g., Duckabush River, Hamma Hamma River, Skokomish River, and Tahuya River) is very low.

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

As described in Section 1.3, changes proposed by the co-managers will modify the numbers of juvenile salmonids migrating out of the Hood Canal as follows: 20 percent more juvenile fall chum salmon released from Hoodsport Hatchery, 27 percent more fall chum salmon released from Enetai Hatchery, and up to 38 percent more coho salmon released from the Port Gamble net pens. The co-managers also propose to release two experimental groups of subyearling fall Chinook salmon, representing about 4.5 percent of the total number of subyearlings released by the program, at earlier and later periods. Here we address the ecological effects of those changes in the abundance and timing of juvenile hatchery fish releases on listed species.

Ecological effects to listed species will occur after hatchery fish are released and begin migrating through freshwater (i.e., Enetai and Finch creeks) and saltwater (i.e., Hood Canal). Ecological effects are, in large part, a function of the time in which hatchery and natural-origin species are present within the same habitat. As such, release timing of hatchery fish and early-life migration are important determinants of exposure to ecological effects. Subyearling Chinook salmon and chum salmon initiate migration after a short period of freshwater rearing (e.g., weeks to months) these fish prefer orienting near the shoreline, and travel slower than larger yearling migrants, such as coho salmon or steelhead. Steelhead travel through the marine waters of Puget Sound at rates varying between 5 to 47 miles per day (Moore et al. 2010). In contrast to hatchery reared salmonids, which are released and first begin migrating in large groups, natural-origin salmonids initiate migration over longer periods and in smaller groups; this dynamic that is thought to reduce density-dependent predation and competition (Beamer et al. 2010a; Beamer et al. 2010b).

In terms of spatial overlap, all three hatchery facilities are miles away from tributaries were listed species may be present. Thus, the only exposure between hatchery and natural-origin fish may occur in the marine nearshore habitat of Hood Canal. In addition, the co-managers timed releases of hatchery fish to reduce the potential for temporal overlap with natural-origin species. The combination of physical and temporal separation between hatchery and natural-origin fish within marine nearshore habitat will result in a minute potential for interaction among species at levels that are not consistent with adverse effects. Early experimental releases from Hoodsport Hatchery in April or May, as opposed to the normal June release period, slightly increases the potential for interaction among hatchery-origin fall Chinook salmon and natural-origin steelhead. However, juvenile steelhead present in the Hood Canal are large in comparison to fall Chinook salmon, and are at no risk of adverse behavioral interactions if the two species do co-occur. Moreover, the experimental release groups are relatively small (i.e., 100,000 fish) and the release point from Hoodsport Hatchery into Finch Creek is more than 5 to 10 miles away from the nearest tributaries where PS steelhead enter the Hood Canal. These factors make the potential for overlap between species and adverse interactions extremely unlikely.

While the ecological effects of releasing hatchery-produced fish previously discussed in the 2016 opinion (NMFS 2016c) are expected to continue, the proposed changes in hatchery production are minor and will not result in adverse interactions among hatchery fish and listed species. Overall, the co-managers will release similar numbers of fish according to established timelines designed to reduce interactions among hatchery and natural-origin salmonids. These proposed changes related to increased production and release of juvenile salmon will not result in effects to listed species that are different from those characterized in NMFS (2016c).

2.4.2.4. Factor 4: Research, Monitoring, and Evaluation

The current amount of collection and handling of PS steelhead, which was analyzed by NMFS in 2016 is 14,400 juvenile steelhead (about 50 percent natural-origin, naturally-reared) and 170 adult steelhead (50 natural-origin, naturally-reared). Incidental mortality of steelhead from these tributaries was estimated at 34 juveniles and 4 adults. The current amount of collection and handling of PS steelhead in the Hamma Hamma and Duckabush rivers and Big Beef Creek is approximately 1,500 hatchery-reared natural-origin smolts and 1,950 naturally-reared natural-origin smolts. Incidental mortality from these seven tributaries associated with RM&E was estimated at 50 juveniles and 7 adults.

The proposed action will add collection and handling of up to 120 PS steelhead at the adult or juvenile life stage, an increase of approximately 6.2 percent of the species previously authorized for this purpose. This level of take is in addition to that characterized in the 2016 opinion. Because the collection and handling is proposed according to standard practices by WDFW, the same entity currently conducting RM&E in the aforementioned seven tributaries, we anticipate similar levels of incidental mortality (i.e., mortality rate of 2.5 percent) will apply to fish proposed to be sampled in the Dosewallips River. Thus, we estimate incidental mortality of PS steelhead associated with the proposed handling is approximately three fish.

WDFW will collect steelhead using the same procedures and described by NMFS in the 2016 biological opinion. Researchers will collect steelhead during the summer and fall, a period when other ESA-listed species are absent. Moreover, researchers will capture and collect biological samples (e.g., fin clips, scales) by angling for juvenile steelhead, a highly selective capture method. These procedures may require temporary containment in buckets lasting for a period of minutes to obtain biological samples and reacclimate fish prior to release. These procedures will subject steelhead to short-term stressors. The physiological effects associated with handling stress depend on environmental conditions (e.g., temperature, humidity, etc.) as well as the time, duration, and frequency of handling. The physiological effects of handling stress are discussed in greater detail below.

Researchers have broadly grouped physiological responses of fishes associated with handling and other stressors as primary, secondary, and tertiary. Primary responses, which involve the initial neuroendocrine responses, include the release of catecholamines from chromaffin tissue (Randall and Perry 1992; Reid et al. 1998), and the stimulation of the hypothalamic-pituitary-interrenal axis culminating in the release of corticosteroid hormones into circulation (Mommsen et al. 1999; Wendelaar Bonga 1997). Secondary responses include changes in plasma and tissue ion and metabolite levels, hematological features, and heatshock or stress proteins, all of which relate to physiological adjustments such as in metabolism, respiration, acid-base status, hydromineral balance, immune function and cellular responses (Iwama et al. 1992; Mommsen et al. 1999). Tertiary responses may also occur such as changes in growth, condition, overall resistance to disease, metabolic scope for activity, behavior, and ultimately survival (Wedemeyer 1972; Wedemeyer et al. 1984; Wedemeyer et al. 1980). The number, duration, and intensity of stressors are factors determining whether the fish's homeostatic response mechanisms are restored, or exceeded, which may cause a sustained reduction in fitness or death (Schreck 1981; 2000).

In the 2016 opinion, NMFS considered cessation of research associated with the steelhead supplementation program would occur in 2023, limiting the effects of collection and handling of PS steelhead in seven Hood Canal tributaries to eight years. These limitations remain in place, which leaves two years to conduct sampling throughout all eight tributaries in the Hood Canal. Overall, the expertise and oversight of WDFW staff conducting the proposed RM&E activities is extensive, while the magnitude, duration, and intensity of the sampling is minimal. Thus, additional sampling proposed by the co-managers will have only minor, short-term effects on steelhead in the Dosewallips River. Most incidental take will be low-intensity in nature (collection and handling) and, based on previous analysis, is likely to result in less than 5 steelhead mortalities. Overall, the effects of the proposed sampling represents too minor of a risk to the species to alter the recovery status.

The programs noted above are ongoing, our analysis is limited to additional effects associated with rearing and releasing more fish, or in the case of fall Chinook salmon at Hoodsport Hatchery, releasing about 5 percent of the fish early and later in the season than the normal June release time. The effect pathways associated with production increases and changes in release timing include: 1) degradation to water quality caused by additional effluents, and 2) ecological interactions of juvenile hatchery fish with listed species after release from the hatchery environment.

2.4.2.5. Factor 5: Operation and maintenance of hatchery facilities

We also address effects associated with proposed changes in operation and maintenance of hatchery facilities related to changes in water quantity and water quality associated with rearing more fish or releasing fish at different times during than described in NMFS (2016c). This includes increases in production of fish from the Enetai Hatchery, Hoodsport Hatchery, and Port Gamble S'Klallam net pens, as well as changes to the release timing of fall Chinook salmon from Hoodsport Hatchery. The co-managers do not propose changes in the amount of water used at the hatchery facilities. However, we anticipate additional rearing of juvenile fish will increase the amount of effluent released from these facilities and describe those effects below.

The co-managers proposed additional releases of fish from Enetai Hatchery, Hoodsport Hatchery, and the Port Gamble net pens will add about 4.8 million fall chum salmon and 250,000 yearling coho salmon into the Hood Canal. Other proposed changes include experimental releases of fall Chinook salmon from the Hoodsport Hatchery during early (April/May) and late (August/September) periods. The co-managers will receive eggs and/or larval fish according to the same schedules and fish will be reared and released according to established procedures, so temporal releases of effluent will be unchanged. An exception to this is due to the later release of 100,000 fall Chinook salmon at Hoodsport Hatchery.

Effluents consist of nitrogen and particulates from waste and excess fish food, and chemicals used for disease and therapeutic treatments. We anticipate production of effluent will increase proportional to the number of additional fish reared at each facility as described above in Section 1.3. We expect that effects from effluent at the Port Gamble net pens will be located within 1,000 feet of this facility (Ali et al. 2011; Bannister et al. 2016). Because effluents at Enetai and

Hoodsport hatcheries are contained within settling ponds we anticipate effluent dispersal will be substantially smaller (e.g., 200 feet or less). The moderate size of the proposed production increases, coupled with the short duration of rearing at the saltwater and nearshore-oriented hatchery facilities (typically 4-7 months) will yield minimal and ephemeral increases in water quality impacts that are unlikely to be experienced by listed species because none will be migrating or using freshwater or nearshore habitats where increased levels of effluents will be present. Likewise, changes in water quality will be too minor to limit factor phytoplankton (*Chaetoceros* spp.) blooms, a factor affecting net pen culture of coho salmon in Port Gamble Bay, because growth of this phytoplankton is associated with higher temperatures that have no established causal relationship to effluent from the net pen facility. There is no documented instance of infectious hematopoietic necrosis, a concern in large net pens in the eastern Puget Sound (NMFS 2019c), due to the small size of this net pen facility the operation and management practices used by the co-managers to preclude disease transmission. We expect that best management practices used by the hatchery operators, such as regular monitoring, maintenance, and removal of suspended solids from settling ponds, disinfection, and therapeutic treatments will preclude the potential for increases in effluent and pathogens released from the hatchery facilities.

Overall, the magnitude of additional effluent released into the marine waters of Hood Canal is too minimal cause adverse effects to juvenile salmonids. All hatchery facilities are located in saltwater or within 500 feet of tidal habitats. We anticipate Enetai Creek, Finch Creek, and nearshore areas adjacent to these tributaries and the Port Gamble net pens are where listed species are at higher risks from effluent exposure. Moreover, no listed species occur in Enetai Creek or Finch Creek, and only occasionally seek refuge in Port Gamble Bay while migrating out of Hood Canal in the spring and summer. We anticipate any exposure to listed species will be brief in duration (e.g., seconds) and too minor to yield a change in habitat use, behavior, or elicitation of a physiological response. Thus, the level of exposure to listed species in freshwater and nearshore marine waters is minimal.

2.4.2.6.Factor 6: Fisheries that Exist because of Hatchery Programs

As described above in Section 1.3, the proposed changes to hatchery programs are intended to provide additional forage for SRKW and information on smolt to adult survival of fall Chinook salmon as a result of juvenile release timing. Therefore, we anticipate the effects of all fisheries on ESA-listed species are expected to continue at levels similar to those described in the Environmental Baseline. These effects are described above in Section 2.3.1 and in NMFS (2016c).

2.4.3. Effects of the Action on Critical Habitat

The proposed action will not change effects to designated critical habitats of ESA-listed species in a manner inconsistent with that described in the 2016 opinion. As described above in Section 2.4.2, water quality degradation will increase slightly due to additional production at Enetai Hatchery, Hoodsport hatchery, and the PGST net pen facilities. However, the increased level of degradation to water quality is minor and not different from that described in NMFS 2016 opinion. We also note that proposed sampling of juvenile steelhead in the Dosewallips watershed will increase foot traffic in the riparian corridor, which is a low-intensity and will otherwise have no effect on designated critical habitat features for any species.

2.5. Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. For the purpose of this analysis, the action area is described in Section 2.3. Future Federal actions, including the ongoing operation of the hydropower system, hatcheries, fisheries, and land management activities will be reviewed through separate section 7 consultation processes. In this section we review any new or changed effects from those considered as part of the 2016 Opinion.

The federally-approved Shared Strategy for Puget Sound recovery plan for Puget Sound Chinook Salmon (SSPS 2007) describes, in detail, the ongoing and proposed state, tribal, and local government actions to reduce known threats to ESA-listed species in the Hood Canal. NMFS recently published a recovery plan for Puget Sound steelhead (NMFS 2019c), and many of the actions described for steelhead recovery will also benefit other listed species. This plan describes ongoing and proposed state, tribal, and local government actions to reduce known threats to PS steelhead in the Hood Canal. Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, policy initiatives, and land use and other types of permits. Government and private actions may include changes in land and water uses, including ownership and intensity, which could affect listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties.

Non-Federal actions are likely to continue affecting listed species. Many of these actions, such as residential, commercial, and industrial building permits are made at the county-level and are subject to state law, but not federal law. State, tribal, and local governments have developed plans and initiatives to benefit listed species (SSPS 2007). The cumulative effects of non-Federal actions in the action area are difficult to analyze because of the political variation in the action area, and the uncertainties associated with funding and implementation of government and private actions. In general, we anticipate gradual increases in effects associated with residential and commercial building throughout the Hood Canal basin that will manifest in minor changes in water quality. However, we expect the activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past.

Ongoing state, tribal, and local government salmon restoration and recovery actions implemented through plans such as the recovery plans (NMFS 2018; SSPS 2007) would likely continue to help lessen the effects of non-Federal land and water use activities on the status of listed fish species. The temporal pace of such decreases would be similar to the pace observed in recent years. Habitat protection and restoration actions implemented thus far have focused on preservation of existing habitat and habitat-forming processes; protection of nearshore environments, including estuaries, marine shorelines, and Puget Sound; instream flow protection and enhancement; and reduction of forest practice and farming impacts on salmon habitat. Because the projects often involve multiple parties using Federal, state, and utility funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects.

With these improvements, as based on the trends discussed above, there is also the potential for adverse cumulative effects associated with some non-Federal actions to increase, such as urban development (Judge 2011). To help protect environmental resources from potential future development effects, Federal, state, and tribal laws, regulations, and policies are designed to conserve air, water, and land resources. A few examples include the Federal Navigable Waters regulations of the Clean Water Act, and in Washington State, various habitat conservation plans (HCPs) have been implemented, such as the Washington Department of Natural Resources (DNR) Forest Practices HCP (Washington Department of Natural Resources (DNR) 2005).

Overall, there little change in the level of cumulative effects from that described in the 2016 opinion. 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.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 2.5.2) to the environmental baseline (2.4) and to cumulative effects (2.6) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (Sections 2.2).

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

2.6.1. Puget Sound Steelhead DPS

As discussed in the 2016 opinion, the best available information indicates that PS steelhead DPS remains threatened (NWFSC 2015b). Since then NMFS published a recovery plan for PS steelhead (NMFS 2019c), which did not yield additional information on the conservation status of the species beyond that which was considered in the 2016 opinion on the 10 Hood Canal hatchery programs. Large recovery projects, such as the 2012 removal of two Elwha River dams and ongoing floodplain restoration in the Dungeness River, continue to improve recovery prospects for the summer and winter-run populations in the Strait of Juan de Fuca MPG. Status of Hood Canal populations have not changed from that characterized in the 2016 opinion (NMFS 2016a; NMFS 2017a).

In this opinion NMFS has evaluated effects of additional capture, handling, holding, and collection of biological samples from up to 120 PS steelhead in the Dosewallips River with methodologies used for several years in seven other watersheds of the Hood Canal. We also considered the effects to listed species resulting from additional effluents released from hatcheries and the ecological interactions associated with releasing more juvenile salmon into freshwater and marine habitats. The increase in take of PS Steelhead will be limited to a single tributary with the West Hood Canal DIP (Dosewallips, Duckabush, Hamma Hamma, and Quilcene rivers, and Tarboo Creek). Hard et al. (2015b) found this DIP had the highest trend in natural origin spawners throughout the entire DPS. Thus, we consider the proposed increase in take associated with additional RM&E activities will have little to no risk to this population, which is considered among the most viable in the DPS.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for this DPS describe the ongoing and proposed state, tribal, and local government actions targeted to reduce known threats. Such actions are improving habitat conditions, and hatchery and harvest practices. NMFS expects current trends in habitat restoration will be slow, but will improve features to critical habitats that increase in abundance, productivity, spatial structure and diversity of PS steelhead.

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 on abundance, productivity, spatial structure, and diversity, will not appreciably reduce the likelihood of survival and recovery of PS steelhead.

2.7. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the Proposed Action, including effects of the Proposed Action that are likely to persist following expiration of the Proposed Action, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of the Puget Sound steelhead DPS or to destroy or adversely modify designated critical habitat.

2.8. 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 impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not prohibited under the ESA, if that action is performed in compliance with the terms and conditions of the ITS. The following Statement includes take that was previously identified in the 2016 Opinion, as well as additional take attributable to the proposed changes to the action.

2.8.1. Amount or Extent of Take

NMFS analyzed six factors applicable to the proposed hatchery salmon actions described above in Section 2.4.1 and in NMFS (2016c) that are likely to result in take of listed Puget Sound Chinook salmon and Puget Sound steelhead. In the previous consultation NMFS did not find that take of Hood Canal summer chum salmon is anticipated, and that has not changed.

The level of take associated with broodstock collection, facility operations, and RM&E are shown in tables for each species: Puget Sound Chinook salmon (Table 4) and Puget Sound Steelhead (Table 5). Exceeding the amount of take noted below will result in reinitiation of this biological opinion.

Table 4. Amount of incidental take of Puget Sound Chinook salmon resulting from the proposed action.

Hatchery program	Status	Observed/ Harassed	Capture, handle, release (mortality)	Incubation/ rearing mortality	Broodstock (direct take)
Hamma Hamma Fall Chinook Salmon Supplementation	Discontinued	100	18 (2) adult	13,100 (egg-juvenile)	Up to 60 adults
Hood Canal Steelhead Supplementation	RM&E ongoing	0	1,000 (25) juvenile	N/A	N/A
Quilcene National Fish Hatchery Yearling Coho Salmon Production	Ongoing	0	2 juvenile 2 adult	N/A	N/A
Hoodsport Hatchery Fall Chinook salmon	Ongoing	0	100 (5) adult	N/A	N/A
Hoodsport Hatchery Fall Chum Salmon	Ongoing	0	5 adult	N/A	N/A
Hoodsport Hatchery Pink Salmon	Ongoing	0	2 adult	N/A	N/A
Port Gamble Coho Salmon Net Pen	Ongoing	0	0	N/A	N/A
Port Gamble Hatchery Fall Chum Salmon	Ongoing	0	2 adult	N/A	N/A
Quilcene Bay Coho Salmon Net Pen	Ongoing	0	0	N/A	N/A
Skokomish Enetai Creek Hatchery Fall Chum Salmon	Ongoing	0	2 adult	N/A	N/A

Table 5. Amount of incidental take of Puget Sound Steelhead resulting from the proposed action.

Hatchery program	Status	Observed/ Harassed	Capture, handle, release (mortality)	Incubation /rearing mortality	Broodstock (direct take)
Hamma Hamma Fall Chinook Salmon Supplementation	Discontinued	0	2 adult	N/A	N/A
Hood Canal Steelhead Supplementation	RM&E ongoing	6,000 egg	14,720 (40) juvenile 175 (12) adult	N/A	N/A
Quilcene National Fish Hatchery Yearling Coho Salmon Production	Ongoing	4,000 egg 50 juvenile 5 adult	5 juvenile 4 adult	N/A	N/A
Hoodsport Hatchery Fall Chinook salmon	Ongoing	0	2 adult	N/A	N/A
Hoodsport Hatchery Fall Chum Salmon	Ongoing	0	2 adult	N/A	N/A
Hoodsport Hatchery Pink Salmon	Ongoing	0	0	N/A	N/A
Port Gamble Coho Salmon Net Pen	Ongoing	0	0	N/A	N/A
Port Gamble Hatchery Fall Chum Salmon	Ongoing	0	0	N/A	N/A
Quilcene Bay Coho Salmon Net Pen	Ongoing	0	0	N/A	N/A
Skokomish Enetai Creek Hatchery Fall Chum Salmon	Ongoing	0	2 adult	N/A	N/A

Factor 2: Hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds

Effects of hatchery fish on the genetics of natural-origin fish 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.

With respect to Chinook salmon, in its previous biological opinion (NMFS 2016c) relied on a surrogate for an indication of the level of incidental take: pHOS. This is the appropriate indicator of take because limiting the number of hatchery-origin fish on the spawning grounds also limits the amount of spawning site competition and redd superimposition that can occur between hatchery and natural-origin fish. Therefore, the take surrogate is logically related to take from genetic and ecological effects. In years when the average natural-origin population abundance for the most recent twelve years remains under the critical value of 200, pHOS for the Hamma Hamma Fall Chinook Salmon program will be limited to the difference between the natural-origin returns and an overall population abundance target of 300 spawners. Once the critical value is exceeded, pHOS will be limited to the HSRG recommendation of 30 percent. The take surrogate can be reliably measured and monitored through spawning ground surveys.

With respect to steelhead, NMFS relied on a surrogate for an indication of the level of incidental take from genetic effects: a minimum natural-origin abundance of 750. When the abundance of steelhead in any of the supplemented Hood Canal steelhead population exceeds 750 fish in any given year, the operators of the Hood Canal Steelhead Supplementation Program would need to confer with NMFS on the potential genetic effects of their program on natural-origin steelhead, until the last of the adult returns is expected in 2019[2]. This is an appropriate indicator of take, because genetic effects would become more of a concern once the demographic effects of extremely small populations (i.e., finding a mate) are no longer as much of a concern relative to low abundance concerns. The take surrogate can be reliably measured and monitored through spawning ground/redd surveys.

Factor 3: Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean

Competition with and predation by residual hatchery-origin Chinook salmon and coho smolts could result in take of natural-origin Chinook salmon and steelhead within the fresh and marine waters of the Hood Canal region. However, it is difficult to quantify this take because ecological interactions cannot be observed. Thus, the surrogate take variable for this take pathway is the date of yearling smolt release. This standard has a rational connection to the amount of take expected from ecological interactions because adverse ecological interactions increase the more overlap there is between hatchery and natural-origin fish.

For this take surrogate, releases of yearling coho and Chinook salmon smolts should take place after the majority of natural-origin Chinook salmon and steelhead have exited the system, which is around the end of March. NMFS considers, for the purpose of this take surrogate, that hatchery yearling smolts cannot be released prior to April 15th. If there is a need to release hatchery yearling Chinook salmon and coho prior to this date, the operator has to consult with NMFS to show information that doing so will not increase the temporal overlap with natural-origin fish. Absent this showing, releases before April 15 will be considered to have exceeded the level of incidental take. In addition, release numbers must not exceed those proposed in the HGMPs by greater than 10 percent. The take surrogate can be reliably measured and monitored through enumeration and tracking of release dates for hatchery yearling Chinook and coho salmon. If NMFS receives information that the emigration of a majority of natural-origin juveniles has shifted to a later time, NMFS will revisit this take surrogate.

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[2] This program, with the exception of research, monitoring, and evaluation activities, was discontinued after the last steelhead returned as adults in 2019. The effects of this program are only included in this incidental take statement for continuity with NMFS 2016 biological opinion.

Factor 4: Research, Monitoring, and Evaluation

Scientific research by the co-managers to monitor the effectiveness of their program may result in take of PS steelhead at the juvenile and/or adult life stage. Take may be in the form of capture, handling, harassment, injury, or mortality when collecting genetic tissue from live specimens. The level of take authorized is defined as the number of individual juvenile or adult fish captured and/or collected by the co-managers and mortalities that may result from research, monitoring, and evaluation activities.

2.8.2. 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 Puget Sound steelhead DPS or result in the destruction or adverse modification of their designated critical habitat.

2.8.3. Reasonable and Prudent Measures

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

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

1. Ensure that genetic diversity and ecological interactions associated with implementation of the HGMPs are not a threat to mid-Hood Canal Chinook salmon and Puget Sound steelhead.
2. Ensure that any natural-origin Chinook salmon and steelhead encountered during salmon broodstock collection operations are released unharmed.
3. Implement the hatchery programs as described in the 10 salmon and steelhead HGMPs and monitor their operation.
4. Indicate the performance and effects of the hatchery salmon programs, including compliance with the Terms and Conditions set forth in NMFS 2016 opinion (WCR-2014-1688), through completion and submittal of an annual report.

2.8.4. Terms and Conditions

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

1. Conduct surveys/assessments to determine the migration timing, abundance, distribution, and origin (hatchery and natural) of Chinook salmon and steelhead spawning naturally as described in the HGMPs.
    a. Use current monitoring data and/or conduct new monitoring as necessary to assess juvenile carrying capacity for the action area based on current habitat conditions.

    b. Conduct surveys/assessments of coho, fall chum, and pink salmon as described in the HGMPs to monitor and report on any redd superimposition or spawning site competition observed where listed Chinook salmon and summer chum salmon and steelhead spawn naturally.
    c. Maintain the percentage of Hoodsport hatchery Chinook salmon below the HSRG guideline of 5 percent of the total spawners in the Hamma Hamma, Dosewallips, and Duckabush Rivers (HSRG et al. 2004).
    d. Maximum releases should not exceed 10 percent of the proposed release numbers.
    e. Releases of yearling Chinook salmon and coho salmon should not occur prior to April 15th.
2. Immediately release unharmed any listed salmon or steelhead incidentally encountered in the course of salmon broodstock collection operations at the point of capture. Record the number, location, and condition of any listed salmon or steelhead encountered during collection.
3. Implement the hatchery programs as described in the HGMPs. Notify NMFS's Sustainable Fisheries Division (SFD) in advance of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.
4. Ensure compliance and performance reporting requirements by completing the following actions:
    a. Notify NMFS as soon as any take thresholds are exceeded within two days of exceedance.
    b. Provide an annual report to NMFS SFD on or before April 1st that includes the RM&E described in Terms and Conditions 1-3. All reports and required notifications are to be submitted electronically to the NMFS, West Coast Region, Sustainable Fisheries Division, Anadromous Production and Inland Fisheries Branch. The current point of contact for document submission is Scott Sebring (360-819-7873; scott.sebring@noaa.gov).

2.9.Conservation Recommendations

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

1. Stop releasing coho salmon upstream of the Quilcene National Fish Hatchery until studies determine if there is a natural coho run present in the Big Quilcene River to preserve the genetic diversity of any natural stock.
2. Screen all unscreened intakes even within water bodies where listed fish are not expected to occur to better ensure authorized take limits are not exceeded.

2.10. Not Likely to Adversely Affect Determinations

In this section NMFS addresses effects to Hood Canal summer chum salmon and Puget Sound Chinook salmon resulting from the five new Hood Canal HGMPs. In both cases, NMFS has found the proposed changes do not result in an increase in the amount of incidental take described and analyzed in the 2016 opinion. These determinations were made pursuant to Section 7(a)(2) of the ESA implementing regulations 50 CFR 402, and agency guidance for preparation of letters of concurrence, and is described below.

The applicable standard to find that a Proposed Action is “not likely to adversely affect” ESA listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur.

2.10.1. Hood Canal summer run chum salmon

Summer chum salmon evolved to use freshwater and estuarine habitats during periods when interaction with other Pacific salmon species and runs is minimal. The uniqueness of the summer chum salmon ESU is characterized by late summer entry into freshwater spawning areas, and late winter/early spring arrival in the estuaries as seaward-migrating juveniles.

Summer chum salmon exhibit a distinct early life history in the Hood Canal based upon timing and development. Depending upon temperature regimes in spawning streams, eggs reach the eyed stage after approximately 4-6 weeks of incubation in the redds, and hatching occurs approximately 8 weeks after spawning (WDFW and PNPTT 2000). Alevins develop for additional 10 to 12 weeks in the gravel before emerging as fry between February and the last week of May. Estimated peak emergence timings for Hood Canal and Strait of Juan de Fuca summer chum populations are March 22 and April 4 respectively. In contrast, fall chum salmon stocks spawn in Hood Canal streams predominately in November and December, and fry emerge from the spawning gravels approximately one month later than summer chum salmon, between late April and mid-May (Tynan 1997). Chum salmon fry recovered in Hood Canal marine areas during the summer chum salmon emergence period range in size from 35 to 44 millimeters.

Upon arrival in the estuary, chum salmon fry inhabit nearshore areas (Bax 1983a; Bax 1983b). Chum salmon fry have a preferred depth of between 1.5-5.0 meters at this stage (Allen 1974) and are thought to be concentrated in the top few meters of the water column (Bax 1983b). In Puget Sound, chum salmon fry have been observed to reside for their first few weeks in the top 2-3 centimeters of surface waters and extremely close to the shoreline (WDFW and PNPTT 2000). Iwata (1982) reports that, in Japan, chum salmon are located in stratified surface waters (20 to 100 centimeters depth) upon arrival in the estuary, showing a very strong preference for lower salinity water (10 to 14 parts per thousand) found above the freshwater/saltwater interface, perhaps as a seawater acclimation mechanism. Onshore location may protect the fry from larger fish (WDFW and PNPTT 2000) and schooling behavior may be an adaptation to predator avoidance (Feller 1974).

Chum salmon fry arriving in the Hood Canal estuary are initially widely dispersed (Bax 1983b), but form loose aggregations oriented to the shoreline within a few days (Bax 1983a; Bax 1983b). These aggregations occur in daylight hours only, and tend to break up after dark, regrouping nearshore at dawn the following morning report that chum salmon fry at this initial stage of out-migration use areas predominately close to shore (WDFW and PNPTT 2000). Hood Canal summer chum salmon fry usually occupy sublittoral seagrass beds with residence time of about one week and maintain a nearshore distribution until they reach a size of 45 to 50 millimeters, at which time they move to deeper offshore areas (WDFW and PNPTT 2000).

Chum salmon fry captured in nearshore environments during out-migration in upper Hood Canal are found to prey predominantly on epibenthic organisms that change to predominantly pelagic organisms in early May (WDFW and PNPTT 2000). Several researchers have documented a reliance on drift insects by migrating chum salmon fry in nearshore tidal areas of the Hood Canal and the Salish Sea (Mason 1974). Migration off-shore could result from opportunistic movement of fry to take advantage of larger, more prevalent prey organisms in the neritic environment (Bax 1983b).

Upon reaching a threshold size (approximately 50 millimeters), summer chum salmon entering the estuary are thought to immediately commence migration seaward, migrating at a rate of 7 to 14 kilometers per day (Tynan 1997). Rapid seaward movement may reflect either “active” migration in response to low food availability or predator avoidance, or “passive” migration, brought on by strong, prevailing south/southwest weather systems that accelerate surface flows and move migrating fry northward (Bax 1983a; Bax 1983b). Assuming a migration speed of 7 kilometers per day, the southernmost out-migrating fry population in Hood Canal would exit the Canal 14 days after entering seawater, with 90 percent of the annual population exiting by April 28 each year, on average. Applying the same migration speed, summer chum salmon fry originating in Strait of Juan de Fuca streams would exit the Discovery Bay region 13 days after entering seawater, or by June 8 each year (90 percent completion).

Migration timing of summer chum salmon into the Strait of Juan de Fuca appears earlier than arrival timing observed for Hood Canal summer chum salmon. The stocks in this region enter the Strait of Juan de Fuca from the first week of July through September (WDFW and PNPTT 2000). Summer chum salmon mature primarily at 3 and 4 years of age with low numbers returning at age 5 (there are rare observations of age 2- and 6-year fish). They enter the Hood Canal terminal area from early August through the end of September. Entry pattern data for Quilcene Bay suggest that summer chum salmon enter extreme terminal marine areas adjacent to natal streams from the third week in August, through the first week in October, with a central 80 percent run timing of August 30 through September 28, and a peak on September 16.

Comparison of extreme terminal area entry timing in Quilcene Bay with spawning ground timing estimates developed from Big Quilcene River data, suggests that summer chum salmon may gather near the confluence of their natal stream for up to ten to twelve days before entering freshwater (with shorter pre-spawn acclimation times later in the run). Thus, it is assumed that summer chum salmon observed on spawning grounds entered the river five days earlier, based on a ten day average survey life. This behavior is likely related to the amount of time required for summer chum salmon to complete maturation and to acclimate to freshwater, but is also affected by available stream flows.

Spawning ground entry timing in Hood Canal tributaries ranges from late August through mid-October. Hood Canal summer chum salmon typically spawn soon after entering freshwater in the lowest reaches of natal streams (Johnson et al. 1997). This characteristic may reflect an adaptation to low flows present during their late summer/early fall spawning ground migration timing confines spawning to center-channel areas with sufficient water volume that may later become exposed to increased risk of scouring. Low stream flow during the summer months is thought to have confined this species to the lowest reaches of watersheds.

Regarding potential changes in effects to the species since the 2016 Opinion, the proposed juvenile steelhead sampling area may occur from RM 0 to 15.6 of the Dosewallips River, which may theoretically coincide with presence of summer chum salmon be present in the lower reaches. In the 2016 opinion NMFS found that sampling for steelhead parr and smolts, proposed for April though the end of summer, may overlap initially with the presence of summer chum salmon fry. In this case, the proposed sampling period for the Dosewallips watershed is limited to about 10 weeks during the late summer that avoids the potential overlap with summer chum salmon at the fry life stage.

Studies of juvenile steelhead in Mid-Hood Canal tributaries report estuary residency is short with minimal adaptation prior to saltwater entry (WDFW and PNPTT 2000). Juvenile steelhead prefer freshwater reaches with abundant cover and structure. The habitat preferences of both chum salmon and steelhead makes the lower reaches of the watersheds, where potential overlap with summer chum salmon is possible, unlikely locations for capturing juvenile steelhead. As a result, the potential for incidental take of summer chum salmon is highly unlikely, as it is in all other tributaries where juvenile steelhead sampling occurs and where the two species may co-occur.

As noted above, HC summer chum salmon exhibit early-entry into freshwater as adults, spawning several weeks prior to the later-returning fall chum salmon that are reared at several hatcheries throughout the Hood Canal. This timing precludes the possibility of co-occurrence between HC summer chum salmon and additional fall chum salmon or coho salmon released from Hoodsport Hatchery or Port Gamble net pens. It is possible that if the early experimental fall Chinook salmon release group is released during the first week of April these fish may be present in Hood Canal concurrent with late-emerging summer chum salmon fry. The small size of the experimental release group and the propensity of this fall Chinook salmon to rapidly migrate oceanward upon saltwater entry (Fresh 2006; Fresh et al. 2006) precludes the potential for adverse interactions among ESA-listed species in Hood Canal.

Summer chum salmon occupy mid- to large tributaries in the Hood Canal and Strait of Juan de Fuca regions that have sufficient flow during the late summer and early fall to provide spawning and rearing habitats (WDFW and PNPTT 2000). The PGST net pen facility is located more than 19 miles away from the nearest summer chum salmon tributary (i.e., Big Beef Creek). This distance allows sufficient space and time for summer chum salmon to migrate to different marine microhabitats that are otherwise unused by larger juvenile coho salmon (Fresh 2006; Fresh et al. 2006). This amount of spatial displacement and the modest increase in coho salmon released at the PGST net pen facility is too small to result in adverse effects to Hood Canal summer chum salmon.

As noted above in section 2.5.2, effluents from Hoodsport Hatchery and the Port Gamble net pens are anticipated to increase proportional to the number of additional fish reared at each facility. The magnitude of additional effluents released into the marine waters of Hood Canal are too minimal and Hood Canal summer chum salmon are unlikely to be exposed to water quality conditions commensurate with adverse effects.

2.10.2. Puget Sound Chinook salmon

Chinook salmon exhibit a 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). Ocean-type Chinook salmon reside in coastal ocean waters for 3 to 4 years and enter freshwater for spawning later (June through August) than stream-type Chinook salmon (March through July; (Myers et al. 1998). Ocean-type Chinook salmon also spawn and rear in lower elevation mainstem rivers and they typically reside in freshwater for no more than 3 months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

The Puget Sound Chinook Salmon ESU encompasses all runs of Chinook salmon from rivers and streams flowing into Puget Sound, including the Straits of Juan de Fuca from the Elwha River eastward, Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. The Puget Sound Technical Recovery Team (PSTRT) determined there are currently 22 extant historical populations (grouped into five biogeographic regions) and 16 additional spawning populations that are now putatively extinct (Ruckelshaus et al. 2006).

Twenty-six artificial Chinook salmon propagation programs are included within the ESU, including the George Adams and Hamma Hamma programs within Hood Canal (70 FR 37160, NMFS 2005). NMFS issued results of a five-year species status review on August 15, 2011 (76 FR 50448), and concluded that Puget Sound Chinook salmon should remain listed as threatened under the ESA.

NMFS adopted the recovery plan for PS Chinook salmon, which describes the population structure, identifies populations essential to ESU recovery and establishes recovery goals (NMFS 2006; SSPS 2007). The recovery goals consider the population level viability criteria recommended by the PSTRT (Ruckelshaus et al. 2002) and will be met when:

1. All populations improve in status and none of the 22 remaining populations goes extinct.
2. At least two populations in each of the five biogeographical regions attain a low long-term risk status.
3. At least one population from major diversity groups historically present in each of the five regions attain a low risk status.
4. Puget Sound tributaries are functioning sufficiently to support ESU recovery.
5. Production of Chinook salmon from Puget Sound tributaries is consistent with ESU recovery.
6. The direct and indirect effects of habitat, harvest and hatchery management actions are consistent with ESU recovery.

Historically, both spring and fall-run Chinook salmon inhabited the Skokomish River and other Mid-Hood Canal watersheds (e.g., Dosewallips, Duckabush, Hamma Hamma, and Big Quilcene rivers) (Skokomish Indian Tribe and WDFW 2017). Chinook salmon in the Dosewallips watershed and throughout the Hood Canal exhibit a fall-spawning life history. Adults returning to spawn in late September and October. The appearance of Chinook salmon in the late summer and fall months will not coincide with sampling activities for juvenile steelhead. As noted in the 2016 opinion, the expertise and oversight of WDFW researchers in the seven Mid-Hood Canal tributaries where sampling of juvenile steelhead previously occurred will avoid the potential for adverse effects to Chinook salmon, but to other salmonids.

Ecological interactions among hatchery fish and PS Chinook salmon are similar to those described in the 2016 opinion because the abundance of fall chum salmon and coho salmon released from the Hoodsport Hatchery and the PGST net pens are similar to those analyzed in 2016. An exception are the experimental release groups of fall Chinook salmon from Hoodsport Hatchery that will enter the Hood Canal approximately 2 to 3 months earlier or later than the typical June release group. Individuals from the late summer experimental release group will enter the Hood Canal weeks to months after natural-origin PS Chinook salmon, thus these fish are not expected to co-occur. The early experimental release group of fall Chinook salmon may co-occur in the marine waters of the Hood Canal with PS Chinook salmon from the Skokomish River. However, the potential for adverse effects to PS Chinook salmon from interactions with individuals from the early release group is extremely low given the physical distance between the Skokomish River and Finch Creek and differences in habitat preferences of hatchery and natural-origin fish upon entering saltwater (Fresh 2006; Fresh et al. 2006). Overall, the size of the experimental release groups are too small to result in an increased potential for adverse interactions among hatchery and natural-origin PS Chinook salmon.

As noted above in section 2.5.2, effluents from Hoodsport Hatchery and the Port Gamble net pens are anticipated to increase proportional to the number of additional fish reared at each facility. The magnitude of additional effluents released into the marine waters of Hood Canal are too minimal cause additional adverse effects to PS Chinook salmon.

2.11. Reinitiation of Consultation

This concludes formal consultation on the NMFS determination on the Hood Canal steelhead supplementation program for additional sampling in the Dosewallips River watershed.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental 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. The Proposed Action includes an increase of the coho program by 300,000, in addition to that discussed in the 2016 opinion.

3.1. Essential Fish Habitat Affected by the Project

As described in the 2016 opinion, the action area includes habitat described as EFH for Chinook, coho, and pink 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. No HAPCs will be affected by the Proposed Action.

3.2. Adverse Effects on Essential Fish Habitat

The biological opinion describes in effects related to capture, holding, handling, and collection of biological samples from steelhead, a species that is not included in the MSA. Moreover, due to the timing and selectivity of effects on individual fish, and not fish habitat, we do not anticipate any effects on EFH that will differ from those described in the 2016 opinion.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook, coho, and pink salmon noted in the 2016 opinion, NMFS believes that the Proposed Action, as described in the HGMPs and the incidental take statement (ITS) (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS did not identify adverse effects to EFH associated with this reinitiation of the 2016 biological opinion. NMFS and BIA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

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. In this case, as no additional adverse effects to EFH were identified no response is necessary.

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 modifications to the Hood Canal steelhead supplementation program 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 and the NWFSC (operating entities). The scientific community, resource managers, and stakeholders benefit from the consultation through the increased understanding of the operation on the viability of natural populations of ESA-listed salmonids. This information will improve scientific understanding of hatchery-origin steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. The document will be available within two weeks at the NOAA Library Institutional Repository (https://repository.library.noaa.gov/welcome). 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 3. 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 2005). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population's current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

Table 6. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	Positive to negative effect Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor	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

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
	limiting population growth (i.e., productivity) (NMFS 2004c).	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	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).

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
	hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	

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

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

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

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

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

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

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

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

5.2.1. Genetic effects

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

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (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 (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 (Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (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)[3] 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 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 study of steelhead (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

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[3] 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.

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 (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[4]. 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 2).

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)[5]. 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

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[4] 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.

[5] 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.

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.

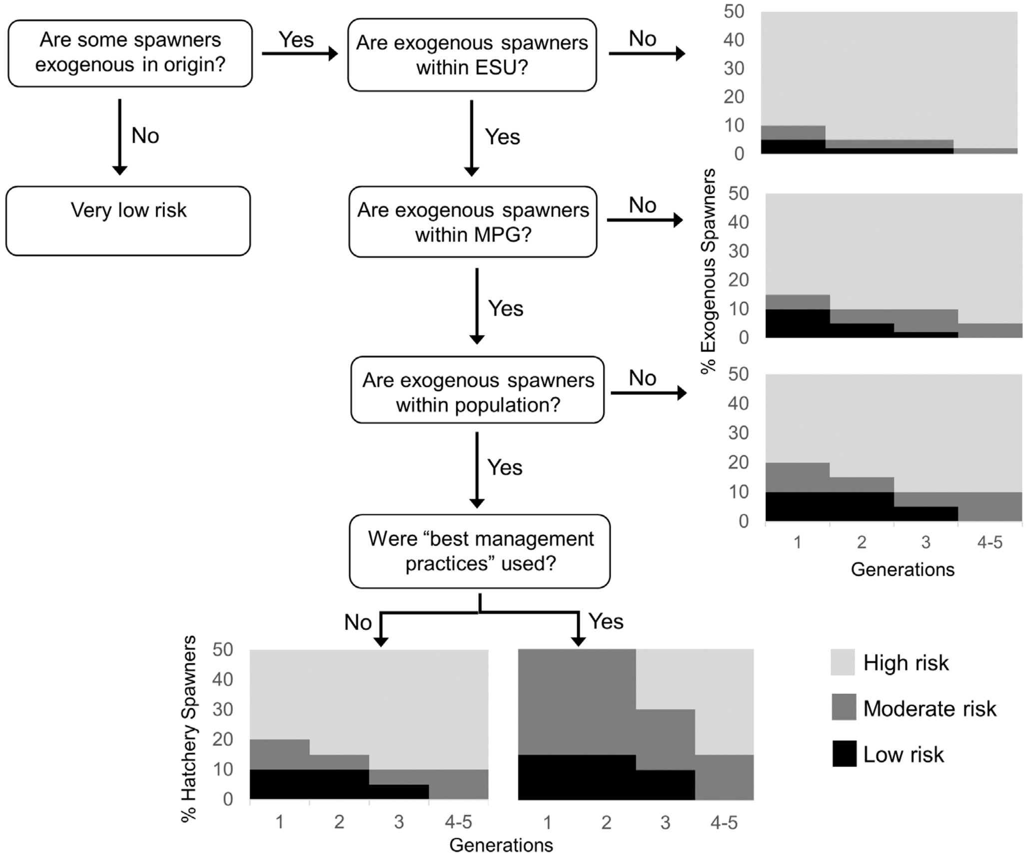

Figure 2. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity." They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.

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

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

$$\mathrm{pHOS}_{\mathrm{eff}} = \mathrm{RRS} \times \mathrm{pHOS}_{\mathrm{census}}$$

where $\mathrm{pHOS}_{\mathrm{census}}$ 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:

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

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

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

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

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 3 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[6]. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be N×N, 18 percent will be N×H, and 1 percent will be H×H. 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 N×H matings decreases; with no overlap, the proportion of N×N matings is 1 minus pHOS and the proportion of H×H 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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[6] These computations are purely theoretical, based on a simple mathematical binomial expansion: $(a+b)^2 = a^2 + 2ab + b^2$.

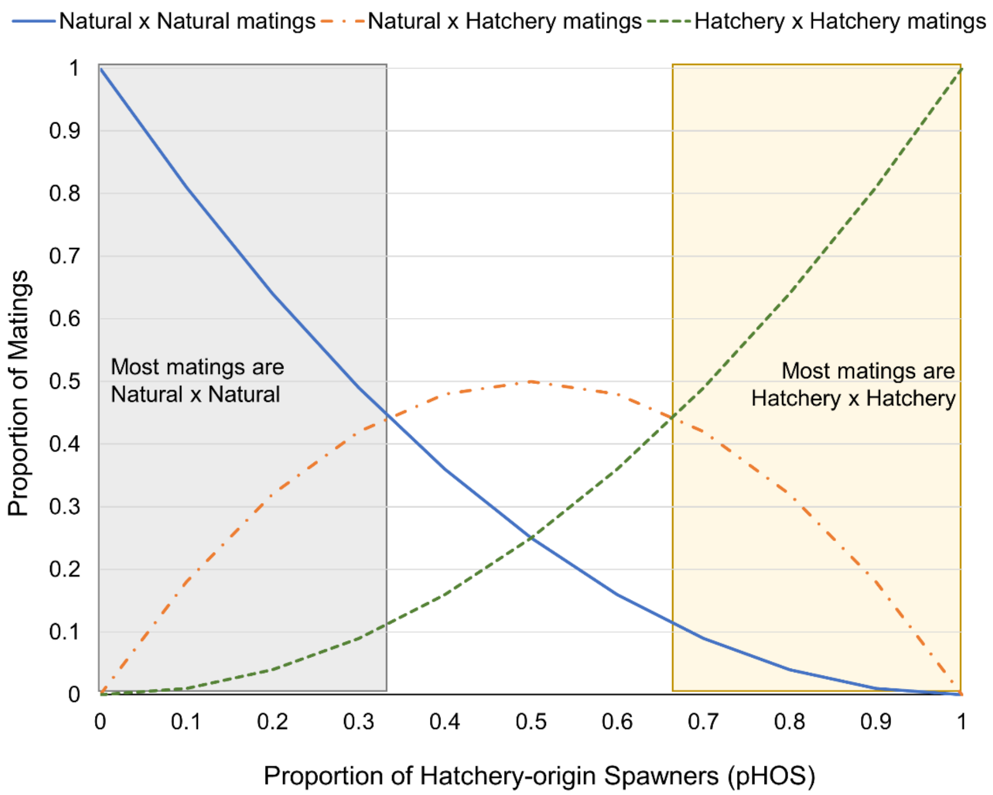

Figure 3. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

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 (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 (Fukushima et al. 1998).

5.2.3. Adult Collection Facilities

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

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

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

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

5.3.1. Competition

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan

1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

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

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

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

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

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

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

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[7] 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 predation is greatest when natural populations of salmon and steelhead are at low abundance,

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[7] "Action area" means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

(Rensel et al. 1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas 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; ODFW 2003; USFWS 2004; WWTIT and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*).

If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

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

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

5.3.4. Acclimation

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014).Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (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. (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 deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

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

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000; NMFS 2008) 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 2005). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

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